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Thai Grade 10 Students Conceptual Understanding of Chemical Bonding

Phatcharanat Kumpha[a]*, Paisan Suwannoi[b], David F. Treagust[c]

[a]Patchra_sced@hotmail.co.th, Khon Kaen University, Khon Kaen 40002, Thailand
[b]Paisan_s@kku.ac.th, Khon Kaen University, Khon Kaen 40002, Thailand
[c]D.treagust@curtin.edu.au, Curtin University, Perth, Australia

Abstract

This article is a part of research for a doctoral thesis about improving teaching, enhancing representations and conceptual change of chemical bonding for grade 10 students (15-16 year-old) in Thailand. The aim of this research is to explore students' understanding of chemical bonding concepts. The sample consisted of 102 grade 10 students from three secondary schools in Chaiyaphum province in the northeast of Thailand. After studying this topic, the students responded to a 9-item two-tier multiple-choice test bonding (Tan & Treagust, 1999), translated into the Thai language which covered the content of chemical bonding. For the data analysis, we report the percentage of students who choose both parts of the two-tier items. The research findings show how many students have difficulty in understanding the concepts of chemical bonding, and there is more potential for the formation of alternative conceptions. The problems identified with students understanding of the abstract concept of chemical bonding are useful for the design and development pedagogical content knowledge of chemistry teachers in secondary school.

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Keywords: Conceptual Understanding, chemical Bonding, thai science education;

1. Introduction

Over the past decade many researchers have been interested in students' understanding and misunderstanding of chemical phenomena either prior to or following instruction (Peterson, Treagust, & Garnett, 1989). Chemical bonding is one of the key and basic concepts in chemistry (Nahum, Naaman, Hofstein, & Taber, 2010), is an

* Corresponding Author: Phatcharanat Kumpha. Tel.: +66-878-871-7008
E-mail address: patchra_sced@hotmail.co.th

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abstract topic, and sometimes is far removed from the daily experiences of secondary school students. One cannot see an atom, nor see its structure and how it reacts with other atoms (Tan & Treagust, 1999). Many students have difficulty understanding the concepts in chemical bonding; similarly high-school students around the world have been shown to lack a fundamental understanding of this concept (Nahum, Mamlok-Naaman, Hofstein, & Krajcik, 2007) and there is potential for the formation of alternative conceptions. Before the development of these programs in Thailand it is worthwhile to determine if Thai students have similar conceptualizations and misunderstandings as secondary chemistry students in other countries.

2. Thailand Science Education

Thailand is an independent country, which lies in the heart of Southeast Asia (Buaraphan, 2009). This also the basic education in Thailand includes 12 years of study, divided into four major levels, namely, Grade1-3 into Level 1; Grade 4-6 into Level 2; Grade 7-9 into Level 3; and Grade 10-12 into Level 4 (Buaraphan, 2009). For the science education is influenced by educational reform in 1999, in which the goals of science education are shaped by the notion of scientific literacy (Yuenyong & Narjaikaew, 2009).

2.1. Thailand Science Curriculum : Basic Education Core Curriculum B.E. 2551 (A.D. 2008) Science

Thai conceptions of scientific literacy may be different, and depends on Thai culture and values (Yuenyong & Narjaikaew, 2009). The Thai science curriculum (A.D. 2008) comprises eight strands in each of the main content areas, one of which is Chemistry, a compulsory subject. The third strand of chemistry is Matter and Properties of Matter. According to the Thai curriculum, after completion of grade 12, students should be able to: 1) understand categories of important constituent particles within atomic structures, arrangement of elements in the periodic table, chemical reactions and their representation as chemical equations, and factors affecting rates of chemical reactions; 2) Understand categories of the attraction forces between particles and various properties of substances related to the attraction forces; 3) Understand formation of petroleum, separation of natural gases and fractional distillation of crude oil; useful applications of petroleum products and effects of such usage on living things and the environment; and 4) understand categories, properties and important reactions of polymers and bio-molecules (The Institute for the Promotion of Teaching Science and Technology, 2008).

2.1.1. How is chemical bonding taught

In Thailand, chemical bonding is usually taught in the early part of the fourth year of secondary school (Grade 10), when 15-16 year-old students study chemistry as a subject for the first time. Chemical bonding is an important topic to be studied in chemistry and is fundamental to other chemical content. Thai students in 10-12 grades in both science and non-science programs need to learn chemical bonding. Also students in the science program study both Fundamental chemistry in the first semester 10 grade level (1.5 credits for 60 hours) and Advanced chemistry book I starting at secondary semester 10 grade level (1.5 credits for 60 hours). Non-science students only study Fundamental science or Matter and properties of matter for one semester, (1.0 credits for 40 hours). Chemical bonding there are three main topics: 1) Covalent bonds 2) Ionic Bonds and 3) Metallic bonds. Also the teachers should teach using the guidelines according to the Thailand science curriculum into Basic Education Core Curriculum B.E. 2551 (A.D. 2008) (IPST, 2008) as shown in table 1.

Strand 3: Matters and Properties of Matters

Table 1. Core Content and Indicators for Grade 10-12 students in Strand 3: Matters and Properties of Matters.

From http://www.ipst.ac.th/images/files/ SciCur_2008_ EngVersion

Grade	Indicators	Core Content
10-12	4. Analyse and explain formation of chemical bonds in crystal structures and molecules of substances.	• Attraction force between ions or atoms of an element holds them together as crystals or molecules. The force is referred to as a *chemical bond*. • *Chemical bonds* can be classified as ionic bonds, covalent bonds and metallic bonds.

3. Aims and Objectives

The aim of this study was to explore the conceptual understanding of chemical bonding by secondary school Thai students using a two-tier multiple choice question test.

4. Methodology

4.1 Research participants

This study is in order to investigate students' prior knowledge and conceptual understanding of chemical bonding content for grade 10 students (n=102) from three secondary schools, who studied in this topic at Chaiyaphum province in the Northeast of Thailand.

4.2 The Instrument

The instrument using 9 two-tier multiple-choice items which covered the content of chemical bonding (Tan & Treagust, 1999) was translated by the researcher into the Thai, the language for Thai students, then translated back into English by Thai expert chemistry educator, who understand both language (Pattamaporn Pimthong). The first tier of each item consists of a content question having two choices [I…, II…]; the second tier of each item contained four possible reasons [A, B, C & D] for the answers given in the first tier, which involved the correct answer and three alternative reasons including misconceptions.

4.3 Data Collection Procedure

The instrument was administered to a total of 102 students from three secondary schools; all students had studied in grade 10 science programs and completed the test in less than 25 minutes. A respondent's answer to an item was considered correct if he or she selected both the correct content choice and the correct reason. Items of the instrument were evaluated for both correct responses and incorrect response combinations selected by the respondents.

4.4 Data analysis

The data analysis was adopted from research reported by Tan and Treagust (1999). If a student did not select a response to both parts of an item, then it was not included in the analysis. The main data reported in the tables in the results section was computed in two steps. Firstly, the data involved the frequency of correct response for each item followed by converting it to percentage. Secondly, these values were used to compute mean percentages for the questions in the instrument as well as its sections separately in terms bonding, continuous covalent lattice, intermolecular and intermolecular force and electrical conductivity of graphite.

5. Results and Discussion

This study explored students' conceptual understanding regarding chemical bonding for grade-10 students in the categories of bonding, continuous covalent lattices, intermolecular and intermolecular forces and electrical conductivity of graphite.

Bonding:

Table 2. Description of students' Responses to Bonding concept for Tier 1 and Tiers 1&2 Choices and Misconceptions

Area of concept	Item no.	% Correct		Tier	Response chosen (%)			
		Tier 1	Tiers 1&2		A	B	C	D
Bonding	1	7.84	4.90	I	25.49	*39.22*	16.67	10.78
				II	0.00	0.00	**4.90***	2.94
	3	65.68	**43.14**	I	9.80	7.84	**43.14***	4.90
				II	6.86	6.86	2.94	*17.65*
	4	66.66	**33.33**	I	3.92	*18.63*	10.78	**33.33***
				II	2.94	5.88	19.61	4.90
	6	32.34	2.94	I	*33.33*	16.67	3.92	13.73
				II	8.82	8.82	**2.94***	11.76
	Mean	**43.13**	**21.08**					

* Correct response combination.

As indicated in table 2, the data show that the sample students' ability to establish the correct bonding measured using items 1, 3, 4 and 6, especially items 1 and 6 was unexpectedly low, 4.90% and 2.94% correct respectively, when considering both tiers, On the average 21.08% of the students responded correctly to both combinations to the four bonding questions. This means that nearly 80% of the sample students in each group were not certain of the position of the chemical bonds. For example, in item 1, only 4.90% of grade 10 students pointed out that sodium chloride forms an ionic lattice. Most percentage of students, 92.16% believed that sodium chloride exists as molecules, and 39.22% thought that one sodium ion and one chloride ion form an 'ion-pair molecule' (Taber, 1994 cited in Tan & Treagust, 1999). As in Tan and Treagust (1999), only 16.7% of this sample of students pointed out that sodium chloride forms an ionic lattice and most of the students (80.4%) understood that sodium chloride exists as molecules, that suggested a high percentage of students misunderstand about bonding.

Continuous covalent Lattice:

Table 3. Description of students' Responses to Continuous covalent Lattice for Tier 1 and Tiers 1&2 Choices and Misconceptions

Area of concept	Item no.	% Correct		Tier	Response chosen (%)			
		Tier 1	Tiers 1&2		A	B	C	D
Continuous covalent Lattice	2	86.27	11.76	I	0.98	2.94	1.96	7.84
				II	8.82	**11.76***	18.63	*47.06*
	7	36.27	14.71	I	4.90	4.90	25.49	*27.45*
				II	8.82	**14.71***	8.82	3.92
	9	64.70	15.69	I	5.88	*33.33*	**15.69***	9.80
				II	6.86	6.86	13.73	6.86
	Mean	**62.41**	**14.05**					

* Correct response combination.

The mean data in Table 3 suggest that on the average 62.41% of the students were demonstrated to respond correctly at the Tier 1 level, whereas on the average 14.05% of the students correctly responded to both tiers. More than 70% of the students were able to respond correctly to item 2 at the Tier 1 level, but less than 20% were able to link their response to correct reason. Tan and Treagust (1999) also reported that the sample of students were confused regarding with the nature of continuous covalent and molecular lattices. In items 2 and 7, most sample students understood that macromolecules are consisted of covalently bonded molecules. According to Peterson et al. (1989), grade-11 students had poor understanding of lattice structures, they confused on the nature and properties of covalent and molecular lattices.

Intermolecular and intermolecular forces:

Table 4. Description of students' Responses to Intermolecular and intermolecular forces for Tier 1 and Tiers 1&2 Choices and Misconceptions

Area of concept	Item no.	% Correct		Tier	Response chosen (%)			
		Tier 1	Tiers 1&2		A	B	C	D
Intermolecular and intramolecular forces	2	86.27	11.76	I	0.98	2.94	1.96	7.84
				II	8.82	**11.76***	18.63	*47.06*
	4	66.66	**33.33**	I	3.92	18.63	10.78	**33.33***
				II	2.94	5.88	19.61	4.90
	8	68.62	10.78	I	*36.27*	6.86	14.71	**10.78***
				II	10.78	4.90	1.96	11.76
	9	64.70	15.69	I	5.88	*33.33*	**15.69***	9.80
				II	6.86	6.86	13.73	6.86
	Mean	**71.56**	**17. 89**					

* Correct response combination.

As indicated in the table 4, all items on the average, 71.56% of the students responded correctly at the tier 1 level, whereas only 17.89% were correctly able to respond to both tiers of Intermolecular and intermolecular forces concepts. For example, on item number 8, only 10.78% of the sample students could correctly to understand the difference in state between molecule of water (H_2O) and hydrogen sulphide (H_2S), they have similar chemical formulae and structures, whereas water is a liquid and hydrogen sulphide is a gas that the reason is the forces between water molecules are stronger than those between hydrogen sulphide molecules. As in Tan and Treagust (1999) reported that 21% (IA) of Secondary Four (15-16 years old) students (n=119) were common alternative conceptions of the strength of intermolecular forces is determined by the strength of the covalent bonds present in molecules; Moreover, 36.27% of the students in this study have the same understanding.

Electrical conductivity of graphite:

Table 5. Description of students' Responses to Electrical conductivity of graphite for Tier 1 and Tiers 1&2 Choices and Misconceptions

Area of concept	Item no.	% Correct		Tier	Response chosen (%)			
		Tier 1	Tiers 1&2		A	B	C	D
Electrical conductivity of graphite	5	89.22	10.78	I	**10.78***	12.75	15.69	*50.00*
				II	1.96	0.98	5.88	0.98

* Correct response combination.

The data in Table 5 suggest that 89.22% of the students were able to respond correctly at the tier 1 level. However when responses to both tiers were considered only 10.78% of the students could correctly ascertain that Graphite can conduct electricity because it has delocalized electrons; only three of the four valence electrons of a carbon atom are involved in bonding and the fourth electron is delocalized and give the correct reason for their choice. Similarly, Tan and Treagust (1999) reported that only 27.7% of their sample understood this concept. Most students know that Graphite can conduct electricity but they lacked the understanding why graphite can conduct electricity. Moreover, 50% of this student sample believed that Graphite can conduct electricity because when some carbon atoms are delocalized, it was classified as a misconception. Some students in the sample did not understand the concept of delocalization of electrons in graphite, it seem like in Tan and Treagust (1999), explained in his study with students may believe that there are 'free' carbon atoms in graphite which move about and are responsible for conducting electricity.

6. Conclusions and Implications for chemistry teaching

Chemistry teachers can use two-tier multiple choice tests not only to identify students who lack complete understanding, but also use the test to diagnose their misconceptions to enable better targeting of their teaching strategies and develop pedagogical content knowledge for improving students' learning outcomes.

6.1 Suggestions for teaching

Chemical bonding is an abstract topic so the teacher should allow students time to practice on models, construct molecular models and design the model-based curriculum on the problem working as individuals or team work. And maybe allow students thinking and taking activity simultaneous or role-played similar to a Tug-of-War game to study the attraction between molecules. Then the teacher should include integrated activities from different textbooks, and e-learning or computer assistance instruction (CAI), animation programs, three-dimension shapes, are suitable for some abstract topic such as molecular shape, students can connect macromolecule and sub-molecule.

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References

Buaraphan, K. (2009). Thai In-service Science Teachers' Conceptions of the Nature of Science. *Journal of Science and Mathematics Education in Southeast Asia, 32*(2), 188-217.

Nahum, T. L., Mamlok-Naaman, R., Hofstein, A., & Krajcik, J. (2007). Developing a New Teaching Approach for the Chemical Bonding Concept Aligned with Current Scientific and Pedagogical Knowledge. *Wiley InterScience*, 579-603. doi: 10.1002/

Nahum, T. L., Naaman, R. M., Hofstein, A., & Taber, K. S. (2010). Teaching and learning the concept of chemical bonding. *Studies in Science Education, 46*(2), 179-207. doi: 10.1080/03057267.2010.

Peterson, R. F., Treagust, D. F., & Garnett, P. (1989). Development and Application of a Diagnostic Instrument to Evaluate Grade-11 and -12 Students' Concepts of Covalent Bonding and Structure Following a Course of Instruction. *Journal of Research in Science Teaching, 26*(4), 301-314.

Tan, K. C. D., & Treagust, D. F. (1999). Evaluating students' understanding of chemical bonding. *School Science Review, 81*(294), 75-83.

The Institute for the Promotion of Teaching Science and Technology, IPST. (2008). *The Basic Education Core Curriculum B.E. 2551 (A.D. 2008) Science*., from http://www.ipst.ac.th/images/files/SciCur_2008_EngVersion.

Yuenyong, C., & Narjaikaew, P. (2009). Scientific Literacy and Thailand Science Education. International *Journal of Environmental & Science Education, 4*(3), 335-349.