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Research Artikel

PROBLEM-SOLVING AND PROBLEM-POSING LEARNING MODEL ENRICHED WITH THE MULTIPLE REPRESENTATION IN TETRAHEDRAL CHEMISTRY TO ENHANCE STUDENTS' CONCEPTUAL UNDERSTANDING

MODEL PROBLEM SOLVING DAN MODEL PROBLEM POSING DILENGKAPI MULTI REPRESENTASI TETRAHEDRAL KIMIA DALAM MENINGKATKAN PEMAHAMAN KONSEP SISWA

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Abstract

A learning model has its characteristics with advantages and disadvantages. A Teacher has a particular way of delivering chemistry materials. This study aims to investigate the implementation of Thinking Aloud Pair Problem Solving (TAPPS) and Problem Posing (PP) to enhance students' conceptual understanding of the topic of the mole concept. The learning model implemented was enriched with the tetrahedral chemistry representation, which included levels of the human element, macroscopic, sub-microscopic, and symbolic. This research used a quasi-experimental method with a randomized pretest-posttest comparison group research design. Data collection used paper-and-pencil tests to sixty-four grade 10 students in a public high school in Sragen, Indonesia. Data analysis employed an independent sample t-test. The research findings indicated that the PP model was able to generate a higher degree of students' conceptual understanding than the TAPPS model and have more students with sound conceptual understanding than the TAPPS model. The chemistry teaching integrated with the tetrahedral chemistry representation increased students' sub-microscopic and symbolic levels of understanding. The new approach should be embedded in every chemistry learning model for enhancing students' understanding.

Keywords: Chemistry teaching; mole concept; conceptual understanding; problem-posing; thinking aloud pair problem-solving

Abstrak

Sebuah model pembelajaran mempunyai ciri tersendiri dengan kelebihan dan kekurangannya. Guru mempunyai cara khusus dalam menyampaikan materi kimia. Penelitian ini bertujuan untuk menyelidiki penerapan Thinking Aloud Pair Problem Solving (TAPPS) dan Problem Posing (PP) untuk meningkatkan tingkat pemahaman konseptual siswa dalam materi konsep mol. Model pembelajaran yang diterapkan tersebut diperkaya dengan representasi tetrahedral kimia, yang mencakup level human element, makroskopis, submikroskopis, dan simbolik. Penelitian ini menggunakan metode eksperimen semu dengan desain penelitian komparasi grup pretest-posttest yang diacak. Pengumpulan data menggunakan tes tertulis terhadap 64 siswa kelas 10 dari salah satu SMA di Sragen, Indonesia. Analisis data menggunakan independent sample t-test. Hasil penelitian ini mengindikasikan bahwa model PP mampu menghasilkan tingkat pemahaman konseptual siswa yang lebih tinggi daripada model TAPPS. Pembelajaran kimia yang terintegrasi dengan representasi tetrahedral kimia mampu meningkatkan tingkat pemahaman sub-mikroskopis dan simbolis siswa. Pendekatan baru tersebut perlu dimasukkan di setiap model pembelajaran kimia untuk meningkatkan pemahaman siswa.

Kata Kunci*: Pembelajaran kimia; konsep mol; pemahaman konsep; problem posing; thinking aloud pair problem solving*

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INTRODUCTION

Chemistry teaching is one part of the science teaching based on facts, results of thought, and product research conducted by experts (Aschbacher, Li, & Roth, 2010; Bernacki, Nokes-Malach, Richey, & Belenky, 2016). The product of science learning is understanding the concepts, principles, and fundamental theories of chemistry, so that students can apply it to more complex things. Considering the material presented in the study of chemistry is full of complex and abstract concepts, it requires a sound understanding of the basic concepts underlying the complex concept (Aschbacher et al., 2010; Bernacki et al., 2016; Furtak, Seidel, Iverson, & Briggs, 2012; Libao et al., 2016; Sheldrake, Mujtaba, & Reiss, 2017; Thompson & Bennett, 2013).

The chemistry teaching referred to in this research is the teaching of the mole concept. The choice of learning model should be adjusted to the characteristics of the materials and students (Abrahams & Millar, 2008; Barnhart & van Es, 2015; Bautista, 2012; Chittleborough & Treagust, 2007; Garritz, 2013; Kisa & Stein, 2015). The mole concept is a matter that contains most of the calculations (Furió, Azcona, & Guisasola, 2013; Indriyanti & Barke, 2014, 2017; Schmidt & Jigneus, 2003). Appropriate learning models for these characteristics are problem-based learning models (Bautista, 2012; Gulacar, Overton, Bowman, & Fynewever, 2013; Kousathana & Tsaparlis, 2002; Şengül & Katranci, 2012; Shehu, 2015; Thompson & Bennett, 2013).

The thinking aloud pairs problem-solving (TAPPS) or problem-posing (PP) model is some of the development of the problem-solving model (Jonassen, 2004; Whimbey & Lochhead, 1986). TAPPS emphasizes on students' analysis skills in conveying problems made by teachers and the steps to solve them (Baars & Gage, 2010; Jonassen, 2004; Whimbey & Lochhead, 1986). This model involves two to four students working together to solve a problem (Whimbey & Lochhead, 1986). In this model, each group has students who act as a problem solver and also listeners (L. K. W. Lee, 1998; Whimbey & Lochhead, 1986). Problem solver assigned to issue the problems (questions) as well as steps to solve it based on his understanding in front of other group members (listener). The listener in charge of understanding the problem-solving steps submitted by the problem solver and ask the problem solver if there is a step that is not precise or cannot be understood (Whimbey & Lochhead, 1986). The teachers' role in these models is to monitor the entire teams' activities and train the listener to ask questions (L. K. W. Lee, 1998; Short, Evans, Friebert, & Schatschneider, 1991; Whimbey & Lochhead, 1986).

The PP model emphasizes students' analytical skills in making or raising problems (questions) based on the information provided and steps to resolve them (Silver, 1994). The information provided by the teacher will be understood and developed by the student into problems and steps to solve them according to the students' understanding (Jonassen, 2004; Silver, 1994; Silver & Cai, 1996). Thus, students' conceptual understanding of the material learned will be more mature (Arikan, Unal, & Ozdemir, 2012; Işik, Kar, Yalçin, & Zehir, 2011; Land, 2017; K.-W. L. Lee, Tang, Goh, & Chia, 2001; Pelczer, Singer, & Voica, 2013; Silver, 1994; Silver & Cai, 1996). The teachers' role in these models is to provide all the information (grids) that students need to create a problem (Jonassen, 2004; Şengül & Katranci, 2012; Silver, 1994; Silver & Cai, 1996).

The similarity of TAPPS and PP models are problem-based and student-oriented, while the difference between them lies in the problem-maker. In the TAPPS, teachers created the problem and the students completing it, whereas, in the PP class, the problem is constructed by the students and the students completing it too. In this study, a comparison study of TAPPS and PP models is used to determine which models generate a higher degree of students' conceptual understanding in chemistry teaching, especially the mole concepts, that integrated with Mahaffys' chemistry tetrahedral representation.

Regardless of the instructional model used, every chemistry teacher ideally applies a complete Johnstone's chemistry triangle representation (Chittleborough & Treagust, 2007; Zarotiadou & Tsaparlis, 2000), that surrounds: something that the five senses can explain (macroscopic level), something that cannot be revealed by the five senses or the microscope (sub-microscopic level), and something to describe (symbolic level) (Johnstone, 2000). However, today chemistry learning occurs only through two levels, the macroscopic and the symbolic, while sub-microscopic is studied separately (Rahhou, Kaddari, Elachqar, & Oudrhiri, 2015). Students tend to memorize the sub-microscopic level rather than understand it (Georgiadou & Tsaparlis, 2000; Johnstone, 2000; Kapıcı & Savaşcı-Açıkalın, 2015). As a result, students cannot imagine how a chemical process occurs.

On the other hand, all things in nature are related to chemistry (Burmeister, Rauch, & Eilks, 2012). Therefore, it is essential to know how a chemical process around us can occur. In class, there are certainly students who love chemistry and do not love chemistry (Mahaffy, 2006). Students who certainly love chemistry will more easily understand the material presented by the teacher. Teachers gave the concept to be understood by all students, and then the content needs to be related to the experience of phenomena in the students' daily lives (Mahaffy, 2004, 2006). Thus, it is expected that students can more easily imagine how a chemical process occurs (Mahaffy, 2006; Uzuntiryaki & Boz, 2007). This reason is what lies behind the human element representation level and the formation of the Mahaffys' chemistry tetrahedral representation.

The difference in Johnstone's chemistry triangle representation and the Mahaffys' chemistry tetrahedral representation is shown in Figure 1 (Mahaffy, 2006). Thus, it can be concluded that there are two important aspects behind the emergence of the Mahaffys' chemistry tetrahedral representation (Mahaffy, 2004, 2006). Human life, filled with economic, political, environmental, social, historical, and philosophical considerations, can be assembled into an understanding of the chemical concepts, reactions, and processes taught to students and the common people as a learner. Along with the increasing technological developments and exploiting natural resources, awareness, and human awareness in maintaining environmental balance need to be improved (Mahaffy, 2006).

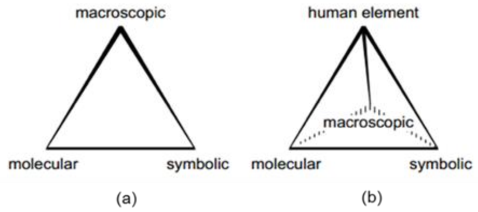


Figure 1. Johnstone's chemistry triangle representation (a) and Mahaffys' chemistry tetrahedral representation (b) (Mahaffy, 2006)

Teaching the mole concept corresponding to the Mahaffys' chemistry tetrahedral representation is novel and deemed capable of providing a better understanding of the concept, but it is still relatively rare for chemistry teachers to apply. Therefore, the researcher tried to apply the Mahaffys' chemistry tetrahedral representation to both models. Thus, this research aims to enhance students' conceptual understanding of the mole concept by comparing it using two different learning models.

METHOD

This research employed the quasi-experimental method with a randomized pretest-posttest comparison group research design. The research design is shown in Table 1.

Table 1. The research design

Class	Pretest	Treatment	Posttest
Experiment Class 1	T1	TAPPS model	T2
Experiment Class 2	T1	PP model	T2

In eight weeks of teaching, the implementation of two learning models has been done. The general difference between TAPPS and PP classroom was the subject present in the questions. The teacher provides problems in the TAPPS class. On the other hand, the students gave problems presented in the PP classroom.

Classroom Context

There are three subtopics in the mole concepts: (1) the mole relationship with mass; (2) the mole relationship with the number of particles; (3) the mole relationship with the molar volume of gas. In every sub-topic was learned using four levels of chemistry representation. The example of the classroom introduction in PP class is presented:

The lesson begins with questions from teachers to stimulate students' curiosity about learning topics (teachers (T) and students (S)).

T: "How do I know the amount of objects around us, such as pencils, clothes, papers, waters, and sugars?"

S : "We can count them."

T : "Show me an example."

S : "We can know the number of pencils, clothes, and papers by counting them one by one, while knowing the amount of water and sugars we can count on the scales."

T : "Is it necessary for a unit to state it?"

S : "Yeah, like a dozen to declare how many pencils, score to declare the number of clothes, and a ream to declare the number of papers."

T : "Then what about waters and sugars?"

S : "The amount of water can be expressed by volume in Liter, and the amount of sugars can be expressed by mass in kilogram."

T : "As you have already said, we can calculate the objects around us to know how many they are. To make it easy for us to calculate it, we need a suitable unit. macroscopic-sized objects, such as pencils, clothes, and papers, can be expressed in units of an amount, but microscopic-sized objects, such as waters and sugars, can be expressed in units of mass, then why are the units of mass required?"

Some students are silent, and some respond,

S : "Because it's hard for us to count them one by one, this will waste a lot of time."

T : "Your answer is true, in other words, the units of mass are necessary for practical reasons, then how to calculate sub-microscopic-sized objects, which cannot be seen with the eyes directly or microscopes, such as atoms, molecules, ions, or other particles?"

S : "Is it impossible to calculate sub-microscopic-sized objects, something that cannot be seen and cannot be counted?"

T : "Of course not. The chemists have found a way to calculate the sub-microscopic-sized objects from ancient times. It takes a special unit to state their number, the 'mole.' This theme is what we will learn today."

Data Collection

Data collection used paper and pencil test consisted of five open-ended questions to 64 students of the tenth grade of one senior high school in Indonesia. The test consisted of five open-ended questions that met the reliability test, obtained α = 0,70. Based on the test results, the percentage of total scores on each item gained by students reflects how sound the degrees of students' conceptual understanding of the tested problem. The degrees of students' conceptual understanding categorized into four categories, No Response (NR), No Conceptual Understanding (NCU), Partial Conceptual Understanding (PCU), and Sound Conceptual Understanding (SCU), as presented in Table 2. (BouJaoude & Barakat, 2003).

Table 2. Categorization of student degree of understanding on chemistry concepts

The degree of understanding *	(%) Score achievement	Criteria for scoring
NR	$S = 0$	Student answers are blank, students do not know, or students do not understand.
NCU	$S \leq 33.33$	Students repeat questions, student answers are inappropriate, or incorrect.
PCU	$33.33 < S \leq 66.67$	Student answers contain at least one correct component, although other parts are wrong.
SCU	$S > 66.67$	Student answers contain all the components and are correct.

RESULTS AND DISCUSSION

The pretest (Pr) and posttest (Po) data of TAPPS Class and PP Class are shown in Table 3. The maximum score is 100. The difference between posttest and pretest (Po-Pr) data tested statistically with an independent sample t-test because the data has a normal and homogeneous distribution.

Table 3. Pretest, posttest, and statistical test results

Class	N	Mean			Std. Deviation	dF	t	p
		Pretest (Pr)	Posttest (Po)	(Po-Pr)				
TAPPS	32	28.25	51	22.75	12.569	62	-2.517	0.014
PP	32	22.5	53.25	30.75	13.339			

Based on the data in Table 3, the mean (Po-Pr) of TAPPS Class and PP Class showed significant differences ($t=-2.517$, $dF=62$, $p<0.05$). The degree of students' conceptual understanding shown in Table 4.

Table 4. Details of students' conceptual understanding of each item of pretest and posttest

Question number to-	Class	Pretest				Posttest			
		(%) Sum of the student with*				(%) Sum of the student with*			
		NR	NCU	PCU	SCU	NR	NCU	PCU	SCU
1	TAPPS	0	28	41	31	0	16	22	62
	PP	13	56	13	18	0	0	13	87
2	TAPPS	6	35	50	9	0	16	50	34
	PP	13	69	15	3	0	3	38	59
3	TAPPS	28	69	3	0	3	47	28	22
	PP	31	69	0	0	0	44	19	37
4	TAPPS	10	56	6	28	3	41	31	25
	PP	0	50	50	0	0	22	28	50
5	TAPPS	25	75	0	0	6	54	31	9
	PP	16	84	0	0	0	38	34	28
Mean	TAPPS	14	52	20	14	3	35	32	30
	PP	15	65	16	4	0	21	27	52

To facilitate understanding the data in Table 3, then the data summarized as in Figure 1. Based on the data in Figure 2 shows that two classes have a mean total student with NCU more dominant on pretest data. In the posttest data, TAPPS has a mean of students with NCU, PCU, and SCU that are almost the same, while PP has a mean total student with SCU more dominant.

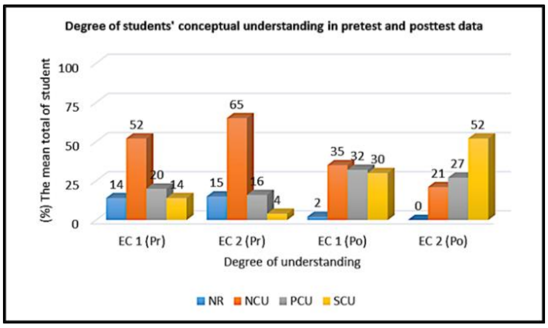


Figure 2. Level of understanding of student concepts in pretest and posttest data

Learning Activities in Tapps Class

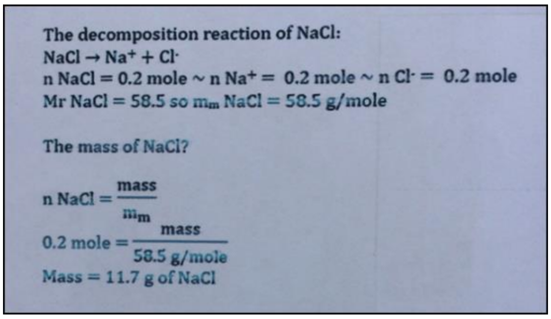
The teacher opens the lesson with recalling matter last week. Furthermore, teachers provide a story regarding the events which exist in the students' surroundings. That event related to the material to be studied at the meeting. It includes stimulus questions such as calculating the number of particles that are very small and unable to be seen with the naked eye or microscope. The teacher gives a brief explanation of the material and some examples of questions to work together by him and students (Arıkan & Ünal, 2015).

The teacher gave the students a mole concept student worksheet (TAPPS) in each student and divided them heterogeneously into eight groups of 4 students each. Then the teacher gives two problems to each group to find the solution through TAPPS discussion (Whimbey & Lochhead, 1986).

In each group, there is a student who acts as a problem solver and rests as a listener. The problem solver begins the discussion by reading the problem clearly and conveying what data has been known and asked on the question. The problem solver expresses the problem-solving steps according to his understanding of the listeners. Listeners listen and practice explanations submitted by the problem solver. The listener asks the problem solver if there is still an explanation that cannot be understood or feel something is a less precise related explanation. After the problem's completion is believed right by all members, the students exchange roles for solving the next problems (Short et al., 1991; Whimbey & Lochhead, 1986).

In this case, the teacher's role ensures that the TAPPS discussion process can run smoothly and provoke the listener to ask questions. The answers of questions given by the teacher to the students shown in Figure 2, the example of the problem resolution (correct) by the students in TAPPS discussion shown in Figure 3, and the example of problem-solving (incorrect) shown in Figure 4. Furthermore, after the students discuss problem-solving to solve the teacher's problems, one group presents the results of the discussion while the other group responds (Whimbey & Lochhead, 1986).

The teacher clarifies the results of the discussion, whether correct or incorrect (Jonassen, 2004). If it is incorrect, the group who knows where the error lies and knows the justification is asked to deliver it. At the end of the learning, the teacher and the students conclude the learning materials (Baars & Gage, 2010; Jonassen, 2004; Short et al., 1991).

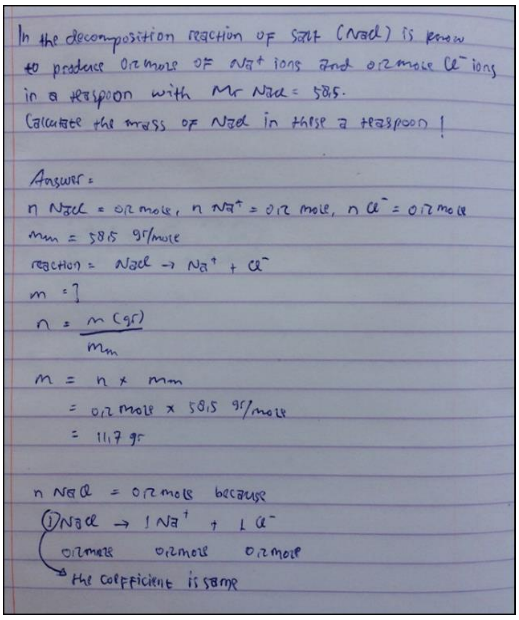


The decomposition reaction of NaCl:
$NaCl \rightarrow Na^+ + Cl^-$
$n\ NaCl = 0.2$ mole ~ $n\ Na^+ = 0.2$ mole ~ $n\ Cl^- = 0.2$ mole
$Mr\ NaCl = 58.5$ so $m_m\ NaCl = 58.5$ g/mole

The mass of NaCl?

$n\ NaCl = \frac{mass}{m_m}$
$0.2\ mole = \frac{mass}{58.5\ g/mole}$
Mass = 11.7 g of NaCl

Figure 2. A sample answer in TAPPS class

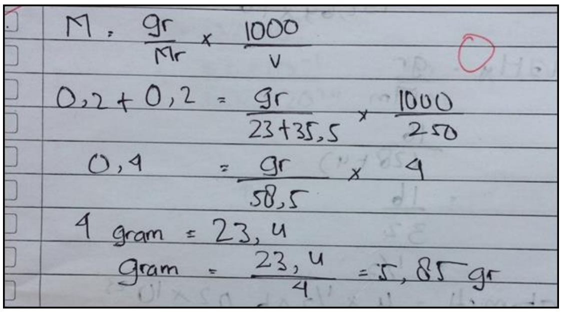


In the decomposition reaction of salt (NaCl) is know to produce 0,2 mole of Na^+ ions and 0,2 mole Cl^- ions in a teaspoon with Mr NaCl = 58,5.
Calculate the mass of NaCl in these a teaspoon !

Answer :
n NaCl = 0,2 mole, n Na^+ = 0,2 mole, n Cl^- = 0,2 mole
m_m = 58,5 gr/mole
reaction = $NaCl \rightarrow Na^+ + Cl^-$
m = ?
$n = \frac{m\ (gr)}{m_m}$
$m = n \times m_m$
= 0,2 mole × 58,5 gr/mole
= 11,7 gr

n NaCl = 0,2 mole because
1 NaCl → 1 Na^+ + 1 Cl^-
0,2 mole 0,2 mole 0,2 mole
the coefficient is same

Figure 3. Correct solution in TAPPS discussions



$M = \frac{gr}{Mr} \times \frac{1000}{V}$
$0,2 + 0,2 = \frac{gr}{23 + 35,5} \times \frac{1000}{250}$
$0,4 = \frac{gr}{58,5} \times 4$
4 gram = 23,4
gram = $\frac{23,4}{4}$ = 5,85 gr

Figure 4. Examples of problem-solving (incorrect) by students in TAPPS discussion

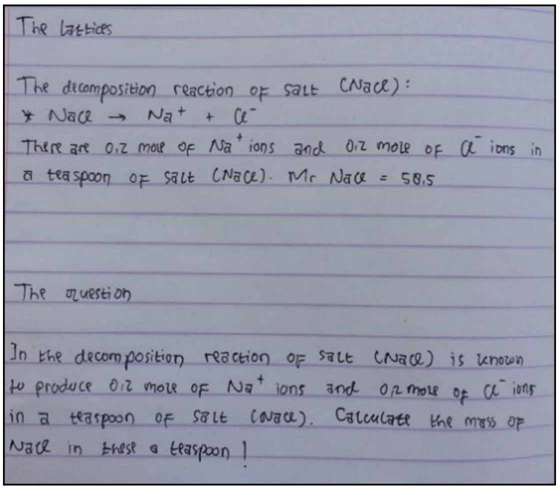
Based on Figure 2 and Figure 3 is shown that the student can write data that is known and asked precisely. The solution steps are detailed and coherent. The results of the work are per the key answers made by the teacher. When Figures 2 and 4 are observed, it is shown that the results of the students' work have different final answers, such as the answer key made by the teacher. The student does not write the complete data, the settlement measures are not coherent and inappropriate, and the units' use has not been consistent. The results of the work are not the same as the correct answers given by the teacher.

Learning Activities in Pp Class

The teacher opens the lesson with recalling matter last week. Furthermore, teachers provide a first story regarding the events that exist in the students' surroundings with the material to be studied at the meeting and include stimulus questions such as how to calculate the number of particles that are very small and unable to be seen with the naked eye or microscope. The teacher gives a brief explanation of the material and some examples of questions to work together by him and students (Arıkan & Ünal, 2015). The teacher gave the students a mole concept student worksheet (PP) in each student and divided the students heterogeneously into eight groups of 4 students each. Then the teacher gives two grids to the students to be developed into two problems (questions). The teacher guides the students to look for what data is already known on the grid (Silver, 1994; Silver & Cai, 1996).

Students make the problem along with its completion in PP discussion then write it in different papers. After the question has been issued, the paper containing the problem is exchanged with other groups to find a solution to the PP discussion (Jonassen, 2004; Silver, 1994; Silver & Cai, 1996). Suppose group A was the group that makes the problem, while group B was the group looking for the problem solving made by group A. One example of teacher-made grids developed group A becomes a problem in discussion PP is shown in Figure 5, while the correct answer question group A shown in Figure 6. An example of solving artificial problem group A by group B is shown in Figure 7.

When all the problems were solved, some groups appointed by the teacher to come forward to present the results of the discussion in front of the class (Arikan et al., 2012; Işik et al., 2011; Şengül & Katranci, 2012). The group that delivers the question is also asked to come to the front of the class to clarify the answer, whether it has been expected or not. The other group can ask questions if there is something to argue (Arikan et al., 2012; Işik et al., 2011). At the end of the lesson, the teacher and the students conclude the learning materials (Silver, 1994; Silver & Cai, 1996).


The lattices

The decomposition reaction of salt (NaCl):

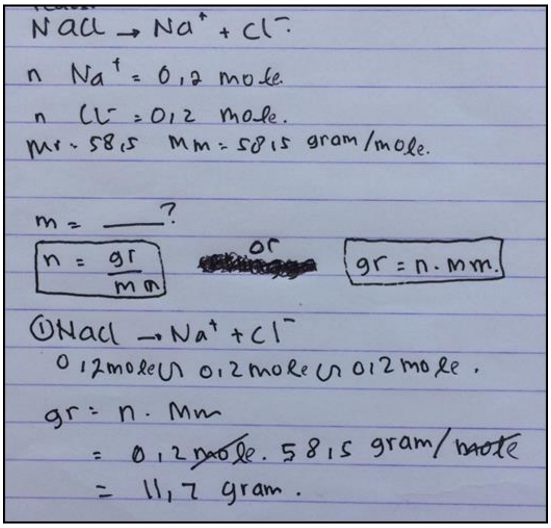
* $NaCl \rightarrow Na^+ + Cl^-$

There are 0.2 mole of Na^+ ions and 0.2 mole of Cl^- ions in a teaspoon of salt (NaCl). Mr NaCl = 58.5

The question

In the decomposition reaction of salt (NaCl) is known to produce 0.2 mole of Na^+ ions and 0.2 mole of Cl^- ions in a teaspoon of salt (NaCl). Calculate the mass of NaCl in these a teaspoon !

Figure 5. One example of a teacher-made grid developed by group A becomes a problem by PP discussion


$NaCl \rightarrow Na^+ + Cl^-$

n Na^+ = 0,2 mole

n Cl^- = 0,2 mole

Mr = 58,5 Mm = 58,5 gram/mole

m = ___?

$\boxed{n = \frac{gr}{mm}}$ or $\boxed{gr = n . mm}$

① $NaCl \rightarrow Na^+ + Cl^-$

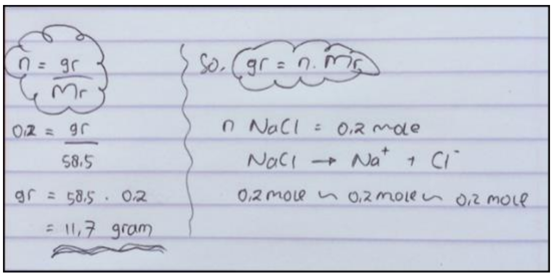
0,2 mole ~ 0,2 mole ~ 0,2 mole.

gr = n . Mm

= 0,2 $\cancel{mole}$. 58,5 gram/$\cancel{mole}$

= 11,7 gram.

Figure 6. Correct answers made by group A


$n = \frac{gr}{Mr}$

$0{,}2 = \frac{gr}{58{,}5}$

gr = 58,5 . 0,2

= 11,7 gram

So, gr = n . Mr

n NaCl = 0,2 mole

$NaCl \rightarrow Na^+ + Cl^-$

0,2 mole ~ 0,2 mole ~ 0,2 mole

Figure 7. Examples of a problem solving made by group A and done by group B

Based on Figure 5, it is shown that group A can develop the problem according to the grid given by the teacher. The problem has covered all the information available on the grid. When Figure

6 and Figure 7 are observed, it is shown that group B can write the data that is known and asked correctly, according to the correct answer. The solution steps are detailed and coherent. The results of the work are the correct answers made by group A.

Students' Conceptual Understanding

In the PP model syntax, there is the submission stage of the problem. Students are given the experience of learning to make one problem (question) of their own based on the grid provided by the teacher (Jonassen, 2004; Silver, 1994; Silver & Cai, 1996). To make a problem requires a sufficient understanding of the material as a prerequisite (Swarat, Ortony, & Revelle, 2012). So that later the problem produced by the student accordant with the grid. Because another group will answer the question they have created, and each group becomes challenged to make the problem somewhat tricky. This strategy leads them to study the material more deeply, and the atmosphere of the discussion was active (Land, 2017).

The mole concept materials require students to more practice understanding concepts and counting so much involving students on mastery in sub-microscopic and symbolic levels (Georgiadou & Tsaparlis, 2000; Indriyanti & Barke, 2017; Khang & Sai, 1987; Pekdag & Azizoglu, 2013). Thus, PP students have a better understanding of submicroscopic and symbolic levels. The PP class has a higher mean (Po-Pr) than the TAPPS class. If viewed through the students' conceptual knowledge on each item of the posttest, then the PP class has more students with SCU and PCU than the TAPPS class.

In the TAPPS model, the problem to be solved by students has been provided by the teacher (L. K. W. Lee, 1998; Whimbey & Lochhead, 1986). Students only in charge of finding solutions (Baars & Gage, 2010). Problem solver in charge of solving problems first while delivering the results of his thoughts makes the listener less responsive to help find solutions to the problem. When the problem solver has finished providing the results of his thinking, not a few listeners who immediately agreed without asking a lot, this makes the atmosphere of the discussion was passive and inclined one way (Noh, Jeon, & Huffman, 2005).

Teachers gave only two questions for each group. In each group, not all students have acted like the problem solver and the listener because the problem-solving step takes much time, whereas the time available is few. Therefore, only a few students have experience exchanging roles and are actively involved in discussions. Thus, the students in the TAPPS class become poorly trained on understanding the material and have poor knowledge in sub-microscopic and symbolic levels. It is proven through the degree of students' knowledge of each item of the posttest.

Based on Table 2 is shown that the TAPPS and PP have a higher score of posttest than the score of the pretest. Meaning appropriate chemistry teaching integrated Mahaffys' chemistry tetrahedral representation can increase the degree of students' conceptual understanding in both classes. The PP model was able to generate a higher degree of students' conceptual understanding than the TAPPS model (Jonassen, 2004; Noh et al., 2005; Sheldrake et al., 2017). Also, according to Table 3 is shown that the two classes have the degree of students' conceptual understanding of each item of posttest better than the degree of students' conceptual understanding of each item of the pretest. Therefore, it can be concluded that appropriate chemistry teaching integrated Mahaffys' chemistry tetrahedral representation can increase the mastery of students' chemistry representation levels on the material well, especially sub-microscopic and symbolic levels (Georgiadou & Tsaparlis, 2000; Gulacar et al., 2013; Indriyanti & Barke, 2017; Kapıcı & Savaşcı-Açıkalın, 2015; Rau, Bowman, & Moore, 2017; Schmidt & Jigneus, 2003). The PP model has more students with sound conceptual understanding than the TAPPS model (Arikan et al., 2012; Arıkan & Ünal, 2015; Işik et al., 2011; Land, 2017; Pelczer et al., 2013).

CONCLUSIONS

This experimental study comparing two specified models explores which model more comprehends students' conceptual understanding. We learned from the results PP Class successfully gains more students with sound conceptual understanding. Comparing two classes in terms of instruction step and strategy is very important to see deeper in students' understanding. Students preferred to pose and solve problems themselves to have longer retention of their knowledge. It would open students' insight into a difficult topic to be fun and meaningful by posing their problems. Meaningful means the activities that are involved in their daily life. As well as a learning model applied, comprehensive learning of the topics in tetrahedral chemistry has goals to sharpen their understanding of the four levels of chemistry representation. The students could learn chemistry as a meaningful subject because they could make the connection in the level of sub-microscopic: the reason for all material acts as they see in the macro world. This new approach was effective to comprehend all aspects of students' understanding.

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