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The Innovation in Chemistry Education in Supporting Green Chemistry Toward The Advanced KalTim 2018

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CHEMISTRY EDUCATION STUDY PROGRAM
DEPARTMENT OF MATHEMATICS AND NATURAL SCIENCE EDUCATION
FACULTY OF TEACHER TRAINING AND EDUCATION
MULAWARMAN UNIVERSITY

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In Hall of Rector 4th floor FKIP UNIVERSITAS MULAWARMAN

Samarinda Indonesia

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DEPARTMENT OF MATHEMATICS AND NATURAL SCIENCE EDUCATION

FACULTY OF TEACHER TRAINING AND EDUCATION

MULAWARMAN UNIVERSITY

SAMARINDA

Proceedings

International Seminar of Chemistry 2015

"The Innovation in Chemistry Education in Supporting Green Chemistry toward the Advanced KalTim 2018"

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PREFACE

International Seminar on Chemistry in 2015 has been carried out on 12 September 2015 in Hall Rector Lt-4 Mulawarman Samarida. Activities of the International Seminar organized by Study Program of Chemistry and fully supported by the Dean of Faculty Teacher and Training Education, Rector Mulawarman University and Forum Cooperation Chemists Eastern Indonesia (FK3TI).

The seminar was attended by a number of participants consisting of: four guest speakers who come from Universitat of Bayreuth Jermany, University of Technology Malaysia, Hasanuddin University Makassar, State University Surabaya, and 36 speakers companion were divided into six groups presenting parallel and six speakers poster of lecturers from various universities in Indonesia and teachers throughout East Kalimantan.

Papers presented in these proceedings is the result of research covering the fields of chemistry, chemistry education, science education and science education. As well as the papers presented in these proceedings has been selected by the Papers evaluation team of the International Seminar of the committee of Chemistry 2015. Efforts publishing these proceedings have been conducted as much as possible and if there are errors and deficiencies in the publication of these proceedings, the criticisms and suggestions are expected in order to improve the The subsequent publication of proceedings.

We as the committee would like to thank all those who have supported and helped the implementation of the International Seminar in 2015 and the publication of these proceedings.

Chairman of the committee

Dr. Usman, M.Sc.

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USING METACOGNITIVE SKILLS
IN LEARNING CHEMISTRY THROUGH PROBLEM SOLVING

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ABSTRACT

Have been done study about using metacognitive skills in learning chemistry through problem solving. Metacognition is the awareness of cognitive processes. By using metacognition, someone does all the activities with full awareness. When students learning chemistry by involving their metacognitive skills, students will be able to observe the relationship between data in the problem with the prior knowledge, to re-examine its accuracy, as well as solving a complex problem with the simple steps, tries to regulate and improve their cognitive processes. This paper aims are prepared in order to build a mindset learning chemistry through problem solving that involve student's metacognitive skills. Metacognitive skills to form a competent student resources, who perform all acts by full awareness. always make good representing problem, planning, monitoring, evaluating, and transfering their action**.** The i-SMART model helps students to solve problems in a systematical way and supported scaffolding metacognitive questioning. So**,** metacognitive support during the solution process in problem solving chemistry more effective.

Keywords: Metacognitive Skills, Problem Solving, Awareness, Learning Chemistry.

INTRODUCTION

Many chemistry problems require students to understanding chemical concepts and translate word problems into mathematical statements (Chandrasegaran et al., 2009). Learning chemistry about new concepts can't be separated from the learning concepts in the representation (Tytler et al., 2013). To solve the problem of learning chemistry, especially chemical concepts that contain lots of mathematical and graphical content, should be macroscopic, sub-microscopic and symbolic levels (through a chemical equation, mathematics, graphics, diagrams, and dynamic visual) is represented well in the classroom.

The development of problem solving related to students' metacognition. Metacognition as the study of self-awareness and reflection on cognitive processes, the ability to monitor, regulate and evaluate one‘s thinking (Brown, 1987). Cooper, Sandi-Urena and Stevens (2008), namely: "metacognition is fundamental in achieving of chemistry and developing of the problem of skills." Bell (2008) has identified eight types of episodes of solving problems, namely: reading was categorized as cognitive, understanding as metacognitive, analyzing as metacognitive, exploring as either cognitive or metacognitive, planning as metacognitive, implementation as either cognitive or metacognitive, verifying as either cognitive or metacognitive, and watching-and- listening was not assigned a cognitive level. Metacognition has an important role in the process of solving problem (Rickey & Stacy, 2000). Others research shows that cueing a student to be metacognitive can help the student to improve his problem-solving skills (Conner, 2007; Kapa, 2002). For example, Kapa (2002) found that when students were cued during a task they became more successful in problem-solving activities than students who were cued only afterwards.

Metacognition skills refers to planning, monitoring, and evaluation skills (Brown, 1987; Cooper & Sandi-Urena, 2009; Delvecchio, 2011). Opinions expressed similar Whitebread, et al. (2009) and Moreno (2010) that metacognition skills include planning, monitoring and evaluation or regulation. Application of metacognition in learning is to involve students in understanding, reflection and feedback. Representation competence is essential for meaningful understanding in solving chemistry problems (Talanquer, 2011). Students often uses representations such as pictures, charts, and diagrams to help understand the problem before using mathematical equations to solve quantitative problems (Corolan et al., 2008). Reflection learning happens when students are engaged in the process of thinking about thinking and practice in a critical way, to learn from the process, and apply what is learned to improve future action. Teachers can use the feedback to help students improve the quality of work, perceptions of competence, self-determination and intrinsic motivation (Moreno, 2010).

Metacognitive skills also related to transfer skills what they learned to new situations will be improved when students are more aware of themselves as learners actively monitor learning strategies and knowledge (Moreno, 2010). Billing (2007) states that transfer of metacognitive strategies is enhanced when learners notice that problems resemble each other and when learners are expected to solve the problems themselves. Conner (2007) claims that when students acquire metacognitive skills in certain contexts these skills can be beneficial in other contexts as well.

Much research has been conducted focusing on the problems solving of learning chemistry, but until now the problems that still continue to appear. For this reason, this paper is prepared in order to build a mindset to solve the problem of learning chemistry using metacognitive skills. Because the students 'knowledge of the process of cognition and metacognition skills will maximize students' potential to think and learn in regulating cognition, to guide them in representing problem, planning the learning environment, choosing strategies, monitoring, evaluating, and transfering to improve cognitive performance in future.

METHOD

The paper was written in a narrative based on the results of studies and reviews some of the literature, the results of research as well as some of the experts thought of learning-oriented model of metacognition and problem-solving chemistry. Analysis and synthesis of how the scientific literature, such as journals, research reports, and proceedings.

DISCUSSION

i-SMART Model is an Alternative Solution in Learning Chemistry

Paradigm of the XXI century education requires students to have metacognition skills in global competition. Researchers will develop indicators metacognitive skills described by Polya (1973), Mac Gregor (2007), (Erskine, 2009), Moreno (2010), Delvecchio (2011), Talanquer (2011), and Sousa (2012) to five aspects of metacognition skills in Table 1.

Table 1 Aspects dan indicators of metacognitive skills

Aspects of Metacognitive	Indicators	Operational Definition
Representing the problem	a) Write down what is known or information in the problem. b) Simply the problem into the form of images or representations of (macroscopic, submicroscopic, and symbolic). c) Checking representations are made of a given problem. d) Formulate and represent the problems.	Students can identify, formulate and represent the problem.
Planning	a) Making predictions. b) Choosing and preparing strategies, tools materials to be used. c) Ordering (sequence) stages of problem-solving strategies. d) Allocation of time and attention influence the outcome.	Students can plan problem-solving strategies.
Monitoring	a) Identifying the tasks. b) Checking implementation strategy to problems and the result. c) Deciding something done has been understood. d) Checking the truth of solutions. e) Improving the result when an error occurs.	Students can understand, implement strategies, and problem solving systematically monitor.
Evaluating	a) Determining the achievement of learning objectives. b) Reflecting itself from the process and achieved results.	Students can evaluate them-selves in problem solving.
Transferring	a) Using the different methods to solve the same problem. b) Using the same method to solve different problems. c) Apply an understanding or skills to new situations. .	Students can transfer strategy/ knowledge effectively and efficiently.

Exercises such skills can be facilitated through the phases of learning: **I**dentifying and representing problem, **S**electing strategies and plans, **M**aking investigation with monitoring strategy use, **A**nalyzing, **R**eflecting and evaluating, and **T**ransfering. This model is named i-SMART (Figure 1), designed to create the reinforcement metacognition skills through problem solving in line with the implementation of Curriculum 2013.

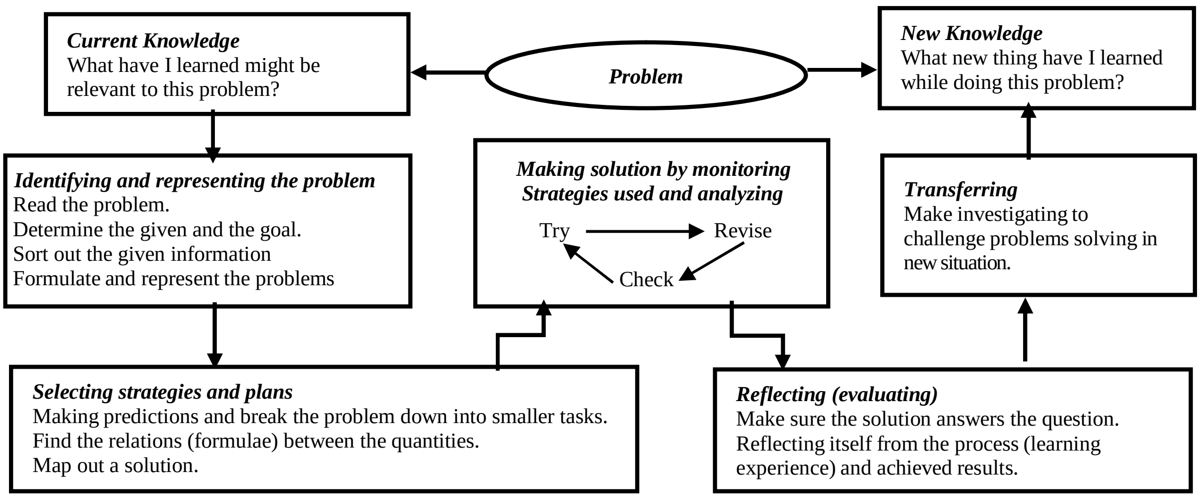


Figure 1 Freme work of Training Metacognitive Skills (modified from Delvecchio, 2011; Java, 2014).

i-SMART model is supported primarily Vygotsky's theory of collaborative interaction with scaffolding principles and Piaget's theory of mental function adaptation. Ernest (1991) explained that the reconstruction of the knowledge of students through four stages. First, objective knowledge is represented students with constructing a circular (with groove investigate, explain, expand, evaluate) resulting in the reconstruction of the initial conception. Second, the initial conception as a result of the reconstruction of the individual is subjective knowledge. Third, the subjective knowledge collaborated with other students, teachers and the learning that occurs as a result of the process of reconstruction scaffolding. Fourth, the concept of chemical reconstructed as a result of the scaffolding represented as a group of new knowledge.

Piaget's theory of mental function adaptation, done by a process of assimilation and accommodation. Students are in the process of assimilation using existing cognitive structures to respond so that there is an imbalance of cognitive on students. Students will interact with existing data on the environment to be processed in the mental structure. The student mental structure in processing the data, may change resulting in accommodation. The investigation activities for example in learning chemistry lab is an effort to accommodate that observed events will make it easier assimilation (Renner et al, 1988). Students must be able to connect new concepts to learn and understand concepts with other concepts in a relationship between concepts (network of relationships). The new concepts must be organized with other concepts that have been owned by the students. Good organization will be reflected in the responses given to the problems faced to form a new concept (equilibrium) in learning.

i-SMART models developed has syntax that consists of six stages. Metacognition skills trained through metacognitive questions on each phase of i-SMART. Details of the syntax stage i-SMART models are as follows.

Identifying and representing problem. The level of cognitive development affects the student ‘s ability to identify and represent the problem. Actually, problem solvers activate their previous interpretations about the problem concepts while reading the problem text. Representing the problem mentally (or visualization problem with a computer program) in a form that is close to optimal for problem solution. This is single most valuable of the metacognitive skills: How an individual state the problem is a prime determinant of success in solving it.

Selecting strategies and plans. Selection of a problem-solving strategies. There are many ways to solve problems. Good problem solvers know many strategies, and they have the ability to select wisely, choosing procedures for solving the particular problems of the specific domain.

Making Investigation with Monitoring Strategy Use. Strategic application of problem-solving methods through investigation. Good problem solvers have strategies for solving the problem. They apply a potentially effective method/strategy, constantly monitoring the changes in problem state that the method produces to see if a solution has occurred. They know what they will try next, and why. During this step, students are asked to reread about to make a solution. This phase includes *try-revise-check* activities.

Analyzing. Ask students to analyze the data, assisted with the question "How the experimental data can be explained ", Then summarize and communicate/presented the results of the group in front of the class, another group of students was asked to respond.

Reflecting and evaluating. The evaluation process involves the interaction of a person, a solution and a strategy. Evaluation of cognitive learning, metacognitive skills, the mission-planning process, good problem solvers evaluate potential solutions, to see if the discrepancy between goal state and current state has been reduced. Yet, using an evaluating process might encourage students to reflect on problem solving through discussion and perhaps find another approach to the specific problem, eventually leading to a final solution that might be more elegant. The evaluation potential could be restricted if the students lack the knowledge resources.

Transfering. Learning in the context of the knowledge that has been owned, or transferring, use and build upon what has been controlled by the students through assignments in different settings. Students have completed the enrichment given by the task group that is the challenge to make new proposals are implementable.

Illustration Students Use Metacognitive Skills in Chemistry Problem Solving

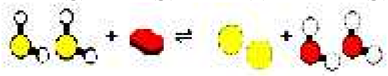
Based on the description that metacognition has an important role in the process of solving problem in learning of chemistry should be prefixed with the grain problem, the need to metacognitive skills. Chemistry learning that foster metacognitive skills are implementing learning chemistry by growing awareness and knowledge of students' thinking processes and activities in every phase of problem solving through the following steps.

Sample Problem 1.

Problem. To improve air quality and obtain a useful product, chemists often remove sulfur from coal and natural gas by treating the fuel contaminant hydrogen sulfide with O_2. What happens to:
(a) $[H_2S]$ if O_2 is added? (b) $[H_2S]$ if sulfur is added? (Silberberg, 2009).

***I**dentifying and Representing Problem*

How to predicting the effect of a change in concentration on the equilibrium position?
Given representing the problem: $2H_2S(g) + O_2(g) \rightleftarrows 2S(s) + 2H_2O(g)$



***S**electing Strategies and Plans.* We write the reaction quotient to see how Q_c is affected by each disturbance, relative to K_c. This effect tells us the direction in which the reaction proceeds for the system to retain equilibrium and how each concentration changes.

***M**aking solution.* Writing the reaction quotient: $Q_c = \frac{[H_2O]^2}{[H_2S]^2[O_2]}$

a) When O_2 is added, $Q_c < K_c$. Some H_2S reacts with the added O_2 as the reaction proceeds to the right, so $[H_2S]$ decreases.
b) The concentration of solid S is unchanged as long as some is present, so it does not appear in the reaction quotient. Adding more S has no effect, so $[H_2S]$ is unchanged (but see Evaluating 2 below).

Monitoring. Apply Le Châtelier principle to see that the reaction proceeds in the direction that lowers the increased concentration or raises the decreased concentration.

***A**nalyzing and Evaluating*

(a) As you know, sulfur exists most commonly as S_8. How would this change in formula affect the answers? The balanced equation and Q_c would be:

$8H_2S(g) + 4O_2(g) \quad S_8(s) + 8H_2O(g) \quad Q_c = \frac{[H_2O]^8}{[H_2S]^8[O_2]^4}$

The value of Kc is different for this equation, but the changes described in the problem have the same effects. For example, in (a), if O_2 were added, $Q_c < K_c$. As above, the reaction would proceed to the right until Q_c again. In other words, changes predicted by Le Châtelier principle for a given reaction are not affected by a change in the balancing coefficients. In (b), you saw that adding a solid has no effect on the concentrations of other components: because the concentration of the solid cannot change, it does not appear in Q_c.

***R**eflecting.*

What extent are you understanding? I already understand about the price of Qc, Kc, and principles Le Châtelier about the shift in equilibrium reactions.
Can this problem be solved in another way? By instantly extracting/ vaporizing the formed moisture into condensed H_2O from a mixture of the equilibrium system.

***T**ransfering.* In a study of the chemistry of glass etching, an inorganic chemist examines the reaction between sand (SiO_2) and hydrogen fluoride at a temperature above the boiling point of water:
$SiO_2(s) + 4HF(g) \rightleftarrows SiF_4(g) + 2H_2O(g)$. Predict the effect on $[SiF_4]$ when HF(g) is removed!

Sample Problem 2 Effect of Temperature Changes on Equilibrium

Goals

1. Being able to observe a shift in chemical equilibrium when the temperature changed.
2. Being able to use metacognition skills and solving problems related to chemical equilibrium shift.

***I**dentifying and Representing Problem*

This situation is represented by Flash simulation lechateliers_principal.swf the equilibrium N_2O_4-NO_2 in room temperature.

What do you find after observe Figure 2?

What happen if this equilibrium increase or decrease temperature?

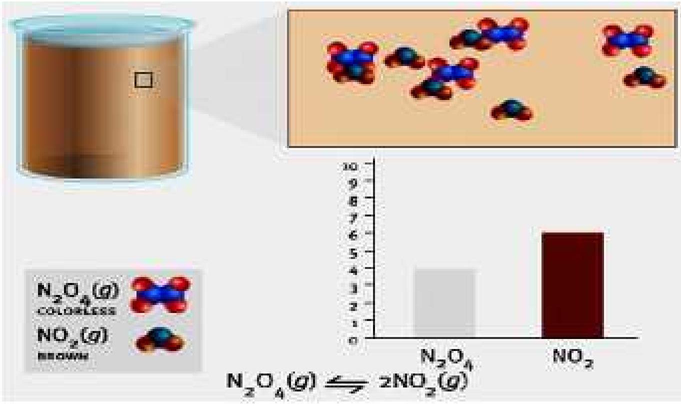


Figure 2 The equilibrium N_2O_4 (g) ⇄ $2NO_2$ (g) at room temperature (Chang, 2000)

***S**electing Strategies and Plans.*

Make hypotheses, tools and materials, any variables in the experiment and plan your strategies!

Tools and materials.

The reaction tube is sealed gas containing NO_2 three pieces, ice, glass chemistry 100 mL, burner spirits, leg three and asbestos, and thermometer.

***M**aking Solution with Monitoring Strategy Use*

Procedure. Labelling test tube with the letters A, B, and C. Fill a beaker with water and bring to a boil burner spiritus until boiling 0^{o}C, 28^{o}C and 100 ^{o}C. Fill a beaker with ice, and enter the test tube A into the beaker. Compare the color of the reaction tube A and B. Insert another beaker the test tube C containing NO_2 gas into a beaker of boiling water. Note the color of the gas in a test tube and compare the color of the reaction tube B Explain why the color of the gas in a test tube becomes different. Discuss with your friends and write reactions that occur.

After conducting experiments, fill in Table 2.

Table 2 Data observations

Tube	Treatment	Observation	Molecule Rasio N_2O_4/NO_2
A	Cooled in ice (0°C)	Colorless	*6:2*
B	Room temperature	Yellow	*4:6*
C	Heated in water	Brown	*2:10*

Figure 3. Sample tubes containing an equilibrium mixture of Nice water (left), at room temperature (center), and immersed in hot water (right) (Murry & Fay, 2012)

Monitoring. Do the experimental results obtain compare with the literature? The darker brown color of the sample at the highest temperature indicates that the equilibrium:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

shifts from reactants to products with increasing temperature, as expected for an endothermic reaction (Figure 3).

***A**nalyzing and Evaluating.*

How does the color of the third solution in the test tube?

How does the equation in these experiments?

When we are dealing with an exothermic reaction (by decreasing temperature), removal of heat is like removing a reactant. The equilibrium shifts to make more reactants.
Molecular ratio $N_2O_4(g) : NO_2(g)$ = 6:2.

The opposite occurs when we are dealing with an endothermic reaction, adding heat (by increasing temperature) has the same effect as adding a reactant. The equilibrium shifts to make more products.
Reaction: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H = 58$ kJ
Molecular ratio $N_2O_4(g) : NO_2(g)$ = 2:10.

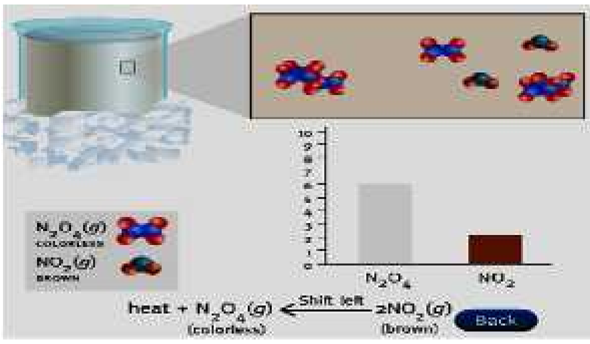


Figure 4 The equilibrium $N_2O_4(g) \rightleftarrows 2NO_2(g)$ at 0ºC (Chang, 2000)

How do your hypothesis acceptable? Yes, accepted.
What conclusions can be made?
Le Châtelier's Principle: temperature
If the temperature of a system at equilibrium is increased, the system reacts as if we added a reactant to an endothermic reaction or a product to an exothermic reaction. The equilibrium shifts in the direction that consumes the "excess reactant," namely heat.

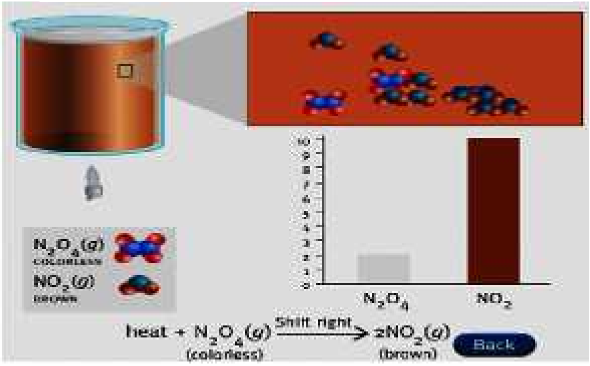


Figure 5 The equilibrium $N_2O_4(g) \rightleftarrows 2NO_2(g)$ at 100ºC (Chang, 2000)

R*eflecting.* Perform a reflection on the results and processes in this experiment! What is the concept that you find difficult or not yet understood? How do I solve the problem related? Summarize your experiment and be prepared to explain it!

T*ransfering.* Experiment using $CoCl_4.6H_2O$ solution and isopropyl alcohol (Figure 6). Enter each 15 mL and 15 mL $CoCl_4.6H_2O$ into three glass beaker. Mark A, B, and C.

A heated solution, while the solution was cooled using an ice B. C solution is used as a comparison color. Observe and record observations.

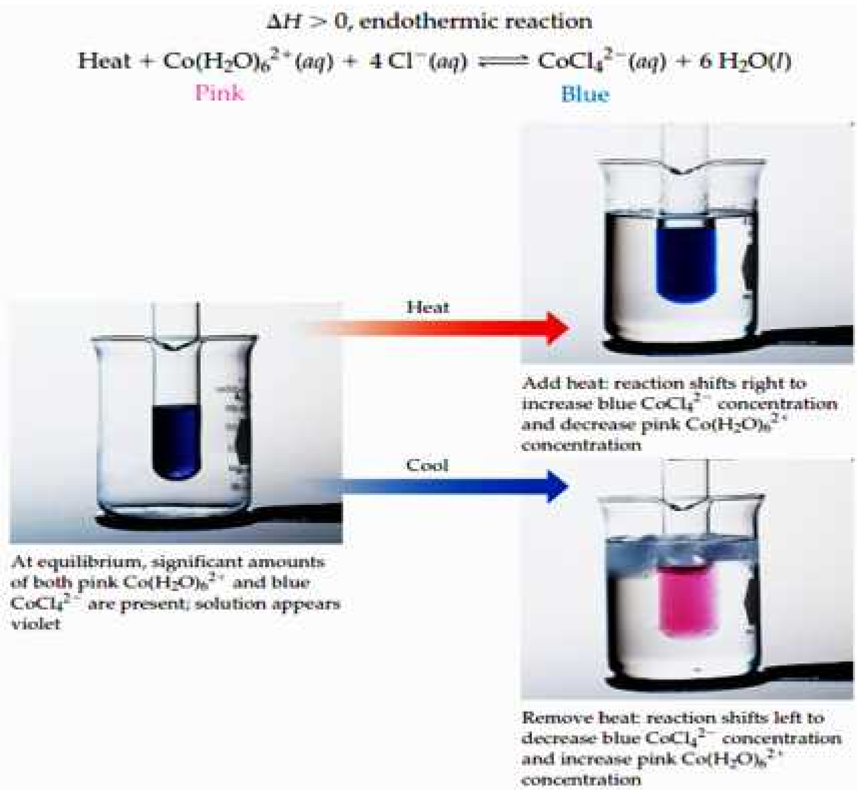


Figure 6 Temperature and Le Chatelier's principle (Brown *et al.*, 2012; Buer 2010)

Metacognitive questions can play an important role in making students learning process more efficient. For example, questions can help students to: (1) activate their pre-knowledge (Osman & Hannafin, 1994), (2) enhance their understanding of the task (Kramarski & Zeichner, 2001), (3) improve their cognitive processes (Kaberman & Dori, 2009), (4) use metacognitive skills (Conner, 2007), and (5) enhance metacognitive skills (Taylor et al., 2002). During a problem-solving task questions can be posed by teachers or by students themselves through self-questioning. Taylor and colleagues (2002) describe self-questioning as a procedure in which students ask themselves questions about the text they read. In the present study, metacognitive questions will be used during teacher-student conversations in order to make improvement of metacognitive skills possible.

According to above explanation, so author made scheme of the student performance activities in the i-SMART model is described Table 3 below.

Table 3 Metacognitive Questioning and Student Performance Activities (modified from Mevarech & Kramarski, 1997; Kapa, 2002; Kramarski & Mizrachi, 2004)

Metacognitive questioning or direction	Performanceactivity
Metacognitive support through the problem solution	
Identifying: What is the problem about? What is given in the problem?	Data coding in the problem
Representing: What are the similarities and differences between the given problem and problems you have solved in the past, and why? In what sense is this represent problems.	Representing the problem mentally (or visualization problem with a computer program and simulation).
Planning: What strategy can be used in order to solve the problem? Why is this strategy most appropriate for solving the problem?	Planning strategies problem?
Monitoring: How can the suggested plan be carried out?	Try-revise-check activities. The solution checks
Evaluating: Is the solution suitable for the problem conditions?	Pressing the Enter key.
Reflecting: Does the solution make sense? Is there another way to solve the problem?	If the answer is yes, a window for writing the additional solution is opened, otherwise the next question is presented.
Transfering: Can I apply an understanding or skills to new situations?	Make discuss group or investigating to

The learning can be implemented with teachers, then proceeded with the group discussion and class discussions. For enrichment, students are given individual tasks. (1) In the group activities, students work on group worksheets, students work with a group of friends to find a solution, discussion, questions and answers among group members, and agree the final results of the work of the group. In this case the student may request assistance from the teacher if all members of the group cannot find the answer. Teachers inform the background of the importance of learning, previous knowledge to remember, and give motivation to the students. (2) In the classically activities, representatives of the group presenting the results of group discussions, the others give response, then get the result of discussions. (3) At the individual activity, students work on independent worksheets, students work alone, and if students find difficulty, students can ask to the teacher, not to their friend.

So i-SMART models appeared to be a useful educational tool for students. The model helps students to solve problems in a systematical way and supported scaffolding metacognitive questioning.

CONCLUSION

Using i-SMART model can support students abilities to solve complex chemistry problems and use metacognitive skills associated with five aspect: (1) representing skills (identifying and representing problems), (2) planning skills (formulating a problem, formulate hypotheses, identify variable manipulation, response variables, and control variables, formulate an operational definition of variables), (3) monitoring skills (conducting experiments and monitor performance, the results of experiment is organizing data, perform analysis of experimental data, (4) Evaluating skills (making inferences, evaluate the effectiveness of trial strategy/problem solving), (5) Transferring skills (applying certain strategies to new situations). Using i-SMART model of learning chemistry to be very useful in developing the student's metacognitive skills through problem solving. The model helps students to solve problems in a systematical way and supported scaffolding metacognitive questioning.

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