Journal of Engineering and Science Research 1 (2): 158-163, 2017
e-ISSN 2289-7127

DOI: 10.26666/rmp.jesr.2017.2.24

Remediating Filipino Engineering Students' Misconceptions Concerning Ionic Bonding Through Outcomes - Based Teaching and Learning Computer Assisted Instructional Material (OBTL-CAIM)

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Abstract: The main purpose of this study is to remediate college engineering students' misconceptions on ionic bonding to achieve conceptual understanding about the concept. Many students find difficult to understand the abstract concept of ionic bonding as one of the types of chemical bonding. In this study, Outcomes – Based Teaching and Learning Computer Assisted Instructional Material (OBTL-CAIM) was developed. The main aim of the instructional material was to activate students' prior knowledge and misconceptions and to help them to scientifically understand the concept of ionic bonding. Results revealed that many students had misconceptions about the formation of ionic compounds, the meaning of ionic bond and ionic bonding; they had no idea that the bond refers to the electrostatic force. During the implementation, two groups of EE general chemistry student participants were taught using the developed OBTL-CAIM. Data were gathered on how effective the OBTL-CAIM to remediate students' alternative conceptions and to assess whether the Intended Learning Outcomes (ILOs) have been successfully achieved by the students. The findings indicated that that OBTL – CAIM is effective in achieving students' conceptual understanding on ionic bonding. Student participants have changed or transformed most of their alternative conceptions into scientifically correct conceptions. OBTL – CAIM helped students to learn the target concepts shown by a statistically significant difference found between pre- and post- test scores. This implied that they have developed a better understanding of ionic bonding as a result of OBTL-CAIM intervention.

Key words: *Remediation, Misconceptions, Constructivism, Outcomes – Based Teaching and Learning Computer Assisted Instructional Material*

INTRODUCTION

Ionic bonding is one of the types of chemical bonding which was found as one of the more abstract topics in chemistry. Studies had shown that students have difficulties in understanding fully the concept and many alternative conceptions formed by the students in this topic may be because one cannot see an atom, its structure and how it reacts with other atoms [1]. Students live and operate within the macroscopic world of matter and do not easily follow shifts between macroscopic and sub-macroscopic levels [2].

Students' pre-conceptions must be addressed properly through meaningful learning of concepts. This involves realigning, reorganizing or replacing students' prior conceptions to accommodate new ideas and this process has been called conceptual change [3]. Conceptual change approach to science instruction represent an alternative approach designed to encourage students to alter their pre- or alternative conceptions [4]. Thus, the researcher wants to find out if utilizing the Outcomes – Based Teaching and Learning (OBTL) approach in the lessons could foster students' conceptual change and be able to remediate alternative conceptions about ionic bonding especially since no study yet had been conducted in this area.

Providing remediation of these alternative conceptions in chemical bonding is far more important than just knowing what students' alternative conceptions on a certain topic are. Ozmen [5] further reported that in all levels students do not learn science concepts with traditional teaching method as expected. One issue in science education particularly in chemistry is that the teachers should consider

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alternative teaching approaches especially for difficult and abstract science concepts wherein many alternative conceptions had been formed by the students. This might be achieved by using more learner-centered approaches and particularly those that employ modern information and communication technologies. Hence, this study anchored on constructivism principle wherein technologies can help facilitate knowledge-construction in the classroom and guide student activities, leaving teachers the opportunity to interact with small groups and to diagnose difficulties [6].

Many studies have shown that integration of Computer Assisted Instructions (CAI) in the classroom can enhance effective students' learning outcomes [7,8,9]. This is an interactive instructional technique whereby a computer is used to present the instructional material and monitor the learning that takes place. Integrating computer-based visualizations and demonstrations in learning abstract concepts and phenomena have great importance in alignment with the idea of visualization to support students' learning on chemical bonding concept [10]. Ozmen [5] reported that using computer assisted instructional material can be effective instructional tools to improve students' conceptual understanding of chemical concepts. This is a kind of student – centered pedagogical approach which is recommended by most authors [8, 9, 10] to facilitate and improve instruction in order to achieve appropriate students' learning outcomes. However, the authors recommended that their proposed methods need to be improved and integrated with some other teaching methods to be more effective in enhancing learning concepts for there were still some alternative conceptions encountered after the implementation [5]. Hence, this viewpoint makes the researcher invest on the development of Computer Assisted Instructional Material (CAIM) to be anchored on an OBTL approach. In such a way, the proposed learning material of this study could facilitate successful learning outcomes through deeper understanding about the concept and foster conceptual change; changing misconceptions to the desired scientifically correct concepts.

METHODS

This study used the mixed-method design which combines qualitative and quantitative research methods. The research was employed in two intact classes as the participants of the study. The pre-test was administered to both groups to determine students' prior knowledge on the selected topics in chemical bonding and one of the bases for evaluating the changes of students' conceptions was by comparing these results with the post test. The difference in the results of pre-test and post-test was determined to find out the improvement of students' conceptual understanding about chemical bonding. To come up with rich, robust, comprehensive and meaningful findings and to best understand the research problem, qualitative techniques were used.

Research Instruments

In this study, the following instruments were used to gather the necessary data needed:

Pretest-Posttest. Diagnostic instrument for ionic bonding that were administered to the participants for pre-and post-test contained two parts (Part A and Part B). The researcher used the Taber's diagnostic test for Part A and two-tier multiple-choice developed by Peterson & Treagust [12] and Tan & Treagust [13] for Part B. The items in two-tier multiple-choice diagnostic instruments are specifically designed to identify students' misconceptions and misunderstandings in a limited content area.

Interview Schedule. The identified six students were interviewed prior to, during, and after the instruction. This was to follow the students' conceptual changes and be able to describe it. Questions were based on verification of their test responses or on identified students' misconceptions.

Audio and VideoTape Recorder. The audio tape recorder was used during interviews while during the implementation of instructional intervention; a videotape recording was secured. The tapes were used as data storage, for filing purposes and enabled to review the classroom interactions.

Learning Journal. Learning journal provided students the opportunity to write down their ideas on the topic before, during, and after the lesson. They also wrote their reasons on the changes of their ideas that may have occurred. The journal reflected the process on how students' changed their prior ideas to what is scientifically accepted. Thus, this was relevant in evaluating the changes on students' conceptions after the implementation of the OBTL-CAIM.

Activity Sheets and Assignments. There were activities, assignments, throughout the learning process. Activity results and assignments were collected and analysed.

Data Collections

In determining students' alternative conceptions on chemical bonding, literature from national and international science education researches which are related to this problem were collected and reviewed. Pre-test and pre-interviews were administered in diagnosing the students' preconceptions. To follow and describe the conceptual evolution of students during

the different stages in implementing the OBTL-CAIM; the results of interviews, learning journals, activities and assignments were gathered properly during the different phases of the entire research procedure.

The results of the pre-post-test and interview were the bases in diagnosing students' conceptual understanding about chemical bonding concepts as well as in evaluating the changes of students' conception. Together with their learning journal, activity results, and assignments these were collected and analyzed to validate the results.

The comparison between pre-test and post test results were item analyzed using SPSS. The scores from pre-test and post-test from the whole group were compared by using paired t-test to determine whether a statistically significant mean difference existed between the pre and post-test. Analysis of the learning gains from the rest of the class was through the use of learning percentage per item.

RESULTS AND DISCUSSIONS

The analysis of the pre-test results and the transcript of the initial interviews generated the following students' misconceptions on ionic bonding: (1) Ionic bond is the attraction between a pair of positive charged ion and negative ion; students unsuccessfully recognize the omnidirectional nature of ionic bond; (2) A metal is covalently bonded to non-metal to form a molecule, thus, sodium chloride is a molecule; (3) Ionic bond is the transfer of electrons between two atoms instead of the result of attraction of ions; they appeared to mistakenly recognize that the electron transfer is the process of ion formation; (4) The reason of electron transfer is to achieve a stable octet even though there are many exceptions to it; the overuse of octet rule; (5) The bond formed is due to the "atoms" transferred from a Na metal atom to Cl non – metal atom; incorrectly identified the electrons and used the term "atom" instead; and (6) Ionic bonding involved sharing of electrons.

Outcomes based instructional material (OBTL-CAIM) was developed and designed and used as the intervention. The understanding of outcomes – based on teaching and learning through the engagement of computer assisted instructions (CAIs) was framed on the perspective that is anchored on constructivism, constructive alignment theory and conceptual change theory. The developed OBTL-CAIM aimed to achieve students' conceptual understanding on the topics of chemical bonding and address or remediate their misconceptions of the topics.

Ionic bond formation.

Table 1. Percentages of Students Who Got Correct Answer During the Pre-and Post-Test on Ionic Bond Formation (n=53)

Questions	Correct Answers	%Correct		% Diff
		Pre-Test	Post-Test	
A positive ion will be attracted to any negative ion.(1)	TRUE	87	100	13
An ionic bond is the attraction between a positive ion and negative ion. (7)	TRUE	85	87	2
A positive ion can be bonded to any neighbouring negative ions, if it is close enough. (8).	TRUE	75	77	2
A negative ion can be attracted to any positive ion. (9)	TRUE	74	81	7
There is a bond between the ions in each molecule, but no bonds between the molecules. (13)	FALSE	45	64	19
The reason a bond is formed between chloride ions and sodium ions is because they have opposite charges(15)	TRUE	87	89	2
A negative ion can be bonded to any neighboring positive ions if it is close enough (19).	TRUE	70	72	2
There are no molecules shown in the diagram (20).	TRUE	26	82	56

Table 2. Percentages of Students Who Got Correct Answer During the Pre-and Post-Test on Ionic Bond Formation (n=53)

Question	Answer Chosen	Reason Chosen and the % of Chemistry students (n=53) selecting each response combination								
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	
		Pre-test				**Post-test**				**% Dif**
Sodium chloride, NaCl, exists as a molecule. (1)	A.True	49.06	18.87	3.77	20.75	1.89	3.77	1.89	1.89	
	B.False	3.77	1.89	**0.00***	1.89	3.77	3.77	**81.13***	1.89	*81.13*
Element Sr and element F react to form an ionic compound SrF_2 (2).	A.True	28.30	7.55	**26.42 ***	0.00	5.66	3.77	**75.47***	5.66	*49.05*
	B.False	11.32	5.66	7.55	13.21	0.00	3.77	5.66	0.00	
An atom of element A has two electrons in its outermost shell while an atom of element B has five electrons in its outermost shell. When A reacts with B, the compound will be: (3)	A. Covalent	26.42	13.21	0.00	13.21	1.89	1.89	3.77	3.77	
	B. Ionic	16.98	18.87	**5.66***	5.66	3.77	26.42	**50.94***	7.55	*45.28*

Note: ***** This indicates the correct answer for the item.

Table 1 shows the post – test results of item number 1 (100%), 7 (87%), 8 (77%), 9 (81%), 15 (89%), and 19 (72%), in which the questions tested the same concept about the attraction between positive and negative ion. Results denote that students had a very clear notion that ionic bonding involves the attraction between a positive and negative ion. These are not surprising because in their pre –test, higher percentage of students got correct in the said items. They already had the idea that any positive ion will be attracted to a negative ion.

In Table 2, "Sodium chloride is a molecule" is another concept highlighted in items number 13 and 20. In the pre-test, 45% of the students correctly did not agree with item number 13. In the post-test, 64% of the students correctly chose the answer in this item. On the other hand, only 26% of the students correctly answered item number 20 in the pre-test, but in the post-test, there was a considerable increase of the percentage of students (82%) who got item number 20 right. These show an increase of 19% and 56% from the pre-test results of questions number 13 and 20.

Results further show that most of the students, after engaging in the OBTL-CAIM had corrected their prior ideas on molecular framework of sodium chloride. This was supported in item number 1 in the two-tier multiple choice diagnostic test, in which none of the students got the correct response combination in this item during the pre-test, however in the post-test, the findings reveals that 81.13% [B3] of the students now believed that the concept "Sodium chloride, NaCl, exists as a molecule" is false. They were able to reason out correctly which is "sodium chloride exists as a lattice consisting of sodium ions and chloride ions".

In item number 2 (Table 2), pre-test result shows that students are confused about the differences between covalent and ionic bonding. In fact, only 26.42% got the correct response choice combination of the said item. But the item in the post-test result reveals that 75.47% of the students already had correct conception about the formation of the ionic compound SrF2. Comparison with pre-test results shows that there was a gain of 49.05% of the students who correctly answered this item.

Pre-test result for item 3 (Table 2) of the two-tier multiple choice implies that students held misconception on the formation of compound when element B reacts with element A. They thought that a covalent compound was formed instead of an ionic compound. In the post-test, a total of 88.68%, majority of the chemistry class had now the correct idea that when the two elements A and B as stated in item 3 combined, they formed into an ionic compound.

However, only 50.94% [B3] of the students got the correct response combination both in their choice and reason of their answer. They had chosen the correct illustration of the bond formation of the said ionic compound. The rest 3.77% [B1], 7.55% [B4], and 26.42% [B2] had chosen the wrong illustration of its bond formation. The students who chose B2 were not able to consider the ratio of metal and non-metal ions required in the formation. It seems like there were still students who need more practice and understanding on how to show the bond formation between elements of the ionic compound.

Omnidirectional nature of ionic bond.

Omnidirectional nature of ionic bond concept was tested in item numbers 2, 3, 5, 6, 10, 11, 14, & 15 both in pre- and post – test (Table 3). Pre-test results of these items showed that many students had misconceptions; they thought that the ionic bond is the attraction between one pair of cation and anion only. This was verified in the prior interview, showing how they pictured the bond between NaCl, they believed that the attraction of two oppositely charged ions is between one pair only.

In the post-test, Table 3 shows the increase of the percentage of students who obtained the correct answers. However, item 2 and 3, show a relatively smaller increase in percentage (11%, 17%). This indicates that 53% (item 2) and 43% (item 3) believed that ionic bond involves the donating of electrons between atoms instead of the electrostatic attractive force existing, holding ions together in an ionic crystal. In some cases, there might be things that can cause their confusion on what was being highlighted on the statements or may be prone to conceptual change resistance. However, despite of the two mentioned items, results as a whole reveal that students had now an understanding of the omnidirectional nature of ionic bond. Increased percentages of students were able to get the correct answers to questions 5, 6, 10, 11, 14, and 15 as shown in Table 3.

Table 3. Percentages of Students Who Got Correct Answer During the Pre-and Post-Test on Omnidirectional Nature of Ionic Bond (n=53)

Questions	Correct Answer	Correct Answers		% Diff
		Pre-Test	Post-Test	
Sodium ion is only bonded to the chloride ion it donated its electron to. (2)	FALSE	36	47	11
A sodium atom can only form one ionic bond, because it only has one electron in its outer shell to donate. (3)	FALSE	40	57	17
In the diagram a chloride ion is attracted to one sodium ion by a bond and is attracted to up to three other sodium ions just by forces. (5)	FALSE	49	81	32
In the diagram each molecule of sodium chloride contains one sodium ion and one chloride ion (6).	FALSE	38	69	31
It is not possible to know where the ionic bonds are, unless you know which chloride ions (10).	FALSE	30	72	42
A chloride ion is only bonded to the sodium ion it accepted an electron from (11).	FALSE	42	65	23
A negative ion can only be attracted to one positive ion (14).	FALSE	43	76	33
A positive ion can only be attracted to one negative ion (15).	FALSE	38	73	35

CONCLUSIONS

Based on the findings, this study concludes that the developed OBTL – CAIM is effective in achieving students' conceptual understanding on ionic bonding. Students have changed or transformed most of their initial misconceptions into scientifically correct conceptions after they were exposed to OBTL – CAIM.

It can be deduced from this study that students acquired correct understanding about chemical bonding as depicted in the increase of percentages of the students who got correct answers during the post-test than in the pre-test. Thus, this study further concludes that OBTL – CAIM provided meaningful experience among learners by remediating their misconceptions on ionic bonding in particular.

ACKNOWLEDGEMENT

The author would like to thank the Department of Science and Technology – Science Education Institute (DOST-SEI), Philippinesthrough its Accelerated Science and Technology Human Resource and Development Program – National Consortium in Graduate Science and Mathematics Education (ASTHRDP - NCGSME) for the financial support through the scholarship grant.

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