Reducing the Misconception Burdens of Students with Balance Visual-Verbal Learning Style through the Conceptual Change Strategy Assisted by Student Worksheet

[1]Suyono, [2]Wahyu Budi Sabtiawan

[1]Department of Chemistry, Faculty of Math. and Nat. Sci., Universitas Negeri Surabaya
[2]Department of Science Education, Faculty of Math. and Nat. Sci., Universitas Negeri Surabaya

Abstract

The purpose of the study was to evaluate the implementation conceptual change strategy assisted by students' worksheets. The evaluation focused on two aspects involving the direction of misconceptions shift and the reduction of misconceptions. This study followed a pre-experimental research design with one group pretest-posttest design type. The participants of this study were 17 high school students who had already studied the concept of chemical bonds, have a balance visual-verbal learning style and were detected to have a high misconception burden (≥ 37.84%). The significance test for the decreased burden of student misconception was done by using the Wilcoxon Signed Rank Test. The results of this research were: (1) the implementation of conceptual change strategy assisted by student worksheet succeeded in decreasing targeted students' misconception burdens significantly in the concept of chemical bonds, (2) researchers found 5 types of student misconceptions shift, and (3) the implementation of conceptual change strategy assisted by student worksheet succeeded in dethcreasing quite largepercentage of students with misconceptions (81.54%) in the three attributes, that were concept definition, characteristic, and example/non examples and the biggest decrease occurred in the definition attribute (97.18%).

Keywords: balance visual-verbal learning style, conceptual change strategy, misconception, misconception shifting type, student worksheet

Introduction

The misconception is a conception which is not in line with the scientific understanding or understanding agreed by experts in the corresponding field (Dhindsa & Treagust, 2009; Unal et al., 2010). Chemical misconceptions in students are one of the world's most global educational problems (Bong & Lee, 2016; Mamlok-Naaman et al., 2017; Saraçoğlu, Doğan, & Kol, 20017), occurring in many countries including Indonesia (Erman, 2017). Barke et al. (2009) found a number of chemical concepts are often misconcepted by students, among them is the concept of chemical bonding. Misconceptions in chemical bonding were also reported by Dhindsa & Treagust (2009), Erman (2017), Luxford & Bretz (2014), Nimmermark, et al. (2016),Pabbacu & Geban (2012), Vladušić, et al. (2016), and Vrabec & Proks (2016). The research results in Indonesia recall as follows. Yunianingsih and Suyono (2013) find the greatest number of students' misconception in chemical bonding topic (44%) occurs in the sample attribute especially the molecular examples, which deviates from the octet, while the smallest misconception number (3%) occurs in the definition attribute. Rahman et al. (2014) depicted the percentage of chemical bonds misconception is 19.8% which some misconceptions identified include: (1) HCN has double bond 3 because it has 3 different elements (40,7%); (2) The ionic bonds are formed by the use of electrons together (18.5%), and (3) Coordinate covalent bonding occurs when the electron pair used to form the bond is derived from 2 atoms attached (18.5%). The misconceptions held by students are because of the abstract chemical bonding characteristics. This is in line with Tan and Treagust's (1999) opinion that chemical bonding is an abstract concept, students can not see atoms and the process how atoms bind each other, so students have difficulty to understand the concept of chemical bonding (Mamlok-Naaman, et al., 2017) and often experience misconceptions in understanding that concepts. Furthermore, Herron (1996) explained that it is difficult to explain a concept without real

examples. If someone can not show tangible examples, it is possible that concepts can only be learned at the formal level and it is impossible to communicate information about the critical attributes of the concept through actual sample observations. The concept uses an actual model or illustration of examples and nonexamples, so that the critical attributes and variable attributes of the concept are shown by using the pseudo examples.

The improvement of student misconceptions on chemical bonding is highly urgent because the concept in chemical bonding is a prerequisite for learning other chemical concepts (Mamlok-Naaman, et al., 2017), such as molecular structures that are also closely related to the physical and chemical properties of compounds (Ozmen et al., 2004). If these misconceptions are not eliminated or reduced, then there will be barriers for students to learn other concepts (Pabuccu and Geban, 2006). The students' chemical misconceptions burden could be solved through a conceptual change strategy based on Piaget (2005) that individual cognitive (scheme) structures can be changed. The main mechanism of conceptual change according to Effendy (2002) is as follows: the misconceptions built up in individual schemes are equilibrated, it can be done by creating a conflict atmosphere (cognitive conflict) for students, so it is expected that the accommodation process will occur first in order to be reorganized, then will be equilibrated into new correct concept. The creation of cognitive conflict can be done through the provision of counter-examples, analogies, demonstrations, and experiments.

Effendy (2002) specifically noted that at the stage of creating cognitive conflict and providing assistance for the occurrence of equilibration should be repeated as needed. A number of researchers have proven the effectiveness of this strategy in reducing student misconceptions, such as Ozdemir and Clark (2007), Pabuccu and Geban (2006), Sinatra & Broughton (2011), Ultay et al. (2014), and Zirbel (2004). Ozmen (2004) and Sari (2015) have proven that the conceptual change strategy can reduce student misconceptions about the concept of chemical bonding. Suyono et al. (2014) found that students with misconceptions are resistant to certain concepts, including the concept of chemical bonding after the treatment. This means that the burden of misconceptions is difficult to be eliminated.

Changing the conception (conceptual change) made by previous researchers has not considered the students' internal factors like the learning style. Sen and Yilmaz (2012) and Abosalem (2013) found that there is a significant effect on between student learning styles and student misconceptions. That is, when the students' learning style is not accommodated by the teacher, it will lead to the fail students' learning process. Suyono et al. (2014) found students who experience resistant misconceptions mostly are students who have balance learning styles both from the dimensions of perception, input, process, and understanding. In this article, remedial learning is based on changing conceptions by paying attention to students' learning style factors, in terms of the input dimension. In addition to observe the students' internal factors, it is necessary to note the conditions that must be appropriate for the conceptual change strategy to give results. Requirements for the rise of conceptual changes in students according to Posner et al. (1982) are: (1) there is dissatisfaction coming from students over existing conceptions. This can be conditioned by bringing anomalies or examples to show that their conceptions can not be used to provide an explanation for something, (2) presenting a new conception that is understandable (intelligible) by the students, can be conditioned by asking students to explore, make an analogy, and make metaphors (figuratively) of their new conception, (3) creating a new conception that makes more sense (plausible), having consistency and can be used to solve problems, and (4) students convinced the new concept is useful (fruitful) or proven to be used for supporting problem solving program (research) and opening a new inquiry path.

Based on the mechanisms and conditions for the success of conceptual change, as well as the tendencies of students with misconceptions related to learning styles, the author tries to reduce the burden of chemical bonding misconceptions on disadvantaged students in learning through conceptual change strategies with student worksheet support. The students are: (1) who have high misconception burden, that are students who have misconception percentage above the mean percentage of misconception in their group and (2) balance visual-verbal learning style students, according to the research of Suyono et al. (2014) that students with balance visual-verbal learning are categorized into students who have resistant misconceptions. The consideration to select the worksheet as a supporting tool in implementing the conceptual change strategy is based on Taslidere research experience (2013). The results suggested that a worksheet is an effective tool in finding out pupils' ideas, and providing a powerful stimulus for learners to focus on their attention on constructing meaningful explanations (Taslidere, 2013: 274). The worksheet used to implement the conceptual change strategy provides individual space and assistance for students to: (1) rewrite the definition of a concept in which according to the researcher's analysis, the concept is missed by the students, (2) makes it easy to revisit the written conceptual definitionorally with a loud voice in front of some friends and teachers for comments, feedbacks, and assessments (verbal learning style services); the student is not forced to change his or her conception, (3) guide herself/himself to observe the animation related concept (visual service) called Chem Activity Visual for the creation of cognitive conflict, (4) guide himself/herself to read Chem Activity Verbal, a written description of concept, (5) writes the observation results of the correct examples and the wrong examples of a concept and then rewrites the currently accepted definition of concepts and writes the logical argument, and (6) guides himself/herself to reinforce the conception Chem Game and Chem Task.

The purpose of this study was to test the effect of conceptual change strategy assisted by student worksheet on the decrease of misconception burdens for students with balance visual-verbal on chemical bonding concept, the direction of misconceptions shift, and the percentage of student misconceptions decline in each concept attribute.

Methods

This study followed a pre-experimental group: the pre-test and post-test design type (Fraenkel, Wallen, & Hyun, 2011). It begins with the stages of students' learning styles and student misconceptions on the concept of chemical bonding. Diagnostic tests of chemical bonds misconceptions are supplemented by Certainty of Response Index (CRI). The research subject were 120 high school students who have already learned the concept of chemical bonding with good learning management. This means that students were taught through inquiry model by using learning tools that have been validated through expert judgment, and implemented (observation data). The determination of the student's conception status is guided by Hasan et al. (1999). From those 120 students, then the target of research was set, they were students who have high misconception burden and balanced visual-verbal learning style. The purposive sampling technique was addressed in this research. Students were classified as having high misconception burden, if they have misconception percentage ≥ 37,84%. This number means the category limit of misconception among 120 students were tested. From the 120 students, the research target was 17 students. Then, for those 17 students the treatment was given by using conceptual change strategy assisted by student worksheet developed by Suyono et al. After the treatment, the targeted students were reexamined with the same misconception diagnostic test.

As mentioned above, there are two instruments used in this study, they were learning style test and comprehension test of chemical bonding concept. The learning style test used in this study was adopted

(translated into Indonesian and licensed by Felder) by Aryungga (2014) from Inventory Learning Style (ILS) developed by Felder & Solomon (1999). This complete test consisted of 44 problems which divided into 4 dimensions, namely dimensions of perception, input, processing, and comprehension; each of them consists of 11 test items. This study was limited to use only 11 items of the input dimension. The adopted learning style test has been validated by three validators, in which the two are experts in the field of chemistry education and the one is expert in psychology. All test items were declared valid either in content (relevance) or in construction (consistency). The reliability of the learning style test based on Cronbach's alpha was 0.77 at the moderate level, based on the criteria cited in Nunnally and Bernstein (1994); Stevens (2002); Suprapto and Chang (2015). The concept comprehension test was validated by two experts in the field of chemistry education. The reliability of the concept comprehension test based on the KR-20 formula was 0.83 at the moderate level.

The significance test of the burdens decreases in students with misconceptions was done by using the Wilcoxon marked rank test (Wilcoxon's Signed Rank Test). The criteria for decision-making was Ho is rejected if T measured <Tα (Djarwanto, 1991). Shifts mapping from misconceptions status to another conception status, that is not knowing the concept and knowing the concept was done descriptively.

The remedial learning applied to students individually with steps according to conceptual change strategy. The steps were: (1) validation of misconceptions, (2) creation of cognitive conflict, (3) provision of assistance for equilibration, and (4) reconstruction of understanding. The operational guidelines of each step were administered in the worksheet. Worksheet consisted of two parts, namely the introduction and the contents of the worksheet. The introductory section contains instructions for using the worksheet, while the content of the worksheet contains facts, concepts, laws, or theories about ionic bonding that are packaged in accordance with the objectives of each stage on the process of altering conception. One example of this student worksheet is at the stage of creation of cognitive conflict conditions, the worksheet presents a table containing examples of compounds formed from metal atoms and nonmetallic atoms, of which there are compounds with a Pauling scale not greater than 1.7 such as $BeCl_2$. In the relief phase for the occurrence of equilibration, the worksheet presents a reinforcing conclusion that $BeCl_2$ is not an ionic compound based on its physical properties and so on.

Results

The impact of the conceptual change strategy assisted by student worksheet on the decrease of misconception burdens from balance visual-verbal learning style students in the concept of chemical bonding is represented in Table 1. In the last row of Table 1, there is also a benchmark value of Wilcoxon marked test results that are useful for decision-making on the significance of decreased students' misconception burdens.

Table 1 Misconception Burdens of Targeted Students Chemical Bonds Concept Before and After Remedial Learning with Conceptual Change Strategy Assisted by Student Worksheet, and Student Misconception Shifting

Students' Number	O_1	O_2	A	B	C
1	10 (67)	1 (7)	9	0	1
2	7 (47)	1 (7)	7	0	0
3	7 (47)	0 (0)	7	0	0
4	9 (60)	2 (13)	7	0	2
5	7 (47)	1 (7)	6	0	1

Students' Number	O_1	O_2	A	B	C
6	6 (40)	1 (7)	6	0	0
7	7 (47)	2 (13)	6	0	1
8	7 (47)	2 (13)	5	0	2
9	8 (53)	3 (20)	5	0	3
10	9 (60)	3 (20)	6	0	3
11	6 (40)	2 (13)	6	0	0
12	5 (33)	1 (7)	4	0	1
13	9 (60)	3 (20)	7	0	2
14	7 (47)	1 (7)	6	0	1
15	7 (47)	2 (13)	7	0	0
16	10 (67)	1 (7)	7	2	1
17	6 (40)	2 (13)	5	0	1
T			0		

Notes. O1: Number of misconceptions (accompanied by the percentage) before remedial learning by using conceptual change strategy assisted by student worksheet; O2: Number of misconceptions after remedial learning by using conceptual change strategy assisted by student worksheet

The data analysis in Table 1 is as follows. Despite the concept of chemical bonding with learning had already given, students still have misconceptions with different percentages one another (O_1). After doing the remedial learning by using conceptual change strategy assisted by student worksheet, all targeted students experienced a reduction in their misconception burdens. The average misconception percentage of targeted students was reduced from 49.94% to 11% after the remedial learning. After the remedial learnings, targeted students (students with balance visual-verbal learning style who have a high misconception burden) still leaves a misconception. From 17 students, only one student has no longer misconception burdens in the chemical bonding, that is student number 3. The critical value T in the Wilcoxon rank test for $n = 17$ and $\alpha = 0.05$ with the two-tailed test was 35. Measuring T value <35, it can be concluded that the mean of the previous misconception (49,94%) and treatment (11%) is different, decreased significantly at $\alpha = 0.05$. The conceptual change assisted by student worksheet had classical effect to reduce the misconception burdens of students with balance visual-verbal learning style in the chemical bonding concept.

The impact of conceptual change strategy assisted by student worksheet on the direction of student misconceptions shift can be explained based on the data in Table 1. The reduction of misconception burdens in chemical bonding from the targeted mostly shifted to the status of knowing the concept. What about some other shifts? To answer this question, it is necessary to analyze the relationship between O_1, O_2, A, B, and C. Notations A, B, C in Table 1 represent the conception shift from misconception status into knowing the concept, from misconception status into not knowing concepts, and fixed misconceptions (resistant misconceptions). If we analyze the relationship between O_1, O_2, A, B, and C, there are five types of targeted students' misconceptions shift after the remedial study by using conceptual change strategy assisted by student worksheet. The five types of student misconceptions shift are presented in Table 2.

Table 2 Five Types of Targeted Students' Misconception shift on the Concept Chemical Bonding Before and After the Remedial Learning

Type	Misconception Shift	Number of Students

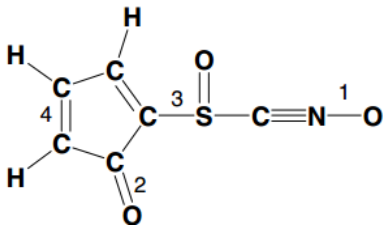
a	The total shift from misconceptions into knowing the concepts.	3 [one student = 5,88%]
b	The shift from misconception status into totally knowing the concept, but a new misconception occurs from the status of knowing the concept/not knowing the concept.	2, 6, 11, dan 15 [four students = 23,53%]
c	Large examples shift from misconception status into knowing the concepts, some shifting into not knowing the concept status, and some remain misconception (resistant).	4, 5, 8, 9, 10, 12, 14, dan 16 [eight students = 47,06%]
d	Mostly shift from the misconception status into knowing the concept and some others are unchanged (resistant).	1 [one student = 5,88%]
e	Mostly shift from the misconception status into knowing the concept and some others are unchanged (resistant). However, a new misconception occurs from the status of knowing the concept/not knowing the concept.	7, 13, dan 17 [three students = 17,65%]

The impact of conceptual change strategy assisted by student worksheet towards the direction of student misconceptions shifts in the five variations or types is shown in Table 2. The five types have similarity, that is the most of the targeted students' conceptions shift from misconception status into knowing the concepts. The status of knowing the concept is the targeted status of the remedial learning performed. With these findings, it can be concluded that the conceptual change strategy assisted by student worksheet has a classical impact to reduce the misconception burdens of a student with of balance visual-verbal-learning style in the chemical bonding concept. The decline occurred because the students experienced a major change from the misconception status into knowing the concept.

If the previously analysis focused on students, the following presented the results of the analysis which focus on the concept of the tested chemical bonding concept. In other words, we want to know the impact of conceptual change strategy assisted by student worksheet. The data for this indicator are presented in Table 3.

Table 3 Number of Students with Misconceptions in Chemical Bonding Before and After Remedial Learning with Conceptual Change Strategies assisted by Student Worksheet

Question Number	Concept Attribute	Misconception	N1 (%)	N2 (%)	Percentage of Decrease (%)
1	Definition	Ionic bonds are the bonds that occur between metal atoms and non-metallic atoms.	71	6	91,55
2	Example/ Non Example	The bonds that occur in NaCl actually are not ionic bonds.	35	0	100
3	Example/ Non Example	Among the following compounds: $BaCl_2$, H_2O, Na_2O, and $BaBr_2$, H_2O	65	0	100

Question Number	Concept Attribute	Misconception	N1 (%)	N2 (%)	Percentage of Decrease (%)
		are compounds that have the greatest ionic bonds characteristic.			
4	Example/ Non Example	Formation of ionic bonds in NaCl (g) from Na (g) and Cl (g) does not happen through electron transfer	76	18	76,32
5	Definition	Not all attractive forces formed between ions which have different charges are called as ionic bonds.	35	0	100
6	Definition	Covalent bonds do not always occur because of the joint use between electron pairs.	35	0	100
7	Example/ Non Example	The bonding of HCl is not a covalent bond.	35	18	48,57
8	Example/ Non Example	The N_2 molecule excludes examples of molecules that have a triple covalent bond.	47	35	25,53
9	Example/ Non Example	I_2 molecule excludes examples of molecules that have non-polar covalent bonds.	65	0	100
10	Attributes / Characteristics	In a covalent bond, there is no relationship between the number of electrons used with the number of bonds.	53	29	45,28
11	Example/ Non Example	 Coordination covalent bonds occurs at positions 2, 3, or 4.	41	0	100
12	Attributes / Characteristics	The number of coordinated covalent bonds on HNO_3 is more than one.	65	0	100
13	Example/ Non Example	O_3 molecules exclude examples of molecules that have a coordinated bond.	59	47	20,34
14	Example/ Non Example	The bonds that occur between NH_3 and BF_3 are not coordinated covalent bonds.	12	0	100

Question Number	Concept Attribute	Misconception	N1 (%)	N2 (%)	Percentage of Decrease (%)
15	Example/ Non Example	In the NH_4Cl compound, there are no coordinated covalent bonds.	53	12	77,36

Notes. N1 = number of students with misconception before remedial learning (%); N2 = number of students with misconception after remedial learning (%)

The impact of conceptual change strategy assisted by student worksheet with the percentage of students with misconception decrease on each concept attribute as the indicator was as follows. The percentage average of the decrease students with misconception number on questions about definition attributes, characteristics attributes, and example/ non example attributes were 97.18; 72.64; and 74.81%. The average of reduction percentage in the three attribute concepts was 81.54%. The largest percentage of decreased students with misconception number in the three chemical bonding concept attributes occurred in the question of definition. On the question of concept sample attributes, namely question number 8 and number 13 it was found a very small percentage of reductions that were 25.53 and 20.34%. Thus, it can be concluded that the conceptual change strategy assisted by student worksheet has a great impact on the percentage average of students with misconception number on each concept of chemical bonds. This conclusion is in line with the result of significance test of targeted students' misconception burdens reduction.

Analysis

The research targets were students who have a high misconception on chemical bonds and have balance visual-verbal learning style. The average misconception burden on chemical bonding of targeted students was 49.94%, although the high school students had already got the chemical bonding material. The similar misconception findings have already reported by Barke et al. (2009), Dhindsa & Treagust (2009), Luxford & Bretz (2014), Nimmermark, et al. (2016), Pabbacu & Geban (2012), Vladušić, et al. (2016), Vrabec & Proks (2016), and also by Indonesian researchers such as Redhana (2008), Yunianingsih & Suyono (2013), Rahman et al. (2014), Sari (2015), and Erman (2017). For example, Redhana (2008) and Sari (2015) found misconception of high school students were 63.4% and 45.56%. Misconceptions in chemical bonding still occur in students although they already got this material because this material has a high level of abstraction, so can cause misconception in students. They can not see the atoms and the process how atoms bind each other, so it is natural that students have difficulty in understanding the concept of chemical bonds (Tan & Treagust, 1999; Mamlok-Naaman, et al., 2017). The condition of such students must be remedied to reduce their misconceptions, since the concepts in chemical bonding are a prerequisite for learning other chemical concepts (Mamlok-Naaman, et al., 2017), such as molecular structures that also have close relation with physical and chemistry properties of a substance (Ozmen et al., 2004).

After doing remedial learning by using conceptual change worksheet strategy, all targeted student (100%) experienced a decrease of misconception burden. Inferential analysis showed a significant decrease in the students' misconception burdens on chemical bonding, although there were still students who have a misconception burdens with an average of 11%. The conceptual change strategy was done by providing special services for students showed positive results. The positive results of conceptual change strategy implementation are in line with previous researchers (Ozdemir & Clark, 2007; Pabuccu & Geban, 2006; Sari, 2015; Sinatra & Broughton, 2011; Ultay et al., 2014; Zirbel, 2004).

The success of the previously mentioned conceptual change strategy can occur because of visual services and verbal services tailored to target students who have a visual-verbal learning style. These services consider the findings of Sen & Yilmaz (2012) as well as Abosalem (2013) that there is a significant influence on student learning styles and student misconceptions. In the implementation of conceptual change strategy, visual services and verbal services are accommodated into learning and realized into the student worksheet in order to focus the student learning as recommended by Taslidere (2013). Such specialized services provide space and assistance for students to individually follow the stages of altering conceptions so that students are able to reconstruct their misconceptions.

The remedial learning by using conceptual change strategy assisted by student worksheet still leaves students who have misconception burdens with 11% average. It means that there are still chemical bonding concepts that exist within the scheme (cognitive structure) that some students are unsuccessfully dis-equilibrated, equilibrated, and reconstructed into correct conceptions. The accommodation process that has not occurred in the student scheme suggests that students are experiencing a resistant misconception. Such a thing can happen for students with a balance visual-verbal learning style. These findings reinforce the results of previous research that students in balance visual-verbal learning style tend to experience a resistant misconception (Suyono et al., 2014).

The remedial learning has not been successful in changing the overall misconceptions attached to each individual's cognitive structure. It means that not the whole status of misconception turns into knowing the concept. This is in line with the Duit's statement (2002) through the stages of conceptual change strategy not all students change the status of conception from misconception into knowing the concept. According to Barke et al. (2009) to correct students' misconception is not as easy as improving student ignorance. Implementation of conceptual change assisted by student worksheet on students with balance visual-verbal learning style with a high misconception burden caused five types of misconception shifts in the student's brain scheme (see Table 2). The five types have similarity, that is the most targeted students' conception shifted from misconception into knowing the concept. The status of knowing the concept is the target status of the remedial learning performed. Of the 17 targeted students only one student (5.88%) whose misconceptions disappear altogether. Another misconception shift in each student was that there were students who did not know the concept and there were students who have fixed misconception (resistance misconceptions). In some students (see Table 2, types of changes b and e) occurred new misconception from knowing the concept and/ or not knowing the concept. The students experienced the shakiness of the true conception they had. In the cognitive structure of students with high misconceptions, there was a shake of conception woke up in it.

Individuals with the same learning style remedied with the same learning strategy but seemed to respond differently, the five types of student misconception shifts prove this. Such a thing may happen because of the specifications of individual's brain schemes different. This difference can occur in two ways, namely the robustness in maintaining the old idea and the weakness in holding the new conception built (Chinn & Brewer, 1993). Individuals with the same learning style who remedied with the same learning strategy, one may be successful while the other may fail. According to Duit & Treagust (2003) there is a probability of failure in changing student conceptions. Failure is because it is still shallow or weak to built new conception. Another cause of the failure to change conception is the existence of old ideas that remain alive in the student's brain scheme. Such a change of conception is known as peripheral conceptual change. In peripheral conceptual change, the initial idea part joins the parts of the new idea and forms some kind of hybrid idea (Chinn & Brewer, 1998). Failure to change conception also occurs due to the failure of the cognitive conflict creation stage. When students are confronted with conflicting

data (when the creation of cognitive conflict conditions), students throw away the data, ignore it, and the process of memorization is born, so there is no conflict situation followed by a change of conception (Hewson & Hewson, 1983).

The percentage decrease in student misconception on the three attributes of the chemical bonds concept was quite large (81.54%), the biggest decrease occurs in the question of definition (97.18%). At the end of the remedial learning, the number of misconception students on the definition attribute was very small and there was even a zero. This is in line with previous findings that after learning the number of students the smallest misconception (3%) occurs in the definition attribute (Yunianingsih & Suyono, 2013). The greatest decline number of students with misconception occurred in the definition attribute was reasonable because the thinking activities in the stages of conceptual change strategy lead to the change of students' conception in the form of definitions. Different things happened to two questions about concept sample attributes (number 8 and number 13), it found a very small percentage decrease of 25.53 and 20.34%. This data reinforces the findings of Yunianingsih & Suyono (2013) that after learning the number of students with on the largest chemical bonding topic (44%) occurs in the sample attributes. If associated with Herron's (1996) thinking, the very small misconception of the sample attribute on the concept of chemical bonding occurs because the examples are not real examples. Examples of chemical bonding concepts are models or illustrations that are not always easy for students to be understood.

Conclusion and Suggestions

The conclusions of this research are summarized into three points as follows:

1 Implementation of conceptual change strategy succeeded in significantly reducing the burden of student misconception on research targets in chemical bonding concept.

2 Implementation of conceptual change strategy assisted by student worksheet succeeded in changing student misconception status on chemical bonds in 5 types of student misconceptions shift: (a) shifted from misconception status into totally knowing the concept, (b) shifted from misconception status into totally knowing the concept, but new misconception occurred from the status of knowing the concept and/ or not knowing the concept, (c) mostly shifted from misconception status into knowing the concept, the other shift into not knowing the concept status, and the other ones stayed in misconception status (resistant), (d) mostly shifted from misconception status into knowing the concept, and the other stayed in misconception status (resistant), and (e) mostly shifted from misconception status into knowing the concept, and the other stayed in misconception status (resistant), but new misconception occurred from the status of knowing the concept and/ or not knowing the concept.

3 Implementation of conceptual change strategy assisted by student worksheet succeeded in decreasing quite a large percentage of students with misconception (81.54%) in the three concept attributes (definitions, characteristics, and examples/non examples) and the greatest decrease occurred in the definition attribute (97.18%).

A suggestion for the further research relating to the development of the students' worksheets is elaborated, as follows:

The concepts of chemical bonding are concepts without real examples. A series of models represents the examples and non-examples of ionic compounds, for example the covalent compound example and noncovalent compound example should be in the student worksheet to support the conceptual change strategy. A series of models represents an ionic example must firmly show the attributes of an ion that are not owned by each model that represents the non-ionic.as well as, for covalent

and coordinated covalent. A series of the ionic model, a covalent compound, and coordinated covalent must also exist in the student worksheet designed to enhance students' understanding of concepts in chemical bonds. At the end of the student worksheet, it needs to be added the assignment section for students to practice identifying examples related to ionic, covalent compound, and coordinated covalent.

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References

Abosalem, Y. M. (2013). The relationship between the learning styles of students in grades five and six and their held misconceptions about dividing fractions based on Kolb's model. *Thesis*. Dubai : The British University.

Arends, R. I. (1997). *Classroom instruction and management*. USA: The Mc Graw-Hill Companies.

Barke, H. D., Hazari, A., & Yitbarek, S. (2009). *Misconceptions in chemistry: Addressing perceptions in chemical education*. Berlin: Springer-Verlag Berlin Heidelberg

Best, R. M., Roe, M.,Ozuru, Y., & McNamara, D.S. (2005). Deep-level comprehension of science texts the role of the reader and the text. *Top Lang Disorders, 25*(1), 65-83.

Black, A. A. (2005). Spatial Ability and Earth Science Conceptual Understanding. *Journal of Geoscience Education, 53*(4), 402-414.

Bong, A. Y. L., & Lee, T. T. (2016). Form four students' misconceptions in electrolysis of molten compounds and aqueous solutions. *Asia-Pacific Forum on Science Learning & Teaching, 17*(1), Article 8.

Çetingül, İ. P., & Geban, Ö. (2005). Understanding of Acid-Base Concept by Using Conceptual Change Approach. *Hacettepe University Journal of Education, 29*, 69-74.

Chinn, C. A. & Brewer, W. F. (1998). Theories of Knowledge Acquisition, In B Fraser & K Tobin, Eds, *International handbook of science education* (pp. 97-114) Dortrecht, The Netherlands: Kluwer Academic Publishers.

Clerk, D. & Rutherford, M. (2000). Language As a Confounding Variable in The Diagnosis of Misconceptions. *International Journal of Science Education, 22*(7), 703-717.

Crawford, A., Saul, W., & Mathews, S. R. (2005). *Teaching and Learning Strategies for The Thinking Classroom*. New York, NY, USA: International Debate Education Association.

Çubukcu, E., & Dündar, Ş. G. (2007). Can Creativity Be Taught? An Empirical Study on Benefits of Visual Analogy in Basic Design Education. *A| Z ITU Journal of the Faculty of Architecture, 4*(2), 67-80.

Dagher, Z. R. (1995). Analysis of Analogies Used by Science Teachers. *Journal of Research in Science Teaching, 32*(3), 259–270.

Dhinsda, H. & Treagust, D. (2009). Conceptual Understanding of Bruneian Tertiary Students: Chemical Bonds and Structure. *Brunei International Journal of Science and Mathematics Education, 1*(1), 33-51.

Djarwanto. (1991). *Nonparametric Statistics*. Yogyakarta: BPFE

Duit, R. (2002). Conceptual Change—Still a Powerful Frame for Improving Science Teaching and Learning. In *third European Symposium on Conceptual Change* (pp. 26-28).

Duit, R., & Treagust, D. F. (2003). Conceptual Change: A Powerful Framework for Improving Science Teaching and Learning. *International Journal of Science Education, 25*(6), 671-688.

Effendy. (2002). Attempts To Overcome Concept Mistakes In Teaching By Using Cognitive Conflict Strategies. *Media Communication Chemistry, 2*(6): 1-19.

Erman, E. (2017). Factors Contributing to Students' Misconceptions in Learning Covalent Bonds. *Journal of Research in Science Teaching, 54*(4), 520-537.

Felder, R. M., & Silverman, L. K. (1988). Learning and Teaching Styles in Engineering Education. *Engineering Education, 78*(7), 674-681.

Felder, R., & Soloman, B. (1999). Index of learning styles questionnaire. Retrieved from website:https://www.researchgate.net/profile/Richard_Felder/publication/228403640_ Index _of_Learning_Styles_Questionnaire/links/00463527bb8b1190be000000/Index-of-Learning-Styles-Questionnaire.pdf

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2011). *How to design and evaluate research in education.* New York: McGraw-Hill Humanities/Social Sciences/Languages.

Hasan, S., Bagayoko, D., & Kelley, E. L. (1999). Misconceptions and The Certainty of Response Index (CRI). *Physics Education, 34*(5), 294-299.

Herron, J. D. (1996). *The Chemistry Classroom: Formulas for Successful Teaching*. American Chemical Society: Washington, DC.

Hewson, M. G., & Hewson, P. W. (1983). Effect of Instruction Using Students' Prior Knowledge and Conceptual Change Strategies on Science Learning. *Journal of Research in Science Teaching, 20*(8), 731-743.

Kang, S., Scharmann, L. C., & Noh, T. (2004). Reexamining The Role of Cognitive Conflict in Science Concept Learning. *Research in Science Education, 34*(1), 71-96.

Laliyo, L. A. R. (2011). Student Mental Model in Understanding Substance Changes. *Journal of Research and Education, 8*(1), 1-12.

Lee, G., Kwon, J., Park, S. S., Kim, J. W., Kwon, H. G., & Park, H. K. (2003). Development of An Instrument for Measuring Cognitive Conflict in Secondary-Level Science Classes. *Journal of Research in Science Teaching, 40*(6), 585-603.

Luxford, C. J., & Bretz, S. L. (2014). Development of the Bonds Representations Inventory to Identify Student Misconceptions About Covalent and Ionic Bonds Representations. *Journal of Chemical Education, 91*(3), 312-320.

Mamlok-Naaman, R., Hofstein, A., & Nahum, T. L. (2017). Teaching and Learning The Concept of Chemical Bonds. *Educació Química*, 13-19.

Nimmermark, A., Öhrström, L., Mårtensson, J., & Davidowitz, B. (2016). Teaching of Chemical Bonds: a Study of Swedish and South African Students' Conceptions of Bonds. *Chemistry Education Research and Practice, 17*(4), 985-1005.

Nunnally, J. C. & Bernstein, I. H. 1994. *Psychometric theory (3rd ed.)*. New York, NY: McGraw-Hill.

Nur, M. (2000). *Learning Strategies*. Surabaya: School Science and Mathematics Center of Universitas Negeri Surabaya.

Özdemir, G., & Clark, D. B. (2007). An overview of conceptual change theories. Eurasia *Journal of Mathematics, Science & Technology Education, 3*(4), 351-361.

Özmen, H. (2004). Some Student Misconceptions in Chemistry: A Literature Review of Chemical Bonds. *Journal of Science Education and Technology, 13*(2), 147-159.

Pabuccu, A., & Geban, O. (2006). Remediating Misconceptions Concerning Chemical Bonds through Conceptual Change Text. *Hacettepe University Journal of Education, 30*, 184-192

Pabuçcu, A., & Geban, Ö. (2012). Students' Conceptual Level of Understanding on Chemical Bonds. *International Online Journal of Educational Sciences, 4*(3), 563-580.

Piaget, J. (2005). *The Psychology of Intelligence*. (M. Piercy, & D. E. Berlyne, Trans.). London: Taylor & Francis e-Library.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of A Scientific Conception: Into a Theory of Conceptual Change. *Science Education, 66*(2), 211-227.

Rahman, A., & Enawaty, E. (2014). Misconception Student Class XI Science SMA Negeri 9 Pontianak On Material Bonding Chemistry. *Journal of Education and Learning, 3*(10).

Saraçoğlu, H., Doğan, M., & Kol, Ö. (2017, December). Investigation of teacher-candidates' level of knowledge and their misconceptions with content analysis. *Asia-Pacific Forum on Science Learning and Teaching, 18*(2), 1-16.

Sari, M. W. (2015). Application of Conceptual Change Learning Model to Reduce Student Misconception on Material of Chemistry Class X State Senior High School 4 Sidoarjo. Unesa *Journal of Chemical Education. 4*(2), 315-324

Sen, S., & Yilmaz, A. (2012). The Effect of Learning Styles on Student's Misconceptions and Self Efficacy for Learning and Performance. *Procedia-Social and Behavioral Sciences, 46*, 1482-1486.

Sinatra, G. M., & Broughton, S. H. (2011). Bridging Reading Comprehension and Conceptual Change in Science Education: The promise of refutation text. *Reading Research Quarterly, 46*(4), 374-393.

Stevens, J. (2002). *Applied multivariate statistics for the social sciences*. Mahwah, NJ: Erlbaum.

Suat, Ü. N. A. L., Coþtu, B., & Alipaþa, A. Y. A. S. (2010). Secondary School Students' Misconceptions of Covalent Bonds. *Journal of Turkish Science Education, 7*(2).

Subagyo, I. A. (2014). Prevention of Student Misconceptions on the Concept of Chemical Equilibrium Using Modified Inquiry and Remediation Using Analogy Strategies. *Thesis*. Unesa Postgraduate.

Suprapto, N., & Chang, T. S. (2015). Research on university student's self-efficacy scale in science education: A systematic review. In *Proceeding of International Conference on Science and Science Education (IConSSE 2015)* (pp. 120-129).

Suyono, Amaria, Muchlis, & Setiarso, P. (2014). Dissemination of Prevention Model and Curation of Student Misconceptions on Chemical Concepts. *Higher Education Research Results Report*. Surabaya: LPPM Unesa.

Suyono, Masriyah, & Muchlis. (2017). Formulating Variation of Strategy for Reducing Burden of Chemistry Students' Misconceptions Based on Conceptual Change Strategy and Individual Characteristic. *Journal of Computational and Theoretical Nanoscience, 23*(12), 12047-12053.

Taslidere, E. (2013). Effect of Conceptual Change Oriented Instruction on Students' Conceptual Understanding and Decreasing Their Misconceptions in DC Electric Circuits. *Creative Education, 4*(4), 273.

Ültay, E., & Ültay, N. (2014). Context-Based Physics Studies: A Thematic Review of The Literature. Hacettepe Üniversitesi Eğitim Fakültesi Dergisi.

Verawahyuni, Helda. (2014). Development of Detecting Instruments Cause Chemical Misconceptions Based on Mental Models on the Concepts of Atomic Structures. *Thesis*. Surabaya: Unesa Postgraduate.

Vladušić, R., Bucat, R. B., & Ožić, M. (2016). Understanding Ionic Bonds–a Scan Across The Croatian Education System. *Chemistry Education Research and Practice, 17*(4), 685-699.

Vrabec, M., & Prokša, M. (2016). Identifying Misconceptions Related to Chemical Bonds Concepts in the Slovak School System Using the Bonds Representations Inventory as a Diagnostic Tool. *Journal of Chemical Education, 93*(8), 1364-137

Zirbel, E. L. (2004). Framework For Conceptual Change. *Astronomy Education Review, 3*(1), 62-76.