EFFECTS OF TEACHING MODEL FOR HOT CONCEPTUAL CHANGE ON STUDENTS' CHEMISTRY CONCEPTIONS

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Abstract: For decades, conceptual change teaching models have been continually developed to promote students conception of science. The recent Teaching Model for Hot Conceptual Change (TMHCC) proposed by Kural and Kocakulah (2016) used the support of motivational and metacognitive strategies to support change in student physics conception. Although the model worked well in Physics, its effects on students' chemistry concept had never been studied. This study was a one group pretest-posttest design which aimed to study the percentage of students who developed chemistry conception after having learned chemistry through TMHCC. Participants were 42 eleventh-grade students who were studying in science program of a public secondary school in Phrae, Thailand. This implementation spent 2 months. The research instrument was a two- tier multiple choice test, consisting of 12 items that covered 12 chemistry conceptions. The findings revealed that before and after implementation, students' average scores in chemistry conception test were 24.07% and 38.12% respectively. The three highest frequencies of chemistry conception that students developed their chemistry conceptions were the concepts of "Nomenclature of terminal triple bond" (76.19%), "Nomenclature of alkene" (69.05%), and "Isomer" (69.05%). The frequencies of students who had no change in some chemistry concepts were founded in the concepts of "Boiling and melting point of alcohol ether and phenol" (61.90%), "Definition of hydrocarbon" (57.14%), and "Bond-line structure" (54.76%). However, there was a declined in the students' chemistry concepts partially in the concepts of "Amide formation" (30.95%), "Esterification reaction" (16.67%), and "Boiling and melting points of alcohol, ether, and phenol" (11.90%).

Keywords: Hot conceptual change, Teaching model, Chemistry conception

Introduction

Science educators have been paying attention to students' alternative conceptions for over decades. The alternative conceptions highly influence how learners construct new scientific knowledge and interfere students' subsequent learning (Sendur and Toprak, 2013). When holding misconception, student will not be able to connect new knowledge to their cognitive structure. Consequently, misunderstanding of knowledge will be formed and will not to be able to relate new knowledge to other relevant conceptions. According to Clement (1993), alternative conception and misconception are synonyms: a conception that can conflict with currently accepted theory.

Moreover, the term of "alternative conceptions" reflects the meaning of misconception and respects diversity of students' existing knowledge. Hence, this study used this term in order to present the idea that was not consistent to the accepted scientific conceptions or partial understanding of accepted scientific conceptions. Numbers of research discuss reasons of alternative conceptions.

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The abstract nature of scientific content has long been identified to be one reason. Abstract concepts are difficult for students to understand. Consequently, students tend to interpret the concepts to the new meaning that makes sense to them, resulting in an alternative conception (Nakhlen, 1992). Textbooks also induce alternative conceptions from poor illustrations and context used for addressing scientific conceptions (NRC, 1997). Additionally, lecture teaching method is the cause of alternative conceptions. With teachers telling and transferring of knowledge, students will be limited with the opportunity to present their own thinking and ideas which makes alternative conceptions to be hard to identified (Chakraborty and Mondal, 2013).

The other reason is teachers holding alternative conceptions which lead them to transfer misconception to their students (Calik and Ayas, 2005) Science educators and science teachers attempt to correct alternative conceptions by using various teaching strategies. Conceptual Change Model (CCM) has been accepted by science educators to be an effective way to correct scientific conceptions. However, there are limitations in CCM. It was found that students' alternative conceptions still existed in cognitive structure. Therefore, they could not change to correct conceptions (Kural and Kocakulah, 2016). These limitations were discussed to be caused by focusing only on cognitive domain and leaving out affective domain (Pintrich *et al.*, 1993). Hence, new models for conceptual change are purposed.

Kural and Kocakulah (2016) later called the CCM as "Classical Conceptual Change Model" or "Cold model" and purposed the learning strategy called "Teaching Model for Hot Conceptual Change" or "TMHCC". It is supported by affective domain including metacognitive and motivational strategies. This model was founded to be effective in changing concepts in physic. In 2016, they taught physics in the topics of quantum physics and photoelectric effect through TMHCC. It was found that TMHCC could enhance students' metacognition. Kural and Kocakulah discussed that the effectiveness resulted from dissatisfaction in prior knowledge that made students change their conceptions in photoelectric effect. Even though TMHCC was found to be effective in physics, no study in chemistry using TMHCC has been reported.

In chemistry, many concepts are considered to be difficult and unfamiliar to students. Hence, the students' alternative conceptions occurred in various topics such as chemical bonding, hydrocarbon compound, alkene, chemical equilibrium, gas, stoichiometry, electrochemistry, molecules and intermolecular forces. (Keawlalim, 2013; Srikhao, 2013; Sendur and Toprak, 2013; Piquette and Heikkinen, 2005; Nakhleh, 1992).

Organic chemistry is a topic that high school students need to learn. It is also a topic that dealt with abstract concepts including chemical bonding, hydrocarbon compound, alkene which are difficult to understand. Therefore, students' alternative conceptions are still existed in their cognitive structure. Even though numbers of research attempted to use CCM to change students' chemistry conceptions, alternative conceptions still existed. The new model of conceptual change that engage motivation and metacognition which was proposed by Kural and Kocakulah may be the possible solution to change students' chemistry concept. However, the research on such model has never been founded in chemistry.

Consequently, this research aimed to explore the effects of TMHCC on students' conception in terms of their average scores on chemistry concepts, percentage of students' who developed their chemistry conceptions after learning with TMHCC, and percentage of students holding certain types of chemistry conception.

Research Objectives

This research aimed to study

1. The effects of TMHCC on students' conception in terms of their average score on chemistry concepts.
2. The percentage of students who developed their chemistry conceptions after learning with TMHCC.
3. The percentage of students holding certain types of chemistry conception.

Research Hypothesis

After TMHCC implementation, at least 60 percent of students will develop their chemistry conceptions.

Literature Review

Conceptual Change Theory (CCT) introduced by Posner *et al.* (1982) was based on constructivism. It described that individual constructs new knowledge through two major processes; the first process is bringing new knowledge to relate with learner's prior knowledge as assimilation. Then, the new knowledge is adapted from old knowledge meaningfully for new equilibrium in cognitive structure (Piaget, 1970 cited in Hoy, 2007). Before the accommodation occur, there are four important conditions that were purposed by Posner *et al.* (1982), 1) Dissatisfaction must be occurred with existing conceptions; 2) A new conception must be intelligible; 3) A new conception must happen initially plausible; and 4) A new concept should be fruitful. Moreover, another important condition that should be set a good surrounding for student's learning to select a new important concept was conceptual ecologies. It promoted students to dissatisfy their existing conceptions and then accept new conceptions significantly.

All mentioned conditions enhance students to solve any problems or transfer the knowledge in several contexts correctly. Conceptual Change Model (CCM) was purposed by Stephan (1996) for decreasing alternative conceptions and changing the concept. This model was based on CCT which was addressed only cognitive domain. Therefore, students still held alternative conceptions as previous time. For instance, Srikhao (2013) studied students' conceptions in the unit of organic chemistry using inquiry approach. Participants were 51 students in 11 grades in Thailand. She addressed that bonding of carbon atom can be related with chemical bonding. When students did not have a strong fundamental on chemical bonding, they might confront some problems and held alternative conceptions about bonding with carbon atom.

The scientific conceptions of bonding were considering the bonding of carbon atom. The numbers of element of carbon atom that were bonded are depended on the other atoms in order to produce 8 valence electrons. Carbon atom bonding was not limited to a specific element but rather could be bond with other elements in the form of either single bond, double bond, or triple bond according to the bonded atoms. In contrast, hydrogen atom could be bonded with carbon or other elements by using single. Moreover, Keawlalims' research (2013) studied hydrocarbon compound through inquiry-based learning with 37 grade 12 scientific conceptions. This research reported that students thought hydrocarbon compounds consisted of carbon, hydrogen and other elements while the scientific conception was that hydrocarbon compound contains only two elements which are carbon and hydrogen. Furthermore, there were the alternative conceptions of isomer. Student though isomers are alike in structures with different molecular formulas. Also, some thought isomer are alike in both structures and formulas. To be correct, isomers are different in structures, but alike in formulas. To enhance the effectiveness of CCM, Pintrich *et al.* (1993) purposed that the affective domain was also important thing for changing students' conceptions. Especially, the motivational factors consisted of four; goals, values, self-efficacy, and control belief. These factors were mediators for process of conceptual change. They also related the metacognition for supporting process of conceptual change as well. Kural and Kocakulah were one of the educators who combined conceptual change theory with motivational and metacognitive strategies and proposed TMHCC model that consisted of 8 steps which were:

1. Motivating students to learning context;
2. Elicit students ideas and preconceptions;
3. Overview which conceptions/knowledge will conflict with the discrepant event;
4. Create a cognitive conflict;
5. Group work/argumentation;
6. Introduction scientific concept;
7. Transferring new concept to different problems; *and*
8. Evaluation.

In 2016, Kural and Kocakulah explored the effectiveness of TMHCC on students physic conception. The samples consisted of 40 eleventh-grade students from two classes in Turkey. It was found that this model influenced changing in students' physics from scientifically unacceptable ideas to scientifically acceptable ideas over 60 % and 70 % in posttests and delayed posttests, respectively. In chemistry, numbers of alternative conceptions were founded. In particular, definition of hydrocarbon in organic chemistry was the fundamental topic that students should study in order to classify the type of organic compounds and it will be the background knowledge of hydrocarbon in higher education. For instance, Srikhao (2013) addressed that bonding of carbon atom can be related with chemical bonding. When students did not have a strong fundamental on chemical bonding, they might confront some problems and held alternative conceptions about bonding with carbon atom. For example, students held the alternative conception that carbon has 4 bonds that can interact with other 4 different elements while H bond can interact with the other element.

Conceptual Framework

This conceptual framework presents as follow;

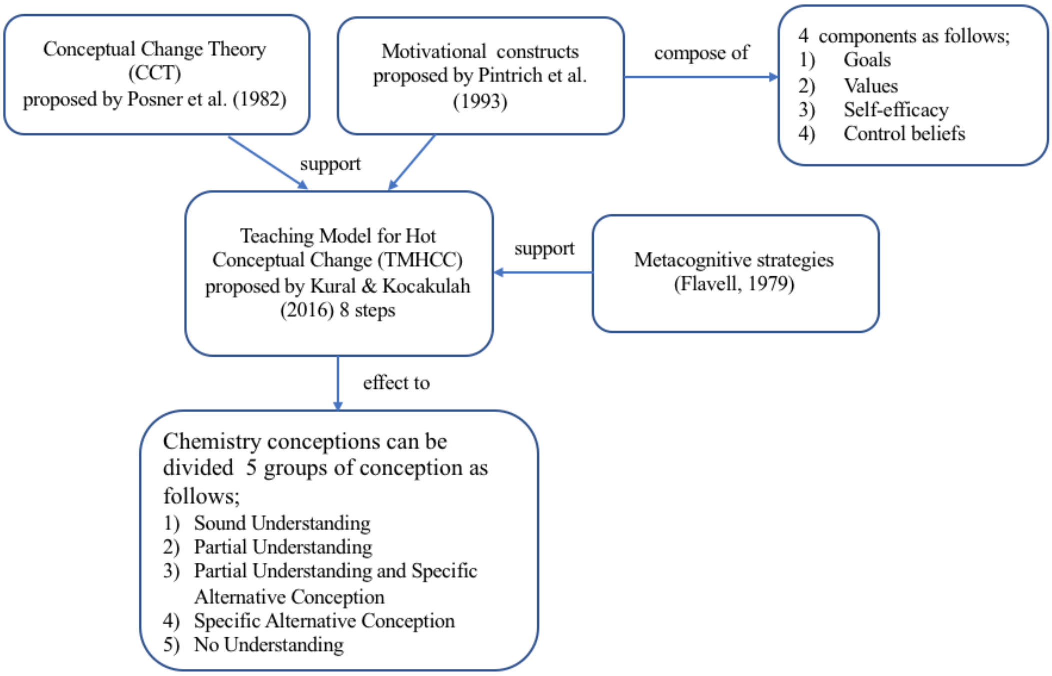


Figure 1. The Model of Enhancing Students' Chemistry Conceptions Based on Teaching Model for Hot Conceptual Change

Research methodology

This research was a one group pretest-posttest design. Participants were 42 eleventh-grade students who were studying in science program of a public secondary school in Phrae, Thailand. This implementation of TMHCC lessons spent 2 months. The research instrument was a two- tier multiple choice chemistry conception test consisting of 12 items that covered 12 conceptions of organic chemistry. The chemistry conception test composes of two parts. Total scores of this test are 5 scores. The first part is multiple choices that was divided into 3 level of scoring (2, 1 and 0). The second part is open-ended question that was divided into 4 level of scoring (3, 2, 1, and 0) depending on the groups of students' conception. They can be divided into 5 groups; Sound understanding (SU), Partial Understanding (PU), Partial Understanding Specific Alternative Conception (PUSAC), Specific Alternative Conception (SAC), and No Understanding (NU). There were 8 lesson plans in organic chemistry which took 24 periods of teaching (50 min/period).

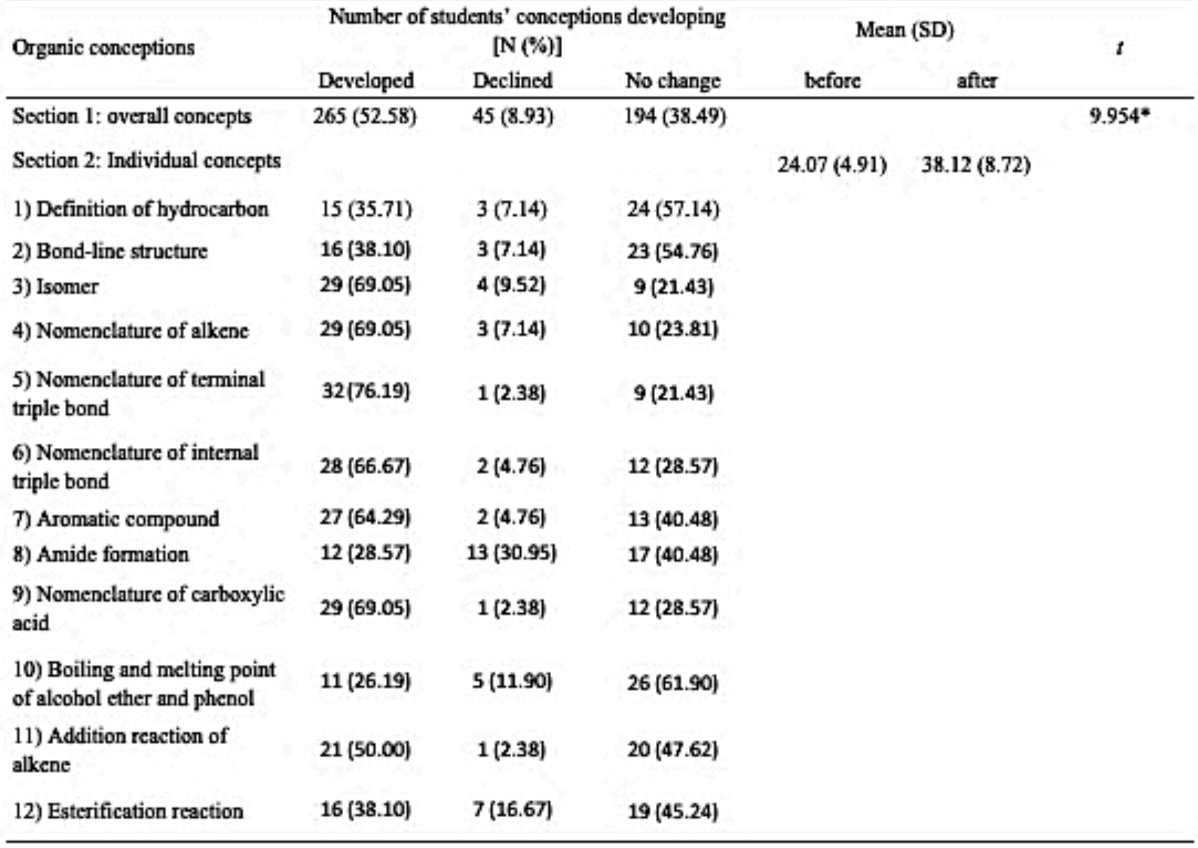
Data Analysis

The analysis described in 2 aspects; 1) the considering students' response particularly from tier 2 (open-ended question) of chemistry conception test into 5 groups of students' conception, and 2) The including students' score in all conceptions. The mean scores of pretest and posttest were compared by using dependent sample t test method. From Table 1, before and after the TMHCC implementation, students' average chemistry conception scores were at 24.04% and 38.12%, respectively. The average score after the implementation was higher than the score before the implementation at .05 level of significance.

Considering individual students' development in overall concepts, 52.58% of students developed their chemistry conceptions. Meanwhile 38.49% made no change and 8.93% declined. Majority of students had developed their chemistry conceptions especially in the concepts of "Nomenclature of terminal triple bond" (76.19%), "Nomenclature of alkene" (69.05%), "Isomer" (69.05%), and "Nomenclature of carboxylic acid" (69.05%). Many students made no changes in some chemistry concepts especially in the concepts of "Boiling and melting points of alcohol, ether, and phenol" (61.90%), "Definition of hydrocarbon" (57.14%), and "Bond-line structure" (54.76%). Regrettably, some students' scores got declined in some chemistry concepts partially in the concepts of "Amide formation" (30.95%), "Esterification reaction" (16.67%), and "Boiling and melting points of alcohol, ether, and phenol" (11.90%).

Findings

Table 1: Average scores of student's chemistry conception before and after TMHCC implementation and numbers of individual student development in chemistry conception.



Organic conceptions	Number of students' conceptions developing [N (%)]			Mean (SD)		*t*
	Developed	Declined	No change	before	after	
Section 1: overall concepts	265 (52.58)	45 (8.93)	194 (38.49)			9.954*
Section 2: Individual concepts				24.07 (4.91)	38.12 (8.72)	
1) Definition of hydrocarbon	15 (35.71)	3 (7.14)	24 (57.14)			
2) Bond-line structure	16 (38.10)	3 (7.14)	23 (54.76)			
3) Isomer	29 (69.05)	4 (9.52)	9 (21.43)			
4) Nomenclature of alkene	29 (69.05)	3 (7.14)	10 (23.81)			
5) Nomenclature of terminal triple bond	32 (76.19)	1 (2.38)	9 (21.43)			
6) Nomenclature of internal triple bond	28 (66.67)	2 (4.76)	12 (28.57)			
7) Aromatic compound	27 (64.29)	2 (4.76)	13 (40.48)			
8) Amide formation	12 (28.57)	13 (30.95)	17 (40.48)			
9) Nomenclature of carboxylic acid	29 (69.05)	1 (2.38)	12 (28.57)			
10) Boiling and melting point of alcohol ether and phenol	11 (26.19)	5 (11.90)	26 (61.90)			
11) Addition reaction of alkene	21 (50.00)	1 (2.38)	20 (47.62)			
12) Esterification reaction	16 (38.10)	7 (16.67)	19 (45.24)			

*p<.05

Table 2: The numbers and percentage of students holding certain types of chemistry conception, before and after TMHCC implementation.

Organic conceptions			1. Definition of hydrocarbon	2. Bond-line structure	3. Isomer	4. Nomenclature of alkene	5. Nomenclature of terminal triple bond	6. Nomenclature of internal triple bond	7. Aromatic compound	8. Amide formation	9. Nomenclature of carboxylic acid	10. Boiling and melting point of alcohol ether and phenol	11. Addition reaction of alkene	12. Esterification reaction
Frequency (%)	NU	after	1 (2.38)	18 (42.86)	5 (11.90)	4 (9.52)	6 (14.29)	8 (19.05)	9 (21.43)	17 (40.48)	13 (30.95)	30 (71.43)	19 (45.24)	22 (52.38)
		before	1 (2.38)	30 (71.43)	23 (54.76)	18 (42.86)	24 (57.14)	27 (64.29)	27 (64.29)	18 (42.86)	37 (88.10)	42 (100.00)	30 (71.43)	29 (69.05)
	SAC	after	0 (0.00)	0 (0.00)	4 (9.52)	0 (0.00)	1 (2.38)	1 (2.38)	1 (2.38)	3 (7.14)	1 (2.38)	1 (2.38)	4 (9.52)	0 (0.00)
		before	1 (2.38)	0 (0.00)	6 (14.29)	12 (28.57)	9 (21.43)	0 (0.00)	5 (11.90)	0 (0.00)	1 (2.38)	0 (0.00)	5 (11.90)	1 (2.38)
	PUSAC	after	0 (0.00)	2 (4.76)	3 (7.14)	11 (26.19)	7 (16.67)	2 (4.76)	5 (11.90)	10 (23.81)	6 (14.29)	4 (9.52)	3 (7.14)	7 (16.67)
		before	10 (23.81)	2 (4.76)	2 (4.76)	4 (9.52)	5 (11.90)	3 (7.14)	3 (7.14)	13 (30.95)	1 (2.38)	0 (0.00)	5 (11.90)	2 (4.76)
	PU	after	2 (4.76)	20 (47.62)	11 (26.19)	17 (40.48)	15 (35.71)	14 (33.33)	1 (2.38)	3 (7.14)	9 (21.43)	1 (2.38)	13 (30.95)	8 (19.05)
		before	3 (7.14)	10 (23.81)	9 (21.43)	8 (19.05)	4 (9.52)	11 (26.19)	0 (0.00)	1 (2.38)	3 (7.14)	0 (0.00)	2 (4.76)	10 (23.81)
	SU	after	39 (92.86)	2 (4.76)	19 (45.24)	10 (23.81)	13 (30.95)	17 (40.48)	26 (61.90)	9 (21.43)	13 (30.95)	6 (14.29)	3 (7.14)	5 (11.90)
		before	27 (64.29)	0 (0.00)	2 (4.76)	0 (0.00)	0 (0.00)	1 (2.38)	7 (16.67)	10 (23.81)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)

The chemistry concepts that most students showed evidence of development in their conceptions were shown in respect; “Aromatic compound” was the conception with the highest development in students’ conceptions from NU (64.29%) to SU (61.90%). Also, “Isomer” showed the development from NU (54.76%) to SU (45.24%). Next, “Nomenclature of internal triple bond” showed the development from NU (64.29%) to SU (40.48%) and PU (33.33%). “Nomenclature of terminal triple bond showed the development from NU (57.10%) to SU (30.95%) and PU (35.71%). “Nomenclature of alkene” developed from NU (42.86%) to SU (23.81%) and PU (40.48%). Lastly, “Bond-line structure” in which students changed their conception from NU (71.43%) to PU (47.62%) and SU (4.76%). Surprisingly, “Definition of hydrocarbon” in which many students (64.29%) already held SU before the TMHCC lesson plans implementation also developed in numbers to SU (92.86%).

Some chemistry concepts indicated only slight development in students’ conception. “Addition reaction of Alkene” developed from NU (71.43%) to SU (7.14%) and PU (30.95%) while slight numbers of PUSAC (7.14%) and SAC (9.52%) still remained. In the same way as “Amide formation”, “Nomenclature of carboxylic acid”, “Boiling and melting points of alcohol, ether, and phenol” and “Esterification reaction”.

Interestingly, after TMHCC lesson plans implementation, significant numbers of students holding PUSAC and SAC were founded in the concepts of “Isomer’ (PUSAC 7.14%, SAC 9.52%), “Nomenclature of alkene” developed (PUSAC 26.19%), “Nomenclature of terminal triple bond” (PUSAC 16.67%), “Aromatic compound” (PUSAC 11.90%), “Amide formation” (PUSAC 23.81% and SAC 7.14%), “Nomenclature of carboxylic acid” (PUSAC 14.29%), “Boiling and melting point of alcohol ether and phenol” (PUSAC 9.52%), “Addition reaction of alkene” (PUSAC 7.14% and 9.52%), and “Esterification reaction” (PUSAC 16.67%).

Discussion and Conclusion

The average chemistry conception score after the implementation of TMHCC was higher compared to the score before the implementation. Also, 52.58% of students developed in their chemistry conception. This result indicated the effectiveness of TMHCC model that could be impacted by the the process of questioning, group work, transfer conception and discussion in TMHCC. This was consistent to Kocaculah and Kural (2016) who explained that TMHCC helped students to change their prior knowledge towards acceptable scientific conceptions. Furthermore, this model potentially to engages students to be more metacognitive. Moreover, motivational constructs in TMHCC that students learned something and solved problem with their peer. So, some peer in group might help another peer in order to understand and summarize the conception together. Furthermore, Posner et al. (1982) cited in Kural and Kocakulah (2016) explained that the cognitive conflict is one of motivator which motivate to change their existing conceptions.

On the other hand, some students had no change in chemistry conception after having learned through TMHCC. This may due to the confusion students had which resulted from the alternative conception they held before the TMHCC implementation. In this regards, Magnusson *et al.*)1999(explained that when students held alternative conception to class, they tended to believe their alternative conceptions rather than scientific conception that newly introduced by teachers .This process obstruct the conceptual change to scientific concept. Also, the students’ responses showed that many students held incomplete and misunderstanding in their background knowledge. For example, students did not understand correctly about how a carbon atom forms a bond with other element which caused the difficulty in forming conception in bond-line structure and some chemical reactions.

Moreover, small percentage of students declined in their chemistry conception. This may result by the nature of abstract concepts in chemistry especially for amide formation, esterification, and boiling and melting points of alcohol, ether, and phenol. In this regards, Nakhlen (1992) explained that abstract concepts are difficult for students to understand and applied them to solve the problems easily. Accordingly, students tend toward interpret the concepts to the new meaning that makes sense to them which leads to alternative conception (Nakhlen, 1992). Also, in this research the time spent for the group work/ argumentation stage was limited. This could be critical in failing to assess whether students construct correct scientific conception.

For implication, the limit of time is another factor that teachers should consider. TMHCC requires the amount of time to practice students to discuss and debate the activities that teachers had used in each lesson. Students can learn the chemistry concepts from their peers through discussion and debate before summarizing the activities by teachers. Furthermore, researcher should be interview their students for probing which conception held by students after having learned chemistry through TMHCC. Finally, peers and teachers interaction could affect students’ change in conceptions. Moreover, the further research should monitor students more about motivation by interview and observation of students.

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