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Remediation of Chemical Bonding Misconception through Conceptual Change Text

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Abstract

The study was conducted to explore the impact of conceptual change texts integrated instruction on 10th class students' understanding of chemical bonding concepts. It mainly aimed to investigate how conceptual change texts stimulate students' prior knowledge, identifying misconceptions, and to help them to understand the chemical bonding concepts by using analogies, explanations, and examples. In conceptual changes text, analogies were used to deal with students' misconceptions. The results analysis revealed that conceptual change texts-oriented instructions have a positive impact on students' understanding of scientific conceptions related to chemical bonding and also helpful in resolving the misconceptions. Mean scores of both groups showed that students in the experimental group performed better with respect to chemical bonding concepts.

Keywords: chemical bonding, misconception, analogy, conceptual change, conceptual change text

Introduction

Science education researchers are more focusing on the students' understanding of scientific knowledge [1][2]. These studies are conducted to investigate conceptual framework of students, support them to improve their understanding of science concepts and for teachers to use it for intended purposes. Most researches in science education revealed that a number of students don't engage themselves in meaningful learning and faces difficulty in relating what is taught to them, what they learnt and connecting that with other science ideas with real world experiences[3]. In meaningful learning, students engage themselves in constructing conceptual framework by using

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experiences, prior knowledge, and another knowledge for new concepts[4]. In recent research interests, researchers have carried out researches on meaning making and learning. These studies shows that students come in school with varied experiences, ideas and perception of natural world. In most cases, students' ideas are different from scientific ideas. These differing frameworks are referred as misconceptions by many researchers [5][6]. So, in the article, term 'misconception' refers the students' conceptions different from scientific conceptions. Some researchers' find the misconceptions resistant to change because these are embedded in students' cognition. Misconceptions hinder the new conception and linking of new knowledge to existing conceptions [7][8]. So, misconceptions are obstacles in meaningful learning.

Many misconceptions are caused due to the pedagogy used by the teachers. Untrained teachers passively engage the learners due to lack of pedagogical knowledge and student psychology of teaching-learning[9]. So, science educators as action researchers have engaged themselves in understanding students' misconceptions in scientific concepts. Various studies focused on students' misconceptions in chemical bonding revealed that students from different grades have a number of misconceptions in chemical boding out which some misconceptions are hard to change, due to untrained teachers' and traditional pedagogy. Conceptual understanding of chemical bonding is fundamental to further learning of various topics in chemistry[10]. So, instructional strategies other than traditional pedagogy can remediate the students' misconceptions. This study focusses on creating a meaningful learning and remediating students' misconceptions in chemical bonding. There are various studies which revealed that a number of the students face difficulty in construction of the concepts in chemical bonding [11][12][13]. Reasons for this might be because chemical bonding require prerequisite knowledge, and a large number of abstract concepts that are difficult to understand for the students[14]. One study conducted on the impact of covid pandemic on mental health and education revealed the impact of physical distancing on the practical classwork and peer learning which impacted the concept construction in chemical education[15]. Language used in social interaction and scientific knowledge meaning differences can also be the reason for misconception, lack of understanding of basic conception in chemical bonding, and inappropriate language used in text books can also be other reasons for misconception. Only a few teachers and textbook focus on constructivist approach, and putting emphasis on theoretical concept is among the recent challenges in science education[16].

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There are various studies on identify and treating the misconceptions in chemical bonding. Various researches suggested using active teaching learning instructional strategies for eliminating students' misconceptions because these strategies are leading to conceptual change. This conceptual change implies that students' actively and rationally replaces misconceptions with scientifically acceptable conceptions which create a network in his conceptual framework. Many science educators used constructivist approach in science education to change science conceptual framework [17][18]. Heuristic writing approaches, and peer review instructional strategies are also found impactful by some researchers conducted on school students in science education[19]. Study conducted on cooperative teaching learning strategies, and computer simulations found the strategies useful in rectifying covalent bonding misconceptions[20]. There are more researches claiming that conceptual change approach including conceptual text is much helpful in rectifying the alternative conceptions in science education. Analogies as explanatory devices used by science educators are also found useful in remediation of chemical bonding misconceptions by some researchers[22]. Studies showed that analogies provide learners' opportunities to work on their existing concepts, felicitate text learning, meaningful learning, and constructing knowledge. These create link between conceptual understanding and real world, that motivate learners to learn more[23]. Analogies are good pedagogical tools that help student learning by providing visualization of abstracts concepts, relating similarities between objects and events in the students' world and the phenomenon under discussion[24]. So, analogies are used in conceptual change texts to support students in abstract conceptions of chemical bonding and making it interesting. Use of chemical games in difficult chemistry concepts stimulate students' cognition and held in resolving the misconception[25].

In the summary of many researches, it is found that students' normally have a lot of misconceptions in chemical bonding conceptions and these misconceptions if not eliminated, they affect subsequent learning negatively. The current study is concerned on remediation of chemical bonding misconception with instructional strategies based on integration of conceptual text, and analogies. Instructional strategies improve the understanding of chemical bonding conceptions.

Methodology

Participants: The study was conducted with 41 class 10th students having age range 14-15 years. Teachers were the subject experts and volunteers who were trained on conceptual strategies.

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Students were selected from the same school and divided in two group, 21 students in experimental and 20 students in control. Instructional methods were randomly assigned to each group. The experimental group was assigned with conceptual strategies and control group was assigned with traditional instructional approach.

Tools: Chemical Bonding Test (CBCT) was developed by the researchers and the subject experts. Science teachers with relevant experience in the teaching learning were involved in the review of the items. The items were written and finalized by examining the test books, instructional objectives, and chemical bonding literature. During the developmental phase of the test, the objectives of chemical bonding unit were taken in consideration to investigate whether the students achieved the behavioral objectives of the current study. Two tiers based 21 MCQs (Multiple Choice Questions) were included in CBCT. The first tier of each item assessed the content knowledge and the second tier consisted of four possible reasons for the first tier. The given reasons include one scientifically correct answer that support the content knowledge presented in the first tier and in second tier it consists three misconceptions from students' conceptual framework identified by the researchers, collected from the chemical education research literature, and intakes from the chemistry teachers. The students' need to choose the correct answer and correct reason for getting the point for correct answer, means, the student chose both correct content option and the correct reason, if one out of the two is correct choice, it was considered incorrect. The content validity of the test items, each item was examined by a group of experts and classroom teachers in science education. The internal consistency reliability of the test was 0.72.

Here is an example of test item.

Example 1. Which out of the following is true for the polarities of $CHCl_3$ and CCl_4?

(I) $CHCl_3$ and CCl_4 are polar

(II) Both $CHCl_3$ and CCl_4 are nonpolar

(III) CCl_4 is nonpolar but $CHCl_3$ is polar

Choose one correct Reason in support of the above answer:

A) If atoms of the molecule have same electronegativities only then the molecule is nonpolar

B) Nonpolar molecules have tetrahedral shape, so if shape is tetrahedral, it is nonpolar.

c) If molecule has polar bonds, it is a polar molecule.

D) Polarity of bonds and the shape of the molecule determine the polarity of the molecule.

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Some misconception used in the test as test items, distractors, are listed below in Table 1.

Table 1. Chemical Bonding misconceptions

1. Polar molecules are formed by polar bonds only.
2. Ionic charges determine the polarity of the bond.
3. Bonds are material conception rather than forces.
4. Bonds are formed between atoms that donate or accept the electrons.
5. Equal sharing of the electron pair occurs in covalent bonds
6. All covalent bonds are nonpolar.
7. Atoms of metals and non-metals combine and form molecules.
8. Atoms combine together to fill their octet only.
9. Nitrogen in bonding share five electrons.
10. Intermolecular forces are between molecules only.

Procedure: The study aimed to explore the impact of the conceptual change texts oriented Instructions on the 10^{th} class students' understanding of chemical bonding and elimination of their misconceptions. The students were taught by using the conceptual approach for two months (8 weeks). 41 students from class 10^{th} of the same school were the subjects where teachers used conceptual approach in experimental group and traditional approach control group. Both groups were taught the same content of the chemical bonding and the topics chosen were the part of regular curriculum in the chemistry course. The design of the study was quasi-experimental design.

In the control group, students studied the textbooks on their own before the classes. The instructions were teacher centered. Teachers' without considering the chemical bonding misconceptions of students used the lecture and discussion methods. Students were provided with worksheets as practice activities and teachers explained each concept. The worksheets required written responses, and reinforced the concepts. Evaluated worksheets were provided to the students by the teacher.

In experimental group, students were engaged conceptual approach through conceptual change text by teachers' lectures. Teachers explored about conceptual change text, and analogies prior the treatment. Conceptual change text and analogies were prepared by the researcher and the subject experts/ teacher volunteered the research collaboratively. Conceptual change text was prepared on

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the bonds, types of bonds, polarity, etc., conceptions in chemical bonding. The text was provided one day earlier to the classes. To make students aware about their misconceptions, firstly teachers engaged the learners by posing stimulating questions. The main aim of the questions was to train the students on the conditions which causes misconceptions and the process of resolving the misconceptions. Some questions in the text were:

1. What is a chemical bond?
2. Why chemical bonds occur?
3. How do hydrogen atoms are held together?
4. Does bond formation always involve transfer of elections?
5. Why atoms share electrons?

The teacher allowed the students to discuss these questions from conceptual change text within their peer group and come with their findings. Students used their prior knowledge related to chemical bonding (conceptions) to answer the questions. When students' ideas were not adequate to answer the items and dissatisfied the pre-existing conception, a cognitive conflict was there. Teacher allowed them to re-read the conceptual change text, brain storm to find the scientifically acceptable answers. Considering the abstract nature of the chemical bonding, analogies were also used in the conceptual change text. Most students think that chemical bonds are material conceptions, and bonds are like things that hold the atoms without knowing that there are forces that held atoms in molecules. To eliminate this misconception, teachers used the magnet analogy as the students were aware about the magnets. The like poles of magnets repel each other, while the unlike poles attract each other. Atoms are electrically charged, thus like a magnet charged species also attract and repel each other. Chemical bond is resulted due to the attractions between particles of atoms and holds the structure together. So, bond means electrostatic forces between the atoms. This analogy was successful in making the relationship between their conceptions and scientific knowledge. By this way, students were trained on using other information and relating it to chemical conceptions. Finally, teacher suggested students to replace the existing misconceptions with scientifically acceptance conceptions.

Homework questions were also based on the conceptual change texts and given to students. Homework was involving the students in creating their own analogies and then discuss the like and unlike points of their analogies. For example, borrowing a book from their friend or the library,

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was an analogy to explain how atoms are held together in molecules like H_2, O_2 and another molecule. Just like the book belongs to you and at the same time it is treated as it belongs to library or friend, so counted part of both, same is applicable on the electrons in Hydrogen and Oxygen molecules. There was discussion on the shared and unshared points of this analogy with real life situations. Many questions related to the above conceptual change text including analogies were discussed by the teacher in the classroom. This use of classroom discussions of analogies has enhanced their critical thinking, by engaging in brain storming and advocated as a way to increase awareness of their limitations.

Results

CBCT (Chemical Bonding Concepts Test) was conducted with all participants in pre-test and post-test. Pre-Test assessed the prior misconceptions and Post-Test assessed the conception after implementing the conceptual change approach. Independent-samples t-test was used to analyses the pre and post test data at a significance level of 0.05. The result of the pre-test showed that there was no significant mean difference at the beginning of the treatment between the experimental and the control group in terms of students' understanding of chemical bonding concepts ($t = 0.52$, $p > O.05$). As indicated by the data in the results of the post-test, there was significant mean differences between the performance of the students in both groups ($t = 3.22$, $P < 0.05$). This shows that conceptual change approach through conceptual change text and analogies provide a better acquisition of chemical bonding concepts.

Discussion and Conclusion

Many learners face difficulty in understanding the scientific concepts as theoretical knowledge in conceptual framework contains misconceptions which are inconsistent with the real-world experiences. Learning science involves meaningful memorization, where new learned material must make sense to learner. It doesn't mean that learning science is adding of new knowledge, it requires realignment in thinking, construction of new ideas and resolving the conflict between new ideas and pre-existing ideas. Students come in chemistry classroom with their own explanation of chemical world, not blank like a slate. They start constructing new concepts on the basis of previous knowledge and preconceptions. Differing framework of students' conception affects

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subsequent learning of scientific concepts. So, for meaningful learning, we must adopt methodology which eliminate and also prevent misconceptions. This approach can be employed to resolve students' misconceptions. This approach implies that a learner actively engages in brain storming and rationally replaces existing or prior misconceptions with scientifically acceptable explanations as new conceptual framework. The conceptual change text and analogies used in the study activate the prior knowledge of the students, stimulate the conceptual framework, engage in peer learning, and support the construction of scientific conception. It involved the text, explanation, analogies and examples. Researcher and the educators so used such analogies in the texts to deal with students' misconceptions more effectively. Some student's misconceptions are hard to change even after the discussion. In one question related to electrical conductivity of graphite, both groups showed low level of achievement. After using remediation, control group students' performance was not improved but 11.6 % students of experimental group performed well and answered correctly. 41.2 % students in the control group were with strong misconception on the electrical conductivity of the graphite. Whereas, 43% students in experimental group explained the electrical conductivity of the graphite very nicely. Although both group students were found with misconceptions in post-test but experimental group students rectified their misconceptions more than control group. After using conceptual change text, analogies and discussion, many students in experimental group resolved their misconception related to Vander Waals Forces, polarity of molecules and Vander Waals Forces etc., but there was no significant change in the misconceptions of control group students on the same topics.

The study found that traditional approach in chemistry teaching is not useful in conceptual change as it is teacher centered and much depend on the exploration of teacher without considering the students' misconceptions. The study found that conceptual change approach uses conceptual change text and analogies that actively engage the students in brainstorming whereas the traditional approach passively engages the students, as reflected during implementation phase of the study in both groups. This might cause the difference in the CBCT scores of both groups. With the limited number of participants, the study was not able to completely understand the effect of conceptual change approach in remediation of chemical bonding misconceptions.

In the conclusion, the study showed that conceptual change text and analogies are better in understanding of chemical bonding concepts and in the remediation of chemical bonding

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misconceptions than traditional pedagogy. It is also found that students found chemical bonding concepts difficult to understand and have misconception in the topics, if these misconceptions are not rectified, may affect the subsequent learning negatively. So, teachers, curriculum developers, and text book writers must be award about the chemical misconceptions. The pedagogy should be based on the action research outcomes and constructivist approaches.

References

1. Fisher, K. M. (1985). A misconception in biology: Amino acids and translation. *Journal of Research in Science Teaching. 22,* 53-62.

2. Chambers, S. K. & Andre, T. (1997). Gender, prior knowledge, interest, and experience in electricity and conceptual Change text manipulations in learning about direct current. *Journal of Research in Science Teaching,* 34(2),107-123.

3. Novak, J. D. (1988). Leaming science and the science of learning. *Studies* in *Science Education,* 15,77-101.

4. Tsai, C. (2000). Enhancing science instruction: the use of 'conflict maps'. *International Journal of Science Education,* 22, 285-302.

5. Griffiths, A. K, & Grant, BA.C. (1985). High school students' understanding of food webs: Identification of a learning hierarchy and related misconceptions. *Journal of Research* in *Science Teaching,* 22, 421-436.

6. Fisher, K. M. (1985). A misconception in biology: Amino acids and translation. *Journal of Research* in *Science Teaching. 22,* 53-62.

7. Taber, K. S. (2000). Multiple frameworks? Evidence of manifold conceptions in individual cognitive structure. *International Journal of Science Education,* 22,4, 399 -417.

8. Palmer, D. (2001). Students' alternative conceptions and scientifically acceptable conceptions about gravity. *International Journal of Science Education,* 23(7), 691-706.

9. Kumar, S. (2019). CASE STUDY ON UNTRAINED TEACHERS IN SCHOOLS (ELEMENTARY SCHOOLS) IN JIND AND HISAR DISTRICTS OF HARYANA. *International Journal of Engineering Research and Modern Education, 4* (1), 7-9. DOI: 10.5281/zenodo.2656138

@2024 International Council for Education Research and Training 2024, Vol. 02, Issue 03, 63-73
ISSN: 2960-0006 DOI: https: https://doi.org/10.59231/edumania/9056
10. Boo, K. H. (1998). Students' understanding of chemical bond and the energetic of chemical reactions. *Journal of Research in Science Teaching*, 35(5),569-581.

11. Nicoll, G. (2001). A report of undergraduates' bonding misconceptions. *International Journal of Science Education, 23(7)*, 707-730.

12. Taber, K. S. (2003). Mediating mental models of metals: acknowledging the priority of the learner's prior learning. *Science Education*, 87,732-758.

13. Harrison, A. G. & Treagust, D. F. (2000). Leaming about atoms, molecules, and chemical bonds: a case study of multiple model use in grade 11 chemistry. *Science Education*, 84, 352-381.

14. Coll, R.K. and Taylor, T.G.N. (2001) Using constmctivism to inform tertiary chemistry pedagogy. *Chemistry Education: Research and Practice* in *Europe*, 2 (3), 215-226.

15. Kumar S. (2021). Psychosocial impact of Covid-19 Pandemic on school educators' mental health and role of cognitive competence in coping with such adversities. *International Journal of Biological Innovations. 3*(2):323-330. https://doi.org/10.46505/IJBI.2021.3212

16. Adesina, A. E., & Gabriel, E. T. (2023). Emerging Trends and challenges in science Education. *Shodh Sari*, *02*(03), 358–371. https://doi.org/10.59231/sari7612

17. Luera, GR, Otto, CA., & Zitzewitz, P.W. (2005). A conceptual change approach to teaching energy & thermodynamics to pre-service elementary teachers. *Journal of Physics Teacher Education Online,* 2(4), 3-8.

18. Dhindsa, H.S. & Anderson, O.R. (2004). Using a Conceptual-Change Approach to Help Preservice Science Teachers Reorganize Their Knowledge Structures for Constructivist Teaching. *Journal of Science Teacher Education*, 15(1),63-85

19. Ovie, A. F. (2023). Remediating students' misconception and achievement in chemistry via science writing heuristics and peer review instructional strategies in Delta State. *Shodh Sari, 02*(04), 73–88. https://doi.org/10.59231/sari7625

20. Dorji, P. & Chophel, Y. (2022). Rectifying misconceptions on covalent bonding using cooperative learning, concrete models, and computer simulation: A case study. International Research Journal of Science, Technology, Education, and Management, 2(2), 1-10. https://doi.org/10.5281/zenodo.6975643

@2024 International Council for Education Research and Training 2024, Vol. 02, Issue 03, 63-73
ISSN: 2960-0006 DOI: https: https://doi.org/10.59231/edumania/9056

21. Tekkaya, C. (2003). Remediating high school students' misconceptions concerning diffusion and osmosis through concept mapping and conceptual change text. *Research* in *Science* & *Technological Education*, 21(1), 5-16.

22. Rule, A. C. & Furletti, C., (2004). Using form and function analogy object boxes to teach human body systems, *School Science and Mathematics*, 104, 155-169.

23. Heywood, D. (2002). The Place of Analogies in Science Education. *Cambridge Journal of Education*, 32 (2), 233-247.

24. Naqsyahbandi, F., Mulyatun, M., Drastisianti, A., & Muhariyansah, J. (2022). Analysis of the use of analogy of chemical Education students on the concept of chemical bond. *Jurnal Pembelajaran Kimia/J-PEK (Jurnal Pembelajaran Kimia)*, *7*(2), 58–72. https://doi.org/10.17977/um026v7i22022p058

25. Ndukwu, D. E., & Ogbu, M. O. (2023). Effective use of chemical games: a panacea to difficulties in learning chemistry concepts in secondary schools. *Edumania*, *01*(03), 96–106. https://doi.org/10.59231/edumania/8998

26. Kumar, S. (2023). Artificial intelligence: learning and creativity. *Eduphoria*, *01*(01), 13–1 https://doi.org/10.59231/eduphoria/230402

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