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ORIGINAL ARTICLE

Misconceptions In Chemistry At Ixth Grade And Their Remedial Measures

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Abstract:

The purpose of this work is to study the level of misconceptions among the students of class IXth grade about the unit structure of atom and the remedial measures of these misconceptions. The sample consisted of 189 students. The research has carried out with two groups' pre test post test control group design during four weeks. After administering entry level test, the experimental group was taught with illustrative materials, as remedial measure, containing various atomic model and then criterion referenced test (CRT) was administered on the same unit to collect the data. Paired sample't' test was used to compare the results obtained from entry level test and CRT using SPSS-16 software. The results from the post-tests indicated that the students in the experimental group, taught with the illustrative material, showed a significant decrease in misconception level than the students in the control group. These results show that the implementation of the new material produced better results in terms of achievement of the student.

INTRODUCTION

Misconceptions play a vital bar in learning chemistry, simply producing inadequate explanations to questions, the students face. Students construct their 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 (Mulford and Robinson, 2002). In addition, misconceptions, once embedded in a learner's conceptual schemes, are extremely hard to remove (Songer and Mintzes, 1994).

In the literature, there are many examples of students' misconceptions in chemistry, many of them belief that atoms in a metal are hard, but those in liquids are soft (Harrison and Treagust, 1996). According to Ben-Zvi, et al (1986), many students do not distinguish between the properties of a substance and the properties assigned to a single, isolated atom. Students believe 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 and Preston, 1992). They found 42 misconceptions hold by the students in grade 12 about the fundamental characteristics of atoms and molecules. D. Cros, et al. (1986) noted that university students who used the Bohr model to describe an atom failed to move beyond this picture, and this apparently stunted their development as chemists, hampering their understanding of interactions between subatomic particles. Lythcott (1990) found that a group of high school students who were able to balance an equation, could not draw a diagram of what was happening. Peterson and Treagust (1989) found that a lot of secondary school students, were unable to answer conceptual questions regarding electron repulsion in valence shells, whereas most of them were successful to write the correct answer when test were designed to verify this understanding. A study by Mulford and Robinson (2002) showed that first semester general chemistry students retained many of their initial concepts about atoms and molecules through the first semester of instruction. Levy Nahum (2004) conducted a study to find the level of misconceptions in chemistry towards atomic structure and chemical bonding and identified several factors that generate misconceptions in the mind of the students. Sarikaya (2007) studied the misconceptions of prospective teacher as well as the students about atomic structure in the context of electrification by friction (ASCEF). Cheung et al (2009) focused on the misconceptions of teachers towards chemical equilibrium.

Many investigators reports that the teaching through lecturing mode is ineffective because it creates the misconceptions among the students. Ahtee and Varjoli (1998) found that approximately 10% of eighth grade students in Finland failed to distinguish between substances and atoms. Beall (1994) lectured college students on the second law of thermodynamics and the ideal gas laws. After the lecture only 11% were able to correctly predict the effect of opening a cylinder of compressed gas would have on the temperature of the gas.

Harrison and Treagust (1996) classified the kinds of models that can be built of a physical phenomenon, and then observed how students used various models and types of model to build a picture of the phenomenon. They deduced that none of the 48 students completing a chemistry course had come to understand that the models they were using were only models, which served the development and testing of ideas, not the depiction of reality. Only one of the 48 seemed to even be "on the verge of achieving this understanding." The authors call for teachers to lead their students in a thorough study of the process of model construction and to an understanding of the limitations of the models so constructed.

Most of the researchers indicate that learning specific concepts is very much important in learning chemistry. Concepts like bonding, structure, rate of reaction, and internal energy apply to all chemical systems (Fensham, 1975). 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 which mainly depends on structure of atom (Taber and Coll, 2002). Therefore, atomic structure is a key concept in chemistry.

OBJECTIVES OF THE STUDY

For this study, we developed some illustrative material designed to encourage conceptual clarity of those students, holding misconceptions about structure of atom. Thus, the objectives of the present study are as follow:-

To study the degree of misconceptions among the students by administering a standardized entry level test for the unit “Structure of atom”(pre test)
To construct and standardize a CRT for the same unit.
To conduct an experiment following a suitable experimental design.
To administer a common CRT after experimentation in order to realize whether misconceptions have been removed or not (post test).

HYPOTHESES

The following hypotheses have been framed for the present study

1Ho : There will be no adequate level of misconceptions among the students of class IX for the unit 'structure of atom'.
2Ho: There will be no significance difference between control and experimental group of rural sector on the basis of post test.
3Ho: There is no significance difference between control and experimental group of urban sector on the basis of post test.
Variables for the Study:
Achievement scores for entry level test and CRT are the dependable variables and teaching strategies are the independent variables for the present study.
Delimitations of the Study

The delimitations of the present study are as follows:-

Population of the present study consists of class IX students of Murshidabad districts, West Bengal, India only
All the Institutions which have been selected for the study are recognized by The West Bengal Board of Secondary Education, WB, India.

POPULATION AND SAMPLE

The population for the sample was secondary school students of class IX grade of Murshidabad district, West Bengal, India. Four schools (two each from urban and rural section) were selected for the present study. Selection of schools was based on systematic multi stage sampling techniques. Firstly, all blocks and all municipality areas of Murshidabad were selected. Two blocks and two municipality areas were selected randomly. Then one school from each block and municipality area was selected through randomised techniques. Figure 1 clears the idea.

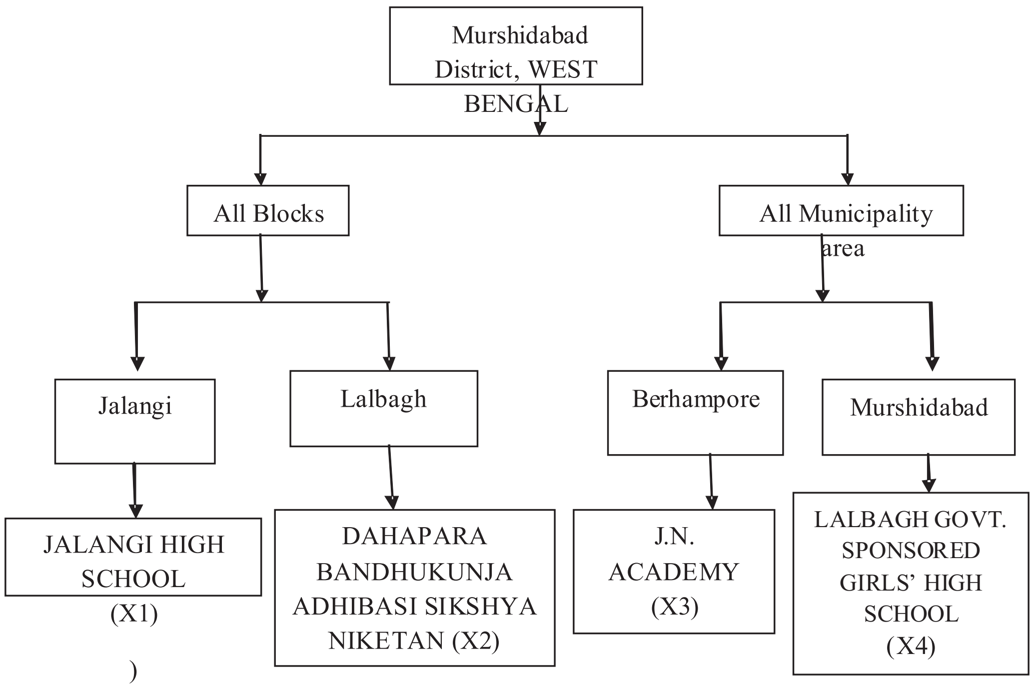

Figure 1. Sample taken from population

The school, selected for study have 45, 49, 48 and 47 students respectively. All of them have been treated either as control group or experimental group. Thus the total sample was 189. Table 1 represents the sample profile.

Table 1 Sample Profile

Serial no	School	No of students
1	X1	45
2	X2	49
3	X3	48
4	X4	47

DESIGN OF THE STUDY

Two group pre test post test control group design (Campbell and Stanley, 1963) has been framed. As we were unable to assign the students randomly to the groups due to constraints of the context, this study was quasi-experimental in nature. First of all, entry level test of diagnostic nature (pre test) was administered to both the group, namely the controlled groups and experimental groups to identify the degree of misconceptions in chemistry. Then controlled group was taught in traditional approaches and experimental group was exposed to proper concept using illustrative materials which help the student to concretize their ideas. In the final stage a common standardized CRT (post test) test was administered to compare the scores obtained by control and experimental groups.

ILLUSTRATIVE MATERIALS

The following models are used as illustrative materials that are used for this study.

1.Solar system model (SSM): The familiar solar-system/atom analogy has been used in a number of contexts to illustrate the analogical mapping process. In this analogy, the sun and planet in the solar-system domain are analogous to the nucleus and electron in the atom domain. The solar-system/atom model simulates the mapping process between these two domains. The model maps planet and sun in the solar-system domain to the electron and nucleus, respectively, in the atom domain (Figure 2).

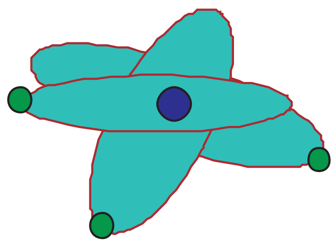

Figure 2. Solar system model of atom

1.Composite atomic model (CAM): A composite material is basically a combination of two or more materials, each of which retains its own distinctive properties. The nucleus is a dense region within the centre of an atom. The nucleus contains the composite particles neutrons and protons; together, neutrons and protons are called nucleons. The atom's nucleus is surrounded by an electron cloud (Figure 3).

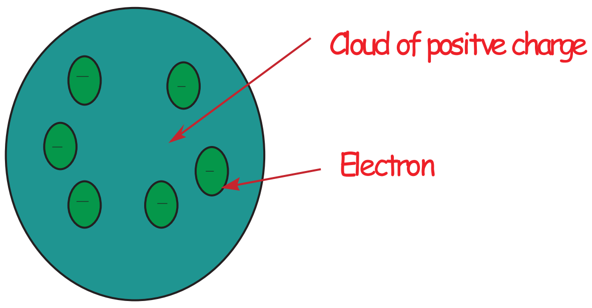

Figure 3. Composite atomic model

1.Ball-stick model: Ball-and-stick model is a molecular model of a chemical substance which aims to display both the three-dimensional position of the atoms and the bonds between them (Figure 4). The atoms are typically represented by spheres, connected by rods which represent the bonds. The chemical element of each atom is often indicated by the sphere's colour. In a ball-and-stick model, the radius of the spheres is usually much smaller than the rod lengths, in order to provide a clearer view of the atoms and bonds throughout the model. By using this model, pupils will describe the molecular arrays not the atom. Thus, applying this model pupil will be able to differentiate between atom and molecule.

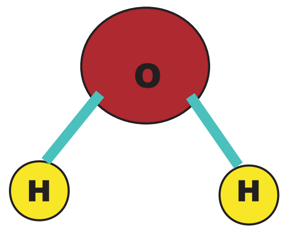

Figure 4. Ball stick model for water

Space filling model : Space-filling model is a type of three-dimensional molecular model, where the atoms are represented by spheres whose radii are proportional to the radii of the atoms, and whose center-to-center distances are proportional to the distances between the atomic nuclei, all in the same scale (Figure 5). Atoms of different chemical elements are usually represented by spheres of different colours

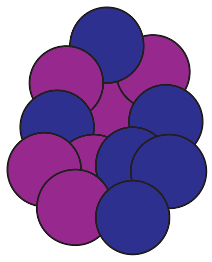

Figure 5. Space filling model

1.Electron cloud model : Figure 6 represents electron cloud model of an atom wherein electrons are no longer depicted as particles moving around the nucleus in a fixed orbit. Instead, as a quantum mechanically-influenced model, we shouldn't know exactly where they are, and hence describe their probable location around the nucleus only as an arbitrary 'cloud'.

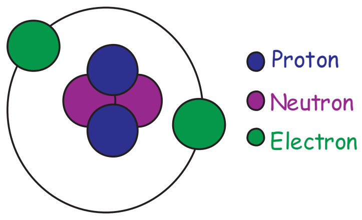

Figure 6. Electron cloud model for atom

EXPERIMENTATION

In class VIII, standard content of the unit “structure of atom” as per West Bengal Board of Secondary Education covered the following areas: general description of proton, neutron, electron with their mass and charge, description of nucleus which consists of proton and neutron and have positive charge, negatively charged electrons that revolve around the nucleus, the electronic shell, introduction of K, L shells only, structure of H and He atom. If the above concepts are not properly taught, there will be a possibility of developing misconceptions regarding this unit. So, first of all a standardized entry level test of diagnostic nature (pre test) was administered to identify the area of misconceptions. Then experimental group was exposed to various models like SSM, CAM, space filling model and Ball-stick models for four weeks whereas controlled group was taught with traditional method of instruction i.e. without help of illustrative materials. At the end of the treatment a common standardized CRT was administered to both the group (post test) and a comparative study was done through suitable statistical techniques.

STATISTICAL TECHNIQUES

Statistical analysis was made by SPSS (statistical package for social science)-16 software. As only two groups are involved in our study, only't' test will be computed to compare the mean score between various groups.

Table 2 The mean and SD of the misconception scores for entry level test

Sl. No	Name of the school	Mean scores (%)	SD
1	X1	41.96	12.98
2	X2	41.12	11.69
3	X3	43.80	12.65
4	X4	42.96	11.75

Table 3 The mean and SD of misconception scores for CRT

Sl. No	Group	Mean (%)	SD
1	Control (rural) (X1)	43.85	13.25
2	Experimental (rural) (X2)	25.92	14.65
3	Control (muni) (X3)	39.14	14.43
4	Experimental (muni) (X4)	22.62	13.35

Table 4 Determination of t-values for entry level test

Pair of comparison	Mean Difference	Std error mean diff	t-value
X1-X2	0.84	3.08	0.272*
X3-X4	1.72	2.89	0.597*

*** not significant even at 0.05 level**

Table 5 Determination of t-values for CRT

Pair of comparison	Mean Difference	Std error mean diff	t-value
X1-X2	16.52	2.66	6.19**
X3-X4	17.94	2.81	6.379**

**** Significant at 0.01 level**

RESULTS AND DISCUSSION

This study focused on the level of misconceptions for the unit 'structure of atom' and how to remove those misconceptions. In this respect we have standardized an entry level test of diagnostic nature carrying 50 marks whose reliability co-efficient was found to be 0.82 by split half methods. The sample items are following:

Which particle has a mass of approximately one atomic mass and a unit positive charge?
Whether the energy of an electron in the second shell of a carbon atom is lesser or greater when compare with the energy of an electron in the first shell?
What is a mass number of an atom that has six protons, six electrons and eight neutrons?
Whether the nucleus of the atom contains little or the most of the atom's mass if compared to the entire atom?
How can the number of neutrons in the nucleus of an atom can be determined?
Draw a diagram of the He-atom.

After careful analysis of the answer script of the students based on entry level test, it is concluded that:

Concept of mass number concept is not properly developed.
Concept of atomic nucleus is not clear to them.
Shell concept is not developed rightly.
Students do not always show the respective size of the atom when dealing with ball-stick and space filling model
Students mentioned only two models but Ball-stick model and electron cloud models are omitted. Ball stick model is generally used for description of molecular array but not for atom. So, pointing out of Ball-stick model is not a strong parameter of misconception measurement, but students were not cited the basic reason due to retention of misconception among atom and molecule. Students also knew an atom is composed of a nucleus that contains proton and neutron and electron cloud. But they have misconception of calculating numbers of proton, neutron and electron and also lack of neutrality concept they were not able to mention the electron cloud model.
Students do not able to differentiate between atom and molecule
So, it is essential to remove such type of misconception. That is why authors have tried to teach through some models like SSM, CAM, ball-stick models which are able to explain the concept of structure of atom. In order to verify whether those models are effective or not, authors have applied such teaching strategies to experimental group only. The concept of atomic number, atomic weight, and isotope, was presented using SSM model. Students of experimental group were divided into small groups and ball and sticks were given to them and asked to clarify structure of N2, H2O, CH4. The control group has taught through traditional method of instruction. After completion of whole work common standardized CRT of reliability co-efficient 0.87 by split half method, was administered to both the group (post test).

From Table 2 it is clear that all the groups have higher mean misconception score which was calculated in the following manner:

1.If the student fails to give proper explanation or give wrong answer or no answer then the misconception scores will be 1.
2.If the student gives correct answer then misconception score will be 0.

The results indicate that there was significant level of misconception among the student irrespective of residential background, and thus hypothesis 0H1 is rejected. Furthermore, 't' test (Table 4) shows that mean of misconception score of rural and urban sector is not significant even at 0.05 level of significance. It is also implied that means experimental and control groups are homogenous in nature.

After experimentation it is found that the conception level of the experimental groups improves significantly as evident from Table 3 as well as by the following feedback:

In the drawing of structure of atom (He and H2O), students drew two models of an atom viz. Solar system model (SSM) and composition atom model (CAM), but they did not mention space filling model, ball-stick model at the time of drawing of the structure of He atom but they mentioned at the time of drawing the structure of H2O molecule. They used the following logic while describing H2O molecule:

H2O molecule is made of two H-atoms and one oxygen atom.
In H2O molecule, two hydrogen atoms are linked with one oxygen atom.
Two H and one O are linked together with simple covalent bond.
One electron of each atom contributes in covalent bonds.

From Table 5 it is clear that 't' value is significant ($P<0.01$) between experimental and control group for both rural and urban sector. So 2Ho and 3Ho were rejected. It indicates that use of suitable device may reduce the level of misconception among the students. The result was supported from the study of Sarikaya (2007) who showed that the modelling atomic structure (MAS) provided a misconception remediation of the students.

REMEDIAL MEASURES

The illustrative materials as described above are very helpful in removing the misconceptions generated in the mind of the learner. The process of removal of misconception has been discussed in Table 6. It is suggested to the prospective teachers to use such type of illustrative materials so that no misconceptions will generate in the mind of the students.

Table 6 Remedial measures of misconceptions

Misconceptions	Remedial measures
Misconception regarding mass number	To eliminate this misconception solar system model (SSM) should be implemented. With this model students have got the idea about nucleus and the components of nucleus thus they can achieve the mass number concept properly.
Misconception regarding shell concept	In SSM orbit or shell concept is clearly viewed. So producing SSM before students they can able to assimilate the shell concept though they have already the concept of solar system in lower grade. In this regard electron cloud model is also an important tool.
Misconception regarding the size of the atom when dealing with ball-stick and space filling model	If students do not understand the mass number concept properly, they cannot show the different size of atom. So first they should be familiar with SSA model for the development of mass number concept.
Misconception regarding revolving of electrons around the nucleus	If shell concept is properly developed then the revolving property of electron around the nucleus is understood by the students in at this grade. In this regard electron cloud model (ECM) is very helpful.
Misconception regarding differentiation between atom and molecule	Proper execution of Ball-Stick model in the classroom is needed. Such model is only applicable for molecular demonstration but when teacher taught the concept of atom in classroom then it is mandatory to teacher also produce some ball-stick model of molecule to differentiate the two concepts.

CONCLUSION

The results of this study provided further evidence to support the findings and indicated that students held misconceptions on a variety of science concepts. This study also highlighted the value that modelling was quite useful in the teaching of science, and those students' misconceptions could be remedied through the use of models (Sarikaya, 2007). Science teaching supported by practical activities could therefore provide alternatives to traditional and other complementary methods to remedy misconceptions. The remediation of students' misconceptions is only possible by teachers, who are well trained and free from misconceptions. All prospective teachers need to be trained as experts who are aware of possible misconceptions. Prospective teachers, their teachers and instructors or lecturers need to be aware of students' prior knowledge and misconceptions, and they need to understand why these misconceptions occur. A successful teacher is a person who is aware of his or her students' misconceptions and knows how to dispel them.

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