PREDICT-EXPLAIN-OBSERVE-EXPLAIN (PEOE) APPROACH: TOOL IN RELATING METACOGNITION TO ACHIEVEMENT IN CHEMISTRY

Princess Ann Bajar-Sales
Recto Memorial National High School, Philippines

Ruel Atendido Avilla
Philippine Normal University, Philippines

Vic Marie Inte Camacho
Philippine Normal University, Philippines

ABSTRACT

The study was conducted to investigate the effectiveness of Predict-Explain-Observe-Explain (PEOE) approach to student's performance in chemistry. This study also determined the correlation of metacognition to student achievement. Specifically, it sought to find out: (1)if there is a significant difference between the pretest and posttest scores of the metacognitive group (MG); (2) if there is a significant difference between the pretest and posttest scores of the comparison group (CG); (3) if there is a significant difference between the posttest scores of the MG and CG; (4) if there is a significant relationship between the metacognitive awareness and achievement in chemistry; (5) the domains of metacognitive awareness should be that are evident among MG and CG; and (6) the learning strategies that the students utilized during the accomplishment of the PEOE tasks.

This quasi-experimental study used seven (7) developed tasks employing PEOE approach to promote metacognition. Instruments such as Metacognitive Awareness Inventory (MAI) to measure students' metacognitive awareness, and teacher-made summative test in Chemistry were used. Students' journal entries were also culled to validate the data and looked for unique responses that would arise from the comparison (CG) or experimental (MG) group.

Results showed that both groups had significantly improved posttest scores, with MG gaining significantly higher posttest scores. For metacognition awareness, while both groups preferred procedural knowledge in the knowledge of cognition domain, they differ in the regulation domain where CG preferred comprehension monitoring while MG favored using debugging strategies. Other learning strategies identified by MG are cooperation, communication and focus on their goal.

***Keywords**:* chemistry achievement, metacognition, learning strategies, PEOE approach

Please direct all correspondence to: Princess Ann Bajar-Sales, Recto Memorial National High School, Philippines, annprincess04@gmail.com

Introduction

Science educators of the 21st century have been motivated to change their way of teaching to ones that fundamentally recognize how people learn (Eberlein, Kampmeier, Minderhout, Moog, Platt, & Varma-Nelson. 2008). This paradigm shift which focuses on students' learning defines learning as "significant long-term changes in knowledge, understanding, skills and attitudes or beliefs" (Williams, 2002, p. 76). The three important aspects– *significant, long-term change* – describe the ability of students to appreciate and understand the content and the effect the learning can have on their lives; to maintain students' knowledge beyond the examination period and use this knowledge for further learning and application; and to integrate new knowledge into existing knowledge (Williams, 2002).

Various effective pedagogies are associated with the paradigm shift. These pedagogies stress the importance of facilitating the critical integration of knowledge, skills and attitudes (Syed Zamri, 2012).The role of teacher is to create an engaging environment, provide a learning stimulus, and support the learner. Therefore, a teacher is no longer a giver of knowledge but a facilitator who can make students generate knowledge on their own (Williams, 2002).

Success in classroom performance is more defined when durable and transferable learning is taking place in the students' thinking processes. Thinking about thinking is metacognition (Parker, 2010). Educators assume that students acquire metacognitive knowledge on their own but students may not acquire this at a young age. Thus, the teacher's role is to carefully plan and use teaching strategies that will train students to be consciously aware about their own thinking and teach them how to regulate it to ensure that they become more responsible in developing of their own learning with confidence and motivation. Developing lessons that enhance students' metacognition when engaging in chemistry activities are anticipated to uplift achievement and to provide an alternative, efficient approach to guarantee effective learning (Efklides, 2006)

Literature and Background

Philippine context

The poor performance in science of Filipino students was reported internationally in the International Science Study, Third International Mathematics and Survey, and International Assessment of Educational Achievement (Imam, Mastura, Jamil, & Ismail, 2014). Nationally, the performance in science was also reported in various tests like the National Achievement Test (NAT). In 2005, the fourth year high school students who took the National Achievement Test showed a mean score of 39.5% in science while only 1.8% of the students attained mastery levels of science curriculum goals (Bernardo, Limjap, Prudente & Roleda, 2008).

Also, the National Career Assessment Examination (NCAE) results during 2012-2013, showed that scientific ability of the students scored lowest among other areas such reading comprehension; verbal, mathematical, clerical and logical reasoning abilities; and visual manipulative, non-verbal, and entrepreneurial skills (Benito, 2014). This means that the sciences were not the primary occupational interest of the Filipino students as shown in the figure below.

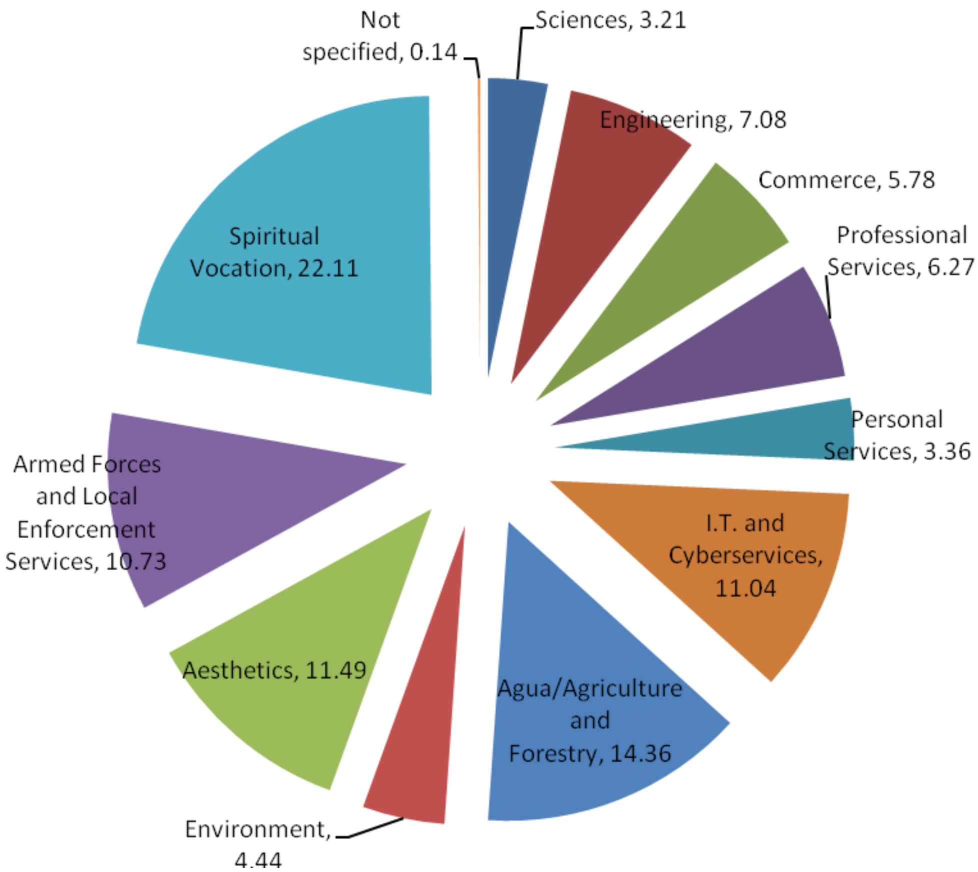


Figure 1. *Percentage distribution of examinees by field of occupational interest (Benito, 2014).*

Chemistry Performance

The decline in students' interest and achievement in chemistry over the past decades has been attributed to students finding chemistry and physics irrelevant and boring (Cardellini, 2012). Aikenhead (2003) reasoned that instruction is out of synchrony with the world outside of school. Several studies also explain why students withdraw from learning science in the Philippines (Carballo, 2009; Espinosa, Monterola, & Punzalan, 2013; Orleans, 2007) and its effects, difficulties of students in learning the chemistry and possible remedy for these difficulties that might benefit both teacher and learner in the chemistry teaching-learning process.

Orleans (2007) stated that the school-related factors like availability of instructional materials can affect student achievement. He found that there is a limited number of physics laboratory guides available in 464 public schools in the Philippines.

Moreover, research findings also confirmed that the most important factor that affects the student performance is teacher quality (Carballo, 2009; Orleans, 2007). It is also found that the Philippine schools use mostly teacher-centered-classroom pedagogies (Cortes, 1993; Magno, 2001; Rogan & Grayson, 2003). The traditional notion of an effective teacher is one who can clearly explain complex science concepts and theories to students and demonstrate the different procedures and operations (De la Cruz, Magno & Punzalan, 2013). Cortes (1993) cited that the usual views of effective teaching refers to the variables like mastery of subject matter, effective communication skills, clarity of expression, and organization of ideas. However, Cortes found that possessing these characteristics is not enough to engage and effectively teach students. This leads to learner problems such as lack of scientific knowledge, skills, values, and attitudes, resulting in poor performance in science (Kibirige, Osodo, & Tlala; Svandova, 2013, 2014).

K-12 science curriculum has started to change the Philippine educational system since 2012. The current curriculum encourages science educators in the Philippines to facilitate science learning using different approaches (K-12 Science Curriculum Guide, 2013) and provide each classroom with learner-centered and inquiry-based environment.

Chemistry is theorized as learned in three levels such as descriptive, submicroscopic, and symbolic forming a closed-cluster concept map as shown in Figure 2. Bradley (2014) further explained each point of the triangle and their interrelationship with chemistry as the focus. Macroscopic is the classification and description of materials/substances and their changes. Symbolic is the representation of chemical substances and chemical reactions which depicts both macroscopic descriptions and microscopic explanations. Submicroscopic is the explanation of why materials and substances behave the way they do.

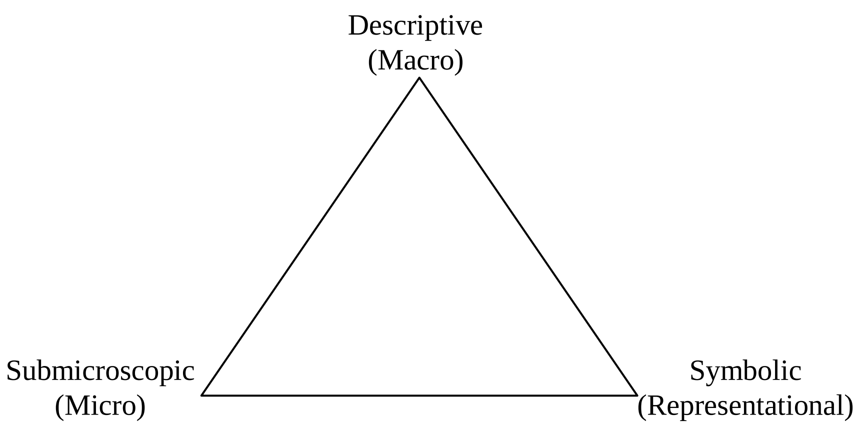


Figure 2. *The chemistry triangle (Sirhan, 2007).*

Sirhan (2007) believed that the link between these levels should be explicitly taught because the interactions and distinctions between them can affect chemical concepts comprehension. Hence, if one level is difficult for a student, this may affect the other levels. Thus, the role of the educators is to determine and overcome these difficulties in chemistry. In an investigation by Gabel (1993), the experimental group was required to link the connections of chemical concepts and principles in particulate nature of matter in terms of three levels. Gabel found that the experimental group performed higher than control group. He said that chemistry can be taught and understood by making connections between these three levels.

Chemical concepts and principles are abstract in nature. The chosen topics (Introduction to chemistry, Matter and its properties, Atoms, Molecules, and Ions, Stoichiometry, and Gases) in Pulmones' study (2007) were utilized to reflect the macroscopic view of the properties of matter. He stated that the students' explorations must start from something they can readily see and experience.

Metacognition

Metacognition is the knowledge about one's capability to accomplish the task and control his/her thinking processes. Metacognition is a thinking activity that is closely related to constructivism because in order to build an understanding of a stimulus, one has to think and monitor his own thinking (Curwen, White-Smith, & Calfee, 2010). Constructivists believe that the knowledge is constructed in the mind of the learner by the learner himself (Eberlein, et. al., 2008). This knowledge is used to interpret objects and events. Interpretations of this knowledge are personal; therefore an individual perceives of the external world based on his/her experiences (Duffy & Jonassen, 1992). Table 1 shows the components of the metacognition.

Table 1*The components of metacognition (Lai, 2011; Schraw & Dennison, 1994)*

Knowledge of Cognition	Regulation of Cognition
• **Declarative** (knowledge about oneself as a learner)	• Information management strategies
• **Procedural** (knowledge about the application of the purposes for completing the procedure of PEOE tasks)	• Debugging strategies
• **Conditional** (knowledge about when and why he/she will use certain learning strategy)	• Comprehension monitoring
	• Planning
	• Evaluation

Some students may acquire metacognition on their own but others are not able to do so and fail to develop metacognition at the adult stage (Pintrich, 2002). The role of the K-12 teacher is to teach metacognition explicitly through providing activities that would make the students aware about their own thinking and learn how to regulate it. In the process, it is expected that the students will gain self-confidence and become more independent learners at an early age.

The PEOE approach

Predict-Explain-Observe-Explain (PEOE) approach is a metacognitive instructional tools that improve conceptual understanding and problem solving abilities of students in science classes (Rickey & Stacey, 2000). This approach was originally designed as Demonstrate-Observe-Explain (DOE) by Champagne, Klopfer and Anderson (1979) and modified as Predict-Observe-Explain (POE) by Gunstone and White (1981). Rickey & Stacey (2000) cited that the students need to explain their predictions to make their beliefs explicit. Joyce (2006) also presented a template of POE with a space for explanation of students' prediction. Students should know that their beliefs are important. Predict-Explain-Observe-Explain (PEOE) is named to emphasize the importance of students' explanation. In PEOE, students make their predictions for an event and explain the reasons for their predictions. Then they observe a demonstration or conduct a laboratory experiment and are required to compare their observations with their predictions.

Various researches support that PEOE approach affects science learning. Hernandez (2002) worked on the effectiveness of POE approach on students' achievement in general chemistry laboratory. She found the scores in pretest and post-test is significantly different when exposed to the POE approach. Similar results were found by Mosca (2007) in which she related the effectiveness of the POE teaching strategy on the performance of students in general chemistry. She found that there is a significant difference between the performance of control group and experimental group. Students who were exposed to POE strategy had improvement on their performance after the POE exposure. Also, she concluded that POE strategy was more effective approach in teaching general chemistry than the traditional strategy. Kibirige, et. al., (2014) also found that the use of POE strategy has a positive effect on learners' misconceptions about dissolved salts. Lucilo (2010) found out that the metacognitive instructions in biological science resulted in a better performance of non-biology major students along the biology topics. It showed on her data gathered that there is a significant difference on the pretest and post-test scores. Capistrano (2000) attempted to use an improvised apparatus in teaching force and motion in physics via POE approach. In her study, she found that the student taught using the POE approach on average scored higher in the post-test than in the pretest.

Methodology

Questions

This study builds on and expands the previous research by using a control group (CG) and intervention group (MG) design. The research seeks to answer the following questions:

(1) Is there a significant difference between the pretest and posttest scores of the metacognitive group (MG)?

(2) Is a significant difference between the pretest and posttest scores of the comparison group (CG)?

(3) Is a significant difference between the posttest scores of the MG and CG?

(4.) Is a significant relationship between the metacognitive awareness and achievement in chemistry?

(5) What are the domains of metacognitive awareness that are evident among MG and CG?

(6) What are the learning strategies that the students utilized during the accomplishment of the PEOE tasks?

Hypotheses

The following are the null hypotheses and tested using t-tests at 0.05 level of significance:

(1.) There is no significant difference between pretest and posttest scores of MG and CG.

(2) There is no significant difference between the posttest scores of MG and CG.

(3) There is no significant relationship between the metacognitive awareness and achievement in chemistry.

Sample

Two intact sections with thirty (30) students were the participants in the study. These students were enrolled in the third year level, ages 14-15 under the old curriculum, Basic Education Curriculum (BEC). The study was implemented in Recto Memorial National High

School during the school year 2012-2013. In the selection of the samples from each section, the researcher considered the students' pretest scores and size of each group to determine the sample that exhibits equal academic achievement and size.

Lesson Plans

Lesson plans can take many forms and follow many philosophical stances. The Adult Experiential Learning Process introduces the 4A's in which lesson plans are guided with four interactive phases: activity, analysis, abstraction, and application. This lesson plan format is intended to utilize the individual and collective experiences as resources for learning new concepts, enhancing skills and developing new orientations.

Lesson plans designed for metacognitive group and control group were based on the 4A's Adult Experiential Learning (AEL) format. This has been adopted by the school to ensure the active participation of the students. The lesson proceeded to the activity proper after the objectives had been discussed with the students. Then, post-laboratory was done which includes the sharing of ideas to the class, set of questions in which the students analyze and apply what they have learned from the tasks.

Instructional strategies

This study utilized the PEOE approach to promote metacognition during chemistry experimentations and discussions. Furthermore, it is assumed that students' metacognition would increased the achievement of the students in chemistry.

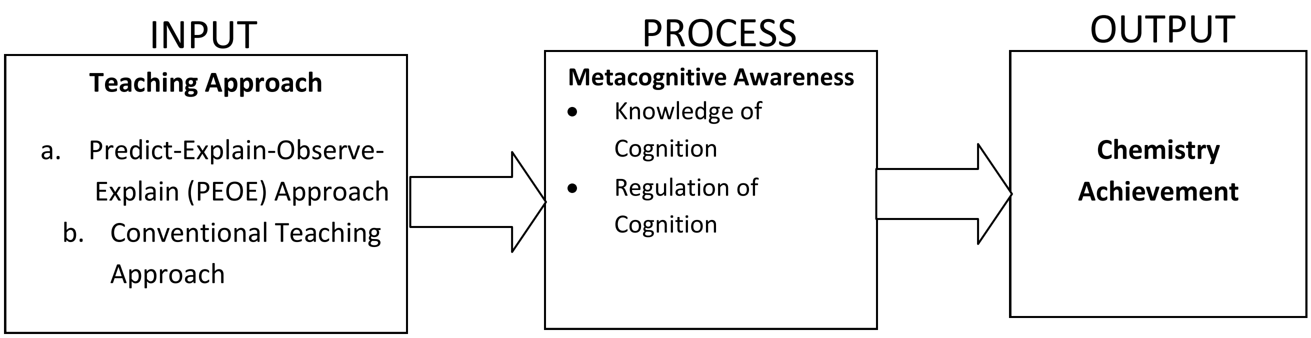


Figure 3.*Research paradigm of the study*

As shown in Figure 3, this study used two teaching approaches: PEOE approach and conventional teaching approach to develop metacognition to students. The PEOE approach was utilized by the MG while conventional teaching approach was utilized by the CG. As metacognition has been developed among students, it is assumed that there would be change in chemistry achievement. Also, the study determined the relationship of metacognitive awareness and achievement in chemistry of third year students.

The PEOE tasks and the traditional laboratory experiments focused on the Classification of Matter were based on the Philippine Secondary Learning Competencies (PSSLC). The study was implemented in the second quarter. Table 2 below presents the summary of PEOE tasks.

Table 2. *The summary of PEOE task.*

Experiment Number	Experiment Title
PEOE Task 1	Kitchen Chemicals
PEOE Task 2	Extensive and Intensive Properties
PEOE Task 3	Elements and Compounds
PEOE Task 4	To be Metallic or Non-Metallic
PEOE Task 5	Household Products: Are they Acidic or Basic?
PEOE Task 6	Solution, Colloid and Suspension
PEOE Task 7	Separation of Mixtures

Each PEOE task is composed of different parts. Objectives are enumerated to familiarize students about what they will learn on a particular task. Equipment, chemicals and precautions are listed so that the students will be directed properly on what and how to avoid accidents during the experimentation. Next, the students are asked to prepare samples using the pre-laboratory procedures before they make their prediction. After pre-lab, a preliminary question is presented to the student in which the students make their own prediction. The task acknowledges the prior knowledge of the students by writing their explanation. Then, they perform the experimentation and write their observation. Finally, they compare their prediction with the data they have gathered. Also, they are allowed to share their ideas with other groups with the supervision of the teacher. This is to avoid misconceptions. The figure 4 below shows the sample of student's output.

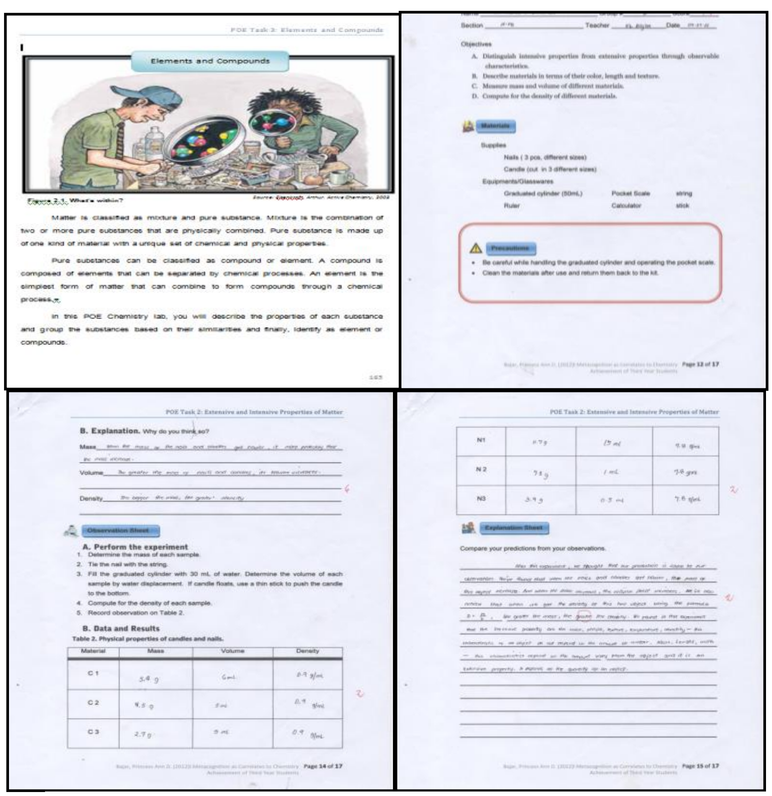


Figure 4. *Part of the student's output on PEOE task 2.*

After sharing ideas, each student was asked to summarize the acquired ideas through concept mapping and writing reflective journals. Below is an example of student's output.

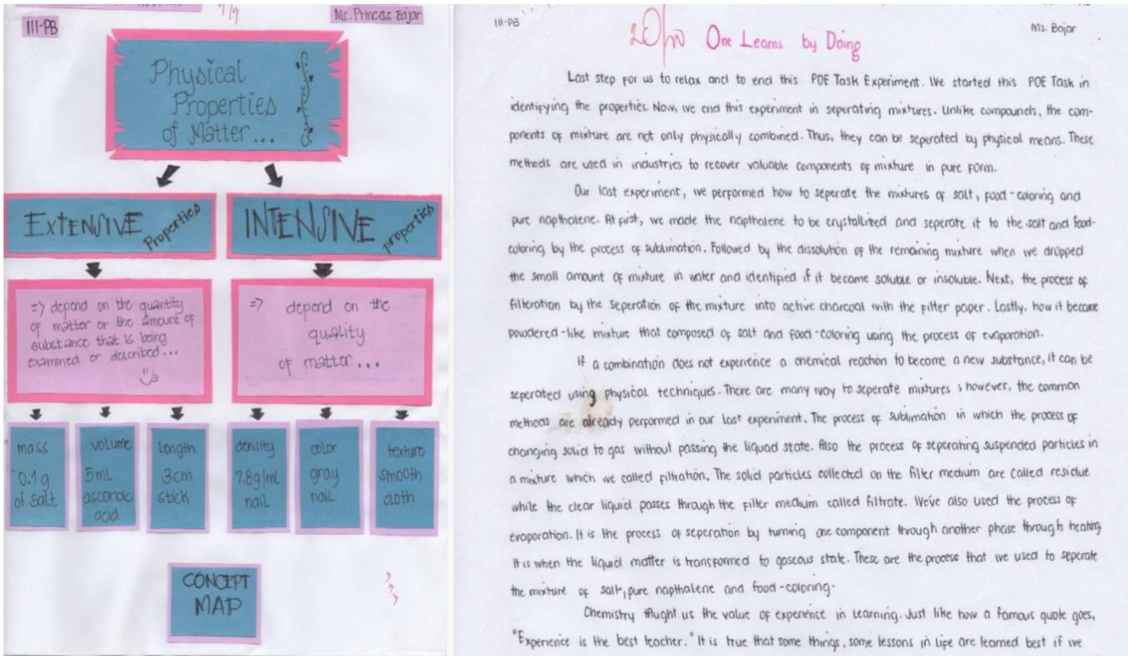


Figure 5. *Part of the MG student's output on concept mapping and reflective journal*

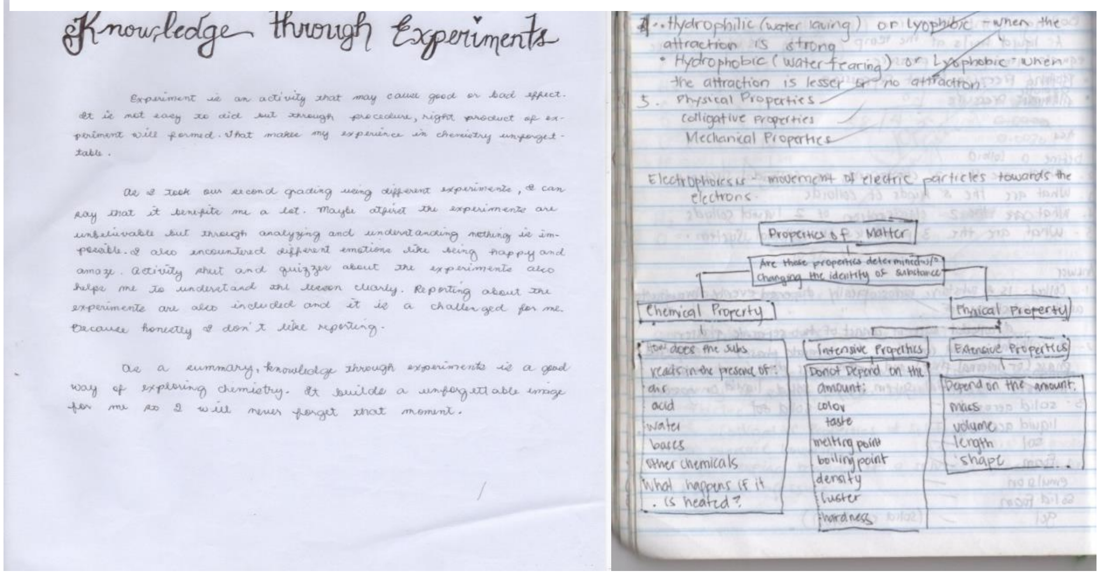


Figure 6. *Part of the CG student's output on concept mapping and reflective journal*

The phases of the two approaches were almost the same for the two groups as shown in Table 3. Phase is the sequence of the tasks to be accomplished by each group. Each phase has a time allotment of seventy-two (72) minutes per day.

Table 3. *Phases of the study*

Day	Experiment Title
1	Pretest
2	Kitchen Chemicals
3	Physical Properties of Matter
4	Post-laboratory
5	Elements and Compounds
6	Metals and non-Metals
7	Post-laboratory
8	Acids and Bases
9	Post-laboratory
10	Solution, Suspension and Colloid
11	Post-laboratory
12	Separation of Mixtures
13	Post-laboratory
14	Posttest
15	MAI

Instruments

Two instruments were used for data collection in the study. These were the Metacognitive Awareness Inventory (MAI) by Schraw & Dennison (1994) to measure students' metacognitive awareness and the teacher-made summative test to measure students' achievement in chemistry before and after the implementation.

Metacognitive Awareness Inventory (MAI)

Lai (2011) organized the different types of knowledge of cognition into three types and listed seven (7) terminologies for all types. Three (3) terminologies were selected to limit the scope of the study as presented in the table 1. Schraw & Dennison (1994) enumerated five (5) terminologies in regulation of cognition.

MAI is a forty-item inventory which determines the frequency of their awareness of students during chemistry classes. This is a 4-Likert scale with number indicators as 4 (always aware), 3 (frequently aware), 2 (sometimes aware), and 1 (never aware) which was used in the knowledge of cognition while the latter has number indicators of 4 (always), 3 (frequent), 2 (sometimes), and 1 (never). Each subcategory comprises five (5) statements as shown in table 4.

Table 4. *Metacognition awareness inventory*

Procedural knowledge (PK)	Information management strategies (IMS)
1. I try to use various strategies that have worked in the past.	16. I consciously focus my attention on important information.
2. I know how to use a specific strategy with purpose on the accomplishment of each task.	17. I focus on the meaning and significance of new information.
3. I know how to track my learning progress and completion of the task.	18. I create my own examples to make information more meaningful.
4. I know how to evaluate the strategy that I used	19. I translate new information into my own words.

after chemistry class. 5. I know how to learn best in chemistry.	20. I focus on overall meaning rather than specifics.
Declarative knowledge (DK)	Debugging strategies (DS)
6. I know what kind of information is most important to learn. 7. I am good at organizing information. 8. I know what the teacher expects me to learn. 9. I am a good judge of how well I understand Chemistry topics. 10. I have control over how well I learn.	21. I ask others for help when I don't understand something in chemistry. 22. I change strategies when I fail to understand. 23. I re-evaluate my assumptions when I get confused. 24. I stop and go back over new information that is not clear. 25. I stop and reread when I get confused.
Conditional knowledge (CK)	Planning (P)
11. I learn best when I know something about chemistry topic. 12. I know when to use different learning strategies depending on the situation. 13. I can motivate myself to learn when I need to. 14. I use my intellectual strengths to compensate for my weakness. 15. I know when each strategy I use will be most effective.	26. I think about what I really need to learn before I begin a task. 27. I ask myself questions about the material before I begin. 28. I read instructions carefully before I begin a task. 29. I organize my time to accomplish my goals. 30. I think of several ways to solve a problem and choose the best one.
	Comprehension monitoring (CM)
	31. I ask myself periodically if I am meeting my goals. 32. I periodically review to help me understand important relationships. 33. I find myself analyzing the usefulness of strategies while I study. 34. I find myself pausing regularly to check my comprehension. 35. I ask myself questions about how well I am doing while learning something new.
	Evaluation (E)
	36. I ask myself if there was an easier way to do things after I finish a task. 37. I ask myself how well I accomplish my goals

once I am finished.

38. I ask myself if I learned as much as I could have once I finish a task.

39. I summarize what I have learned after I finish.

40. I know how well I did once I finish a task.

Chemistry Summative Test

The table of specifications (TOS) for chemistry test development was made to determine the number of items to be distributed for each task. TOS has been used in the school as test development for quarterly exams in various subject areas. The number of items is equal to the percentage of the approximate total time that will be spent for each task multiplied by the total number of items. Table 5 presents the tasks, general objectives, proposed number of time allotment, percent of time, number of items per task, and item number placement.

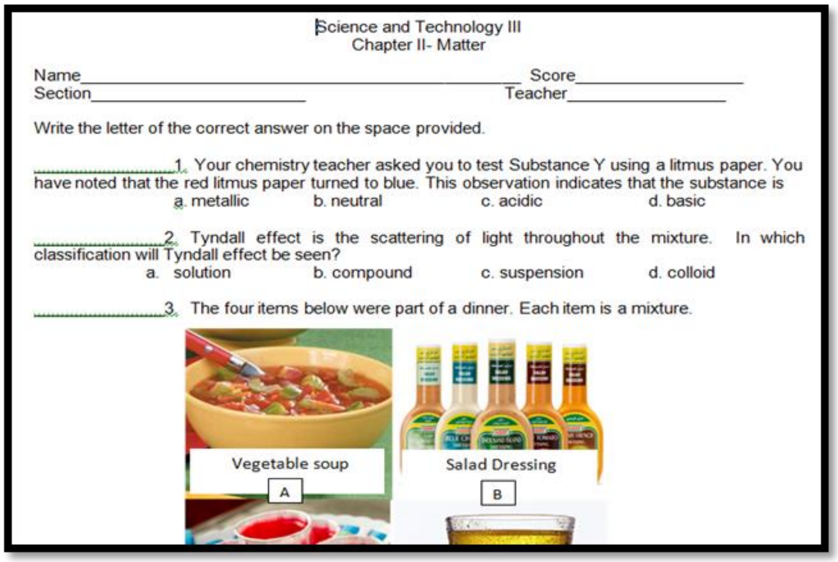
Knowledge, application and analysis were the thinking skills in the chemistry pretest and posttest development. The item number placements for knowledge (12 items) thinking skill are 2, 6, 11, 13, 18, 21, 22, 23, 25, 26, 32, and 44; for application (11 items) thinking skill, 8, 10, 20, 27, 31, 33, 36, 40, 42, 46, and 48; analysis (27 items) thinking skill; 1, 3, 4, 5, 7, 9, 12, 14, 15, 16, 17, 19, 24, 28, 29, 30, 34, 35, 37, 38, 39, 41, 43, 45, 47, 49, and 50.

Finally, the researchers came up with chemistry fifty-item summative test with four choices.

Table 5. *Table of specifications for chemistry test development*

PEOE task	General objectives	Proposed number of hours that will be spent	% of total time	Number of items	Item number placement
PEOE task 1	Describe the physical and chemical properties of the given material	3	0.24	12	1,14, 23,45, 2,16,22,24, 33, 34, 12,18,26,36
PEOE task 2	Differentiate intensive properties and extensive properties	1.5	0.12	6	3, 11,19,43
PEOE task 3	Categorize substances as to elements, and compounds.	1.5	0.12	6	9,13,28,37, 41,42
PEOE task 4	Classify elements as metals, nonmetals and metalloids based on their observable characteristics.	1	0.08	4	21,38,44, 50
PEOE task 5	Distinguish acid compounds from basic compounds	1	0.08	4	15,20,46,35
PEOE task 6	Understand the nature of three types of mixtures.	2.5	0.20	10	4,8,10,25,27, 30,39, 40,47,48

PEOE task 7	Apply ways to separate mixtures	2	0.16	8	5,6,7,17,29, 31, 32, 49
	Total	12.5	1.00	50.0	


Science and Technology III
Chapter II- Matter

Name_______________ Score_______________
Section_______________ Teacher_______________

Write the letter of the correct answer on the space provided.

_______1. Your chemistry teacher asked you to test Substance Y using a litmus paper. You have noted that the red litmus paper turned to blue. This observation indicates that the substance is
a. metallic b. neutral c. acidic d. basic

_______2. Tyndall effect is the scattering of light throughout the mixture. In which classification will Tyndall effect be seen?
a. solution b. compound c. suspension d. colloid

_______3. The four items below were part of a dinner. Each item is a mixture.

Figure 8. *Part of posttest.*

Chemistry summative test and MAI were validated by five science education experts. The data were consolidated and their reliability was measured. The instruments used were found to be acceptable based on Cronbach alpha tests.

Data Gathering

Before the implementation of the study, the pretest was administered to both groups to determine the level of achievement of each group. Both groups were told that their grades will not be affected after the pretest. MG was taught using PEOE approach while CG was taught using the traditional teaching approach. Each meeting was equivalent to seventy-two (72) minutes per day. The MG and CG wrote their reflective journals for each task to collect unique responses that would arise during the implementation of the study. The posttest was given followed by administration of MAI after the study had been implemented.

Data Analysis

Descriptive statistics was used to determine the average score on each strand and domain from the MAI. Paired samples t-test was used for testing significant differences between pretest and posttest mean scores of both groups. Independent samples t-test was used for testing of significant differences between groups in terms of their pretest and posttest mean scores. Pearson-r correlation was employed to determine the significant relationship between metacognitive awareness and achievement in chemistry.

Results and Discussion

Data were analyzed quantitatively and qualitatively. The results of each are provided below.

Quantitative Analysis

Initial Comparability

The pretest was administered to the CG and the MG to test their initial comparability. Scores were obtained and the t-test for independent samples was used to analyze the data as shown in Table 6. Both groups had thirty students. The CG's mean score is 20.17 while the MG's mean score is 20.27. The standard deviation of the CG and the MG are 2.87 and 2.24 respectively. The df value is 58 and p-value is 0.88 at 0.05 level of significance. Since the p-value is higher than 0.05 ($p>0.05$), there is no significant difference between pretest scores of the CG and the MG.

Table 6. *Independent samples t-test on achievement in chemistry pretest (N=30)*

Groups	Mean	SD	Df	p-value	Remark
Metacognitive Group	20.27	2.24	58	0.88	Not significant
Comparison Group	20.17	2.87			

$p>0.05$

This implies that both groups had nearly equal performance in chemistry prior to the conduct of the study.

Significant difference between the pretest and posttest scores of MG and CG

Table 7 summarizes the significant difference between pretest and posttest mean scores of both groups. Since the p-values of both groups are less than 0.05, the null hypotheses are rejected. There are significant differences in their pretests and posttests after the implementation of the PEOE and conventional laboratory-teaching approaches.

Table 7. *Test of significant difference between chemistry pretest and posttest (N=30)*

Groups	Pretest mean	Posttest mean	df	p-value	Remark
Metacognitive Group	20.27	36.43	29	0.00	Significant
Comparison Group	20.17	26.23	29	0.00	Significant

$p>0.05$

This implies that the students of both groups learned chemistry using the two approaches.

Significant difference between MG and CG posttest scores

Table 8 shows the summary of testing of the significant difference between the mean scores of both groups on the post-test. The mean score for CG is 26.23 while for MG is 36.43. The df value is 58; and the p-value is 2.97×10^{-10} at 0.05 level of significance. Since the p-value is less than 0.05, the null hypothesis is rejected. Therefore, there is a significant difference in the posttest means of the CG and the MG. The data suggests that the students achieved more meaningful learning using the PEOE approach than using conventional teaching approach.

Table 8. *Independent sample t-test on achievement in chemistry posttest between CG and MG (N=30)*

Groups	Highest Score	Lowest Score	Mean	SD	df	P	Interpretation
Metacognitive Group	47	23	36.43	4.58	58	0.00	**Significant**
Comparison Group	39	17	26.23	5.76			

$p>0.05$

Correlation between achievement and metacognitive awareness of MG and CG

Table 9 shows the correlation of the posttest and metacognitive awareness of the MG and CG. Both groups showed weak correlation between their posttest mean scores and knowledge of cognition. Also, both groups showed weak correlation between their posttest mean scores and regulation of cognition. The strength of correlation is based on Dancey and Reidy's (2004) interpretation.

Table 9. *Correlation between posttest and knowledge of cognition of MG and CG (N=30)*

	MG			CG		
	Pearson Correlation	Sig (1-tailed)	Remarks	Pearson Correlation	Sig (1-tailed)	Remarks
Knowledge of Cognition						
Procedural	.346*	0.031	Weak	.462**	0.005	Moderate
Declarative	.419*	0.011	Moderate	.322*	0.041	Weak
Conditional	.326*	0.039	Weak	.426**	0.009	Moderate
Regulation of Cognition						

Information Management Strategies	.325*	0.04	Weak	.376*	0.02	Weak
Debugging Strategies	.417*	0.011	Moderate	.367*	0.023	Weak
Planning	.335*	0.035	Weak	.350*	0.029	Weak
Comprehension Monitoring	.349*	0.03	Weak	.330*	0.037	Weak
Evaluation	.443**	0.007	Moderate	.470**	0.004	Moderate

***. Correlation is significant at the 0.01 level (1-tailed).*
**. Correlation is significant at the 0.05 level (1-tailed).*

Evidence of metacognitive awareness

Table 10 shows the total mean scores and their interpretation. The data showed that the CG was more aware about PK (mean score of 2.53). This means that the students knew what, when and how to use a strategy in a particular task. Also, results showed that they sometimes used their DK and CK. The MG frequently used all their knowledge of cognition in all chemistry learning experiences. Among the components of knowledge of cognition, the students knew most about PK. It has the highest mean score of 3.31. In the regulation of cognition, CM has the highest mean score of 2.49 for the CG as shown in the same table. The CG sometimes regulates their cognition. The MG frequently regulated their cognition in accomplishing a task and in their learning. They used DS frequently while doing of the task. It has the highest mean score of 3.45.

Table 10. *Consolidated mean score of metacognition of MG and CG (N=30)*

	MG		CG	
	X	Extent	X	Extent
Knowledge of Cognition				
Procedural Knowledge (PK)	**3.31**	**Frequently**	**2.53**	**Frequently**
Declarative Knowledge (DK)	3.02	Frequently	2.45	Sometimes
Conditional Knowledge (CK)	3.01	Frequently	2.47	Sometimes
Regulation of Cognition				

Information Management Strategies (IMS)	3.19	Frequent	2.47	Sometimes
Debugging Strategies (DS)	**3.45**	**Frequent**	2.45	Sometimes
Planning (P)	3.05	Frequent	2.39	Sometimes
Comprehension Monitoring (CM)	3.05	Frequent	**2.49**	**Sometimes**
Evaluation (E)	3.14	Frequent	2.39	Sometimes

Qualitative analysis

Moreover, there are other learning approaches that the students utilized other than the presented metacognitive awareness which were drawn from students' journal.

One of the strategies they used is **cooperation**,

"Cooperation-that was the best thing that we may have."

"Cooperation was absolutely present for it made the group more functional."

"I also need to communicate to others so that they can add facts in my discoveries."

"…I've learned a very important lesson- being together, working together, learning together…"

Some also used **background knowledge**;

…while using your [my] background knowledge regarding the experiment can help us to answer observation and even prediction too."

"I can easily predict because of my background knowledge…."

They also mentioned that **communication** helped them perform well in the accomplishing their tasks.

"We just combined our ideas together to gather good information about the activity."

"Before we make our predictions, we consulted all of the members first of what they know."

"Performing the experiment, we've just followed the given instructions and some advises from our teacher."

They also suggested that **focus on the goal** aided them to complete the task at hand.

"We did focus on our work…."

A metacognitive learner knew other strategies that might help him to learn the Chemistry topic and was able to change the old one when proven inadequate. This kind of learner is also called a self-regulated learner. He is also able to extract the main ideas more efficiently which can be seen on the concepts that transpired in the journals written by the MG.

Conclusions

Chemistry is an abstract and challenging subject for students. They find it difficult because they cannot extend their knowledge into the real world. Durable and transferable chemical knowledge depends on the three levels (descriptive, symbolic, and submicroscopic) of chemistry. Due to the interconnections of these levels, there's a need to strengthen up each one of them by providing an environment conducive for learning.

In the midst of limited resources, Filipino educators have to be creative and resourceful to still provide a metacognitive environment for students. In this study, seven PEOE tasks which focused on the macroscopic nature of matter motivated the MG to predict, explained their prediction, observed and gathered data from experimentation, and explained to reconcile their prediction with the data that they had gathered.

The MG and CG achieved learning using the PEOE approach and conventional teaching approach respectively. However, MG achieved more meaningful and better learning in chemistry when they were exposed to the PEOE approach. It was found that there is a weak positive correlation between metacognitive awareness and achievement of the MG and CG. The result is similar to the results of the studies conducted by Sperling & Lockl (2002), and Young & Fry (2008). Also, Sperling, Howard, & Staley, (2004) concluded that MAI scores and student achievement had little correlation of 0.02. They were surprised that the SAT and MAI scores had a negative correlation.

The common domain of metacognitive awareness is the Procedural Knowledge as part of the Knowledge of Cognition. Furthermore, in Regulation of Cognition, the CG dominantly used Comprehension Monitoring while the MG used Debugging Strategies. This finding is the same with that of Schraw (1994). He stated that the learners tend to differ in the use of regulatory skills but not of knowledge.

The study also revealed that the students from both groups presented metacognitive experiences though this variable was not included in the study. It is believed that these experiences affected the accomplishment of the PEOE tasks as well as chemistry learning. One student from CG wrote on her journal: "[Experiment] *It is not easy to did* [do] *but through* [following] *procedure, right product* [outcome] *of experiment will form(ed).*" Efklides (2006) stated that metacognitive feeling of difficulty correlates with the performance.

In this study, the group utilized different strategies such as cooperation, background knowledge, communication, and focus on goals. Efklides & Petkaki (2005) stated that the metacognitive feeling of liking of a task correlates to the positive mood. Their findings suggest that positive affect eases the person's effort and ensures student engagement on the tasks. In this study, one student from MG wrote on her journal that "*Personally, I really enjoyed the class. Not that I don't like the traditional way of teaching but let's just say I like this one* [PEOE approach] *more than the other one.*"

Recommendations

Based on the findings, it is suggested that science teachers may develop and adopt the use of predict-explain-observe-explain approach to increase the students' metacognition in teaching other Chemistry topics.

It is also encouraged to conduct seminar-workshops and other in-service training programs which focus on the development of inquiry-type experiments for teachers to become fully equipped of the knowledge and skills necessary in their fields.

Further studies might be conducted on the interrelationship between metacognition and achievement of the students and other factors like metacognitive experiences, learning strategies, attitudes, and motivation that give insights on how students learn best in chemistry and other subject areas.

Further researches can be conducted to further validate the PEOE tasks and its effects.

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