"Science Stays True Here"
Biological and Chemical Research (ISSN 2312-0088), Vol.7, 97-114 | Science Signpost Publishing

Factors Affecting the Ability to Depict Mental Models of Chemical Solutions Among Chemistry Students

Mary Joy M. Villamora

Philippine Science High School – Central Visayas Campus, Talaytay, Argao, Cebu 6021 Philippines.

Received: June 16, 2020 / Accepted: July 22, 2020 / Published: September 25, 2020

Abstract: This was a descriptive study to determine the factors affecting the ability to depict mental models of chemical solutions among General Chemistry II students of Philippine Science High School-Central Visayas Campus during SY 2013-2014. Thirty students were randomly selected as respondents. Their profiles which consisted of their sexes and grades in General Chemistry I were obtained. The students' attitude towards Chemistry, as well as their ratings in the prior conception test and in their depiction of mental models of chemical solutions were determined. The probing of the mental models was done using an interview protocol that included the use of a variety of common chemical solutions and focus cards that depicted model use (Unal, Calik, Ayas, & Coll, 2006; Jansoon, et al., 2009). Findings revealed that 1) the more able respondents were able to present consistent representations of chemical solutions at each level of representations: the macroscopic, submicroscopic and symbolic levels. In contrast, the less able respondents were able to depict in an unrelated manner the concepts at the three levels. It was also shown that 2) the following variables were significantly correlated with the respondents' ability to depict mental models of chemical solutions: General Chemistry 1 grade, $r(28)= 0.370$, $p = 0.044$; attitude towards Chemistry, $r(28)= 0.380$, $p = 0.038$; and prior conceptions rating, $r(28)= 0.384$, $p = 0.036$; and, 3) there is no significant difference between males ($M= 75.5553$, $SD= 7.85312$) and females ($M= 73.3333$, $SD= 7.84207$) in terms of their ability to depict mental models of chemical solutions, $t(28)= 0.775$, $p = 0.445$. Therefore, one's ability to depict mental models of scientific concepts can be enhanced by certain factors. In this study, the attitudes of students towards Chemistry, their prior conceptions of the subject matter and performance in prerequisite subjects are key determinants in their performance to depict mental models of chemical solutions.

Key words: chemistry education, chemical solutions, mental models

1. Introduction

One major goal of science education is to make students understand and be able to do science. With this, students should be able to understand the natural phenomena and the principles and theories used to explain them. But even with reforms in science education, the goal is still difficult to achieve because students find it hard to perceive some scientific phenomena and the principles and theories that are used explain such are abstract and complex (Rompayom, Tambunchong, & Dechsri, 2011).

In the case of Chemistry, students find it to be highly abstract and complex (Gabel, 1999; Johnstone, 1993). Some chemistry concepts are just too difficult for them to understand (Lythcott, 1990). One primary reason for this can be that everyday experiences can provide evidence that supports incorrect understanding of the concepts.

Another reason would be the fact that Chemistry teachers often provide students with algorithms or formulas for solving chemical problems. It seems this mostly occurs because of the pressure to perform well in examinations that reward correct numerical answers (Dahsah & Coll, 2008). In effect, the students often use mathematical equations without understanding them in terms of the underlying chemistry or science concepts (Bealle & Prescott, 1994; Bunce, Gabel, & Samuel, 1991).

One part of General Chemistry that students have difficulty solving problems with is on the topic of solutions. Most Chemistry experiments require students to know how to prepare solutions of known concentration (Dunnivant, Simon, & Willson, 2002; McElroy, 1996; Wang, 2000). And when students cannot solve certain problems on chemical solutions it is often because they misunderstand the underlying concepts. Solutions and related topics are abstract and difficult leading to many student alternative conceptions (Calik, 2005). Since the students' understanding of chemical solutions and related concepts is often evaluated by their ability to solve numerical problems and not necessarily on their conceptual understanding on chemical solutions, it is much possible that they would retain alternative conceptions even after the instruction of the topic (Jansoon, et al., 2009; Hinton & Nakleh, 1999).

With this predicament, the researcher is motivated to probe how the students describe and explain phenomena particularly on chemical solutions using the mental models or representations that they create when trying to understand scientific knowledge. Furthermore, it is aimed by the researcher to evaluate the factors that affect their ability to depict these mental models.

2. Materials and Methods

This study employed a descriptive survey method of research that determined the factors affecting the ability to depict mental models of chemical solutions among Third Year students at PSHS-CVisC during SY 2013 - 2014. The study was conducted at PSHS-CVisC in Talaytay, Argao, Cebu. The campus was established on September 30, 2005 in accordance with Philippine RA 8496, also known as the PSHS System Act of 1997.

Being part of the PSHS System, its mandate is to offer free scholarship to students with high aptitude in the Sciences and Mathematics with the purpose of preparing them for a science career. Although the school emphasizes the best instruction in Sciences and Mathematics, it also provides a well-rounded curriculum that gives attention to all aspects of the scholar's academic, physical and social development (http://cvisc.pshs.edu.ph/about-us/history.html, 2011).

Research Respondents

The respondents of this research were thirty randomly selected Third Year students of PSHS-CVisC in Talaytay, Argao, Cebu who took the General Chemistry II subject offered in the PSHS System for SY 2013-2014. During the First Semester of the School Year, they have already been exposed to the topic on chemical solutions under the same instructor.

Research Procedure

The research procedure began with the determination of the profile of the respondents. This consisted of their sexes and grades in General Chemistry I. Their attitude towards chemistry as a subject was determined. Also, their ratings in the prior conception test and in their depiction of mental models of chemical solutions were obtained. The mental models were assessed for the correctness of the students' conceptions on chemical solutions. Furthermore, the correlation between General Chemistry 1 grade and mental models rating, attitude and mental models rating, and prior conceptions and mental models rating were determined. Finally, the male and female respondents were compared in terms of their mental models rating.

Data Gathering Procedure

A letter of request was given to the campus director requesting for the conduct of diagnostic tests to third year students and for the gathering of their General Chemistry I grades from the registrar. After the letter's approval, the attitudes and prior conceptions questionnaires were given by the researcher to the respondents. The accomplished questionnaires were collected on the same day. Next, the respondents were subjected to a standardized mental models examination.

Research Instruments

The study utilized three questionnaires. The first was for the assessment of the respondents' prior conceptions on chemical solutions. The aim of this assessment was to draw out a range of student responses to two-tier questions after the instruction on chemical solutions. To elicit the students' ideas, a nine-item standardized paper-and-pencil test (Calik et al, 2005; Calik et al, 2009; Calik et al, 2010) with some modifications was used as an instrument. This was administered to the selected respondents. Two types of questions were involved: the multiple choice questions, wherein the respondents were asked to choose an answer and give an explanation to support it, and the direct open-ended questions wherein the respondents were asked to provide an answer and explain it.

The open-ended questions in the test were analyzed using the following categories and headings (Calik & Ayas, 2005): ***Sound Understanding*** (responses that included all components of the validated response); ***Partial Understanding (***responses that include at least one of the components of the validated response, but not all the components); ***Partial Understanding with Alternative Conception*** (responses that showed understanding of the concept but also made statements, which demonstrated an alternative conception); ***Alternative Conception*** **(**responses that included illogical or incorrect information); and ***No Understanding*** (irrelevant or unclear response; blank). As for the multiple choice questions, the following categories were employed: ***Correct Choice with Sound Understanding; Correct Choice with Partial Understanding; No Choice with Sound Understanding; Incorrect Choice with Sound Understanding; No Choice with Partial Understanding; Correct Choice with Alternative Conception; Correct Choice; Incorrect Choice with Alternative Conception***; ***Incorrect Choice***; and ***No Answer***. Such criteria provided an opportunity for the classification of students' responses and make comparisons about their level of understanding (Calik, 2005).

The second questionnaire utilized was the standardized attitudes questionnaire by Salta and Tzuograki (2004) with some modification. This Likert Scale questionnaire was composed of thirty statements which served as indicator to express the respondents' feelings towards the Chemistry subject in terms of difficulty encountered, interest and the deemed usefulness. Responses were expressed on a four-point scale: highly positive, positive, negative and highly negative.

The third questionnaire involved probing of the respondents' mental models of chemical solutions in a three-item exam. This was administered using the Interview-About-Events (IAE) Technique (Gilbert, Watts, & Osborne, 2005). The students were first interviewed about their understanding of some concepts on chemical solutions using cards presented to them. They were then asked to represent their answers using drawings at the three levels of representation: macroscopic, submicroscopic and symbolic. In the interviews, the students were encouraged to speak freely, and the cards were designed to connect the events to possible students' life experiences (Unal, Calik, Ayas, & Coll, 2006). The use of the cards helped establish a relaxed environment for the student rather than by posing them questions (Coll & Treagust, 2003). The correct depiction of the mental model at each level was given 2 points. This showed full understanding of the concept. One (1) point was given to the drawing with partial or an incorrect understanding of the concept. Finally, zero (0) point was given to blank drawing which showed no understanding at all.

The qualitative descriptions for the percentage ratings that the respondents obtained were based on that being used by PSHS for its academic ratings. They are as follows: the ratings 96-100 have a qualitative description of “excellent”. Ratings between 84 and 95 are considered “very good”. Those between 72 and 83 are considered “good”. Those ranging from 60 to 71 and 40 to 59 have ratings described as “satisfactory” and “unsatisfactory, respectively.

In the case of the mental models rating, the respondents were considered to be “more able” to depict the mental models of chemical solutions when they obtained total percentage ratings between 72 and 100. On the other hand, they would be considered “less able” to depict the mental models of chemical solutions when they obtained total percentage ratings lower than 72.

Statistical Treatment of Data

The statistical treatment in this study involved the percentage distribution, simple arithmetic mean, Pearson Product-Momentum Correlation Coefficient, r, t test for r, and t-test for independent samples. All computations were done using Statistical Package for the Social Sciences (SPSS) software at 5% level of significance. Computation result of *p* values lower than 0.05 indicated significant correlations or difference; and *p* values greater than 0.05 would mean the correlations or difference was not significant.

3. Results and Discussion

Profile of the Respondents

The data were gathered from 30 randomly selected Third Year students of PSHS-CVisC who were currently taking up General Chemistry II subject. Table I shows the profile of these students in terms of their sex and grade in General Chemistry I.

Table 1. Profile of the Respondents

Sex	Frequency	Percentage
Male	15	50
Female	15	50
Grade in General Chemistry I		
90-99	2	6.67
80-89	5	16.67
70-79	12	40.00
60-69	7	23.33
50-59	4	13.33

As can be seen in the table, the respondents were composed of 15 males and 15 females. In terms of their grades in General Chemistry 1, only two or 6.67% got grades between 90-99. There were five (16.67%) who had grades between 80 and 89. Next, twelve or 40.00% of them got grades between 70 and 79. This was followed by seven (23.33%) of the respondents with grades in the range 60-69. Finally, four or 13.33% had grades between 50-59 which is below the passing mark of 60.

Performance Level of the Respondents in General Chemistry I

Table 2 shows the performance of the respondents in General Chemistry I.

Table 2. General Chemistry I Grades of the Respondents

n	Mean	SD	Qualitative Description*
30	72.90	10.450	Good

* 96-100 – Excellent

84-95 – Very Good

72- 83 – Good

60 – 71 – Satisfactory

40-59 – Unsatisfactory

From Table 2, the sample mean was 72.90 with a standard deviation of 10.450. This indicates that the respondents had a “Good” rating in this subject. Furthermore, this implies that the respondents generally have grades higher than the passing grade of 60 and that they are performing well in the subject.

Attitudes of the Respondents towards Chemistry

Another factor explored in this study which may correlate with the respondents' ability to depict mental models of chemical solutions is the attitude of each respondent towards Chemistry. Table 3 reveals the attitude rating of the respondents towards chemistry as a subject.

Table 3. Attitudes of the Respondents towards Chemistry

n	Mean	SD	Qualitative Description*
30	3.06	0.252	Positive

* 3.26-4.00 – Highly Positive

2.51-3.25 – Positive

1.76-2.50 – Negative

1.00-1.75 – Highly Negative

As can be seen from the above table, the respondents had a mean attitude rating of 3.06 and a standard deviation of 0.252. This means that the respondents generally have a positive attitude towards the subject which implies that the respondents generally like Chemistry.

Respondents' Prior Conceptions on Chemical Solutions

The third factor considered in this study is the respondents' prior conceptions of chemical solutions. These would include their acquired conceptions from their General Chemistry II subject during the First Semester of this course and their own conceptions from everyday experiences. Table 4 shows the respondents' prior conceptions rating on chemical solutions.

Table 4. Prior Conceptions Rating of the Respondents on Chemical Solutions

n	Mean Percentage	SD	Qualitative Description*
30	66.72	10.849	Satisfactory

* 96-100 – Excellent

84-95 – Very Good

72- 83 – Good

60 – 71 – Satisfactory

40-59 – Unsatisfactory

From the above table, the mean prior conception percentage rating is 66.72 with a standard deviation of 10.849. Thus, this indicates that they have a satisfactory rating. It can be noted however that this rating is just slightly above the passing mark. When compared to the mean performance rating in General Chemistry I, this was lower as the former was rated "Good". This implies the possibility that the respondents might have retained incorrect conceptions on chemical solutions even after the instruction of the topic.

Respondents' Abilities to Depict Mental Models of Chemical Solutions

The abilities of the respondents to depict mental models of chemical solutions were assessed using their drawings at the macroscopic, submicroscopic and symbolic levels. Table 5 shows the mental models rating of the respondents on chemical solutions.

Table 5. Mental Models Rating of the Respondents on Chemical Solutions

n	Mean Percentage	SD	Qualitative Description*
30	74.44	7.794	Good

* 96-100 – Excellent

84-95 – Very Good

72- 83 – Good

60 – 71 – Satisfactory

40-59 – Unsatisfactory

As shown in the above table, the respondents' mental models were found to have a mean mental models percentage rating of 74.44 with a standard deviation of 7.794. This rating has a qualitative description of "Good". This implies that the respondents are generally able to depict precise and accurate representations of chemical solutions at the macroscopic, submicroscopic and symbolic levels.

Respondents' Mental Models of Chemical Solutions

The findings suggest that the respondents' mental models of chemical solutions were generally in accordance to the scientific concepts. That is, they did not show many alternative conceptions. However, their ability to represent the concepts at the three levels of representations varied.

At the macroscopic level, they were able to depict their mental models by what they have observed in their laboratory classes and daily lives. At the submicroscopic level, they were able to depict their mental models by imagination at the particulate level. And finally at the symbolic level, the respondents were able to depict their mental models by using chemical symbols, chemical equations and mathematical formulas.

Three Focus Cards were shown for analysis by the respondents. Each focus card bore a question about a specific concept relating to chemical solutions. Also, each would require from the respondents to depict their answers in terms of mental models at the macroscopic, submicroscopic and symbolic levels.

For Focus Card 1, the respondents' understanding was first probed by asking, "What do you understand about 1M solution of sodium chloride"? And the following typical responses were obtained by all respondents:

Female Student 1: 1 mol/of NaCl per 1 liter solution. The NaCl dissociates in water, the positive end of the water attracts the Cl^- ion and the negative end is attracted to the Na^+ ion.

Female Student 2: 1 mol/L

Male Student 1: 1 mol NaCl/ L solution. The solute is NaCl and the solvent is water. Since NaCl is soluble in water, it is thoroughly dissolved in the solution.

Male Student 2: 1 M means 1 mole or 6.022×10^{23} NaCl particles present in 1 liter of solution

These data suggest that the respondents were successfully able to describe "1 M of sodium chloride". But in terms of mental models, some representations made by the respondents bore incorrect concepts. Examples of such depictions of mental models can be seen in Figure 4:

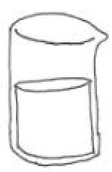
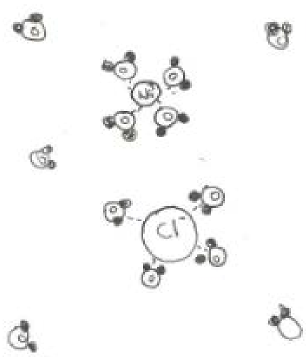
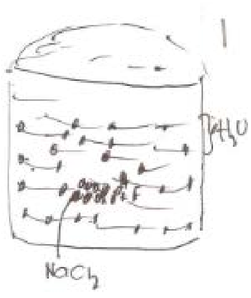
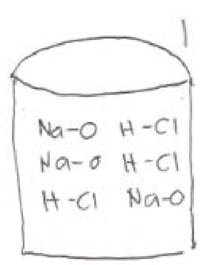
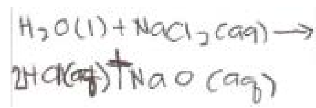
Level of Representation		
Macroscopic	Submicroscopic	Symbolic
Female Student 1's Drawing 		
Male Student 2's Drawing 		

Figure 4. Some respondents' depictions of 1 M solution of sodium chloride at the three levels of representation.

Female Student 1 was able to depict correctly the concept at the three levels of representation. At the macroscopic level, the respondent was able to draw what was observed in the laboratory. At the submicroscopic level, she was able to depict the dissociation of the NaCl substance to form Na^+ and Cl^- ions. Furthermore at this level, she was able to show the primary intermolecular force that caused the NaCl to be dissolved in water: the negative part of water is attracted to the Na^+ ion and the positive part of the water molecule was attracted to the Cl^- ion. At the symbolic level, she was also able to represent the dissolution of solid NaCl in water to form aqueous Na^+ and Cl^- ions.

On the other hand, Male Student 2 had misconceptions. At the macroscopic level, he mistook the formula of sodium chloride to be $NaCl_2$ when it should have been NaCl. Furthermore at the submicroscopic level, he wrongly depicted the solution, stating that NaO and HCl species were present. When asked about this, the respondent showed his symbolic mental model and answered that a reaction happened causing the formation of such products. This is a wrong concept because in dissolution, no new products are formed; the NaCl is just dissociated into its ions.

For Focus Card 2, the respondents' understanding was first probed by asking, "What do you understand about 10% w/v sugar solution?" And the following were typical of the responses obtained from all respondents:

Female Student 1: The solute is sugar and the solvent is water. For example, a 1 liter solution contains 100 grams sugar.

Female Student 3: 10% w/v sugar solution means that the volume of the solution is ten times greater than the solute's weight.

Male Student 3: It is a solution of a certain volume of solvent and a solute with a mass that is 10% of the total volume of the solution.

Based on the responses, it can be said that the respondents provided the correct answer. But their representations varied when asked to depict the concepts of dilute and concentrated solutions at the macroscopic, submicroscopic and symbolic levels. To recall, the respondents were considered to be "more able" to depict the mental models of chemical solutions when they obtained total percentage ratings between 72 and 100. On the other hand, they would be considered "less able" to depict the mental models of chemical solutions when they obtained total percentage ratings lower than 72. Figure 5 shows a more able respondent's depictions of the differences between a dilute solution and concentrated solution.

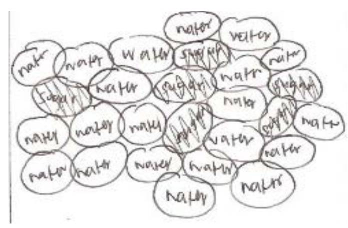
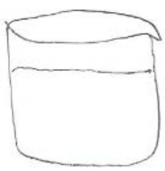
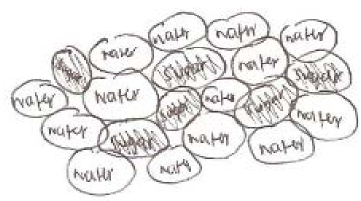
A dilute solution Level of Representation		
Macroscopic	Submicroscopic	Symbolic
		$C_nH_{2n}O_{n\,(s)} \rightarrow C_nH_{2n}O_{n\,(aq)}$
A concentrated solution Level of Representation		
Macroscopic	Submicroscopic	Symbolic
		$C_nH_{2n}O_{n\,(s)} \rightarrow C_nH_{2n}O_{n\,(aq)}$

Figure 5. Sample of a more able student's depictions of the differences between a dilute solution and concentrated solution.

From Figure 5, it can be seen that the student was able to depict the concepts of dilute and concentrated solutions at the three levels of representations. The difference between the two types of solutions was further correctly pointed out in the submicroscopic level wherein there were a greater number of sugar particles in the concentrated solution than in the dilute solution. Also emphasized correctly in that level were the attachments of the water molecules to the sugar molecules thus showing the intermolecular forces existing between the two. This was a correct concept since sugar would dissolve in water mainly due to hydrogen bonding between the –OH parts of both molecules. This hydrogen bonding would cause the separation of the sugar molecules and be surrounded by water molecules. But this force is not enough to break apart a molecule of sugar. In contrast, misconceptions can be seen in Figure 6.

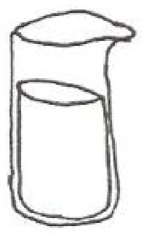
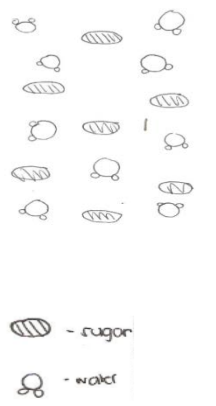
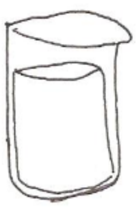
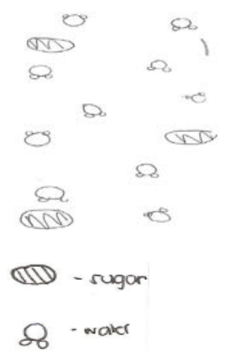
A concentrated solution Level of Representation		
Macroscopic	Submicroscopic	Symbolic
		$sucrose_{(s)} + H_2O_{(l)} \rightarrow sucrose_{(aq)} + H_2O_{(l)}$
A dilute solution Level of Representation		
Macroscopic	Submicroscopic	Symbolic
		$sucrose_{(s)} + H_2O_{(l)} \rightarrow sucrose_{(aq)} + H_2O$

Figure 6. Sample of a less able respondent's depictions of the differences between a dilute solution and concentrated solution

From Figure 6, the student was able to correctly depict the concepts of dilute and concentrated solutions both in the macroscopic and symbolic levels. But at the submicroscopic level, the student was not able to depict the concept correctly. In her drawing, she was able to depict the difference in the number of sugar particles in the dilute and concentrated solutions correctly. But the water and sugar molecules were separated from each other. Thus it failed to show the intermolecular force of attraction (hydrogen bonding) between the two types of molecules, which could have been responsible for the dissolution of sugar in water.

Lastly, the respondents were asked to depict for Focus Card 03 the distribution of ethyl alcohol, water and oil when they were poured into a beaker respectively. Figure 7 shows some depictions of such concept.

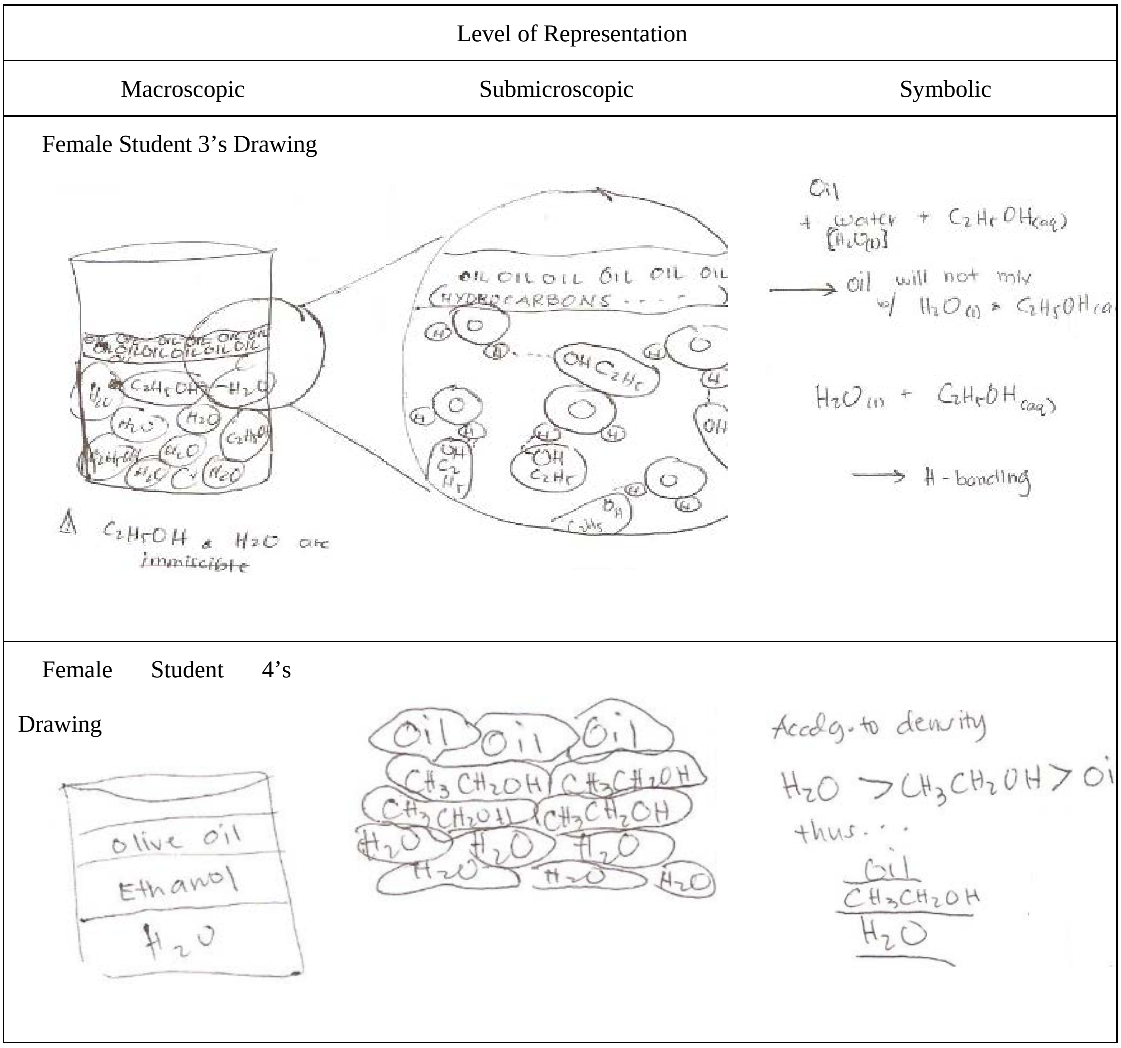


Figure 7. Some respondents' depictions of the distribution of oil, water and ethyl alcohol in a beaker.

The data in Figure 7 suggest that Female Student 3 had a good understanding of the mixture concept. She was able to show the immiscibility of oil and water and the miscibility of ethyl alcohol and water. On the other hand, Female Student 4 was able to depict the concept correctly at the symbolic level only in which the concept of density was involved. Female Student 4 failed to account for the miscibility of ethyl alcohol in water due to hydrogen bonding between the two types of molecules. Based on the respondents' depictions of mental models on chemical solutions, it can be said that the more able respondents were able to present consistent representations of chemical solutions at each level of representation.

In contrast, the less able respondents were able to depict in an unrelated manner the concepts at the three levels. They were able to create representations at symbolic levels and subsequently described the phenomena at the macroscopic and submicroscopic levels. However, these latter representations were typically unrelated to that at the symbolic levels. These implied that the less able students somehow struggled to connect the symbolic level to the submicroscopic and macroscopic levels. This was due to their failure to relate the solution concept to other related concepts such as intermolecular forces of attraction and solubility.

Thus, as might be expected, the students' mental models varied, with the more able students possessing more complete and more consistent mental models than their less able peers. The focus on the symbolic level may be related to the mode of chemistry instruction at PSHS-CVisC where the use of algorithms (e.g., in determining chemical solution concentrations) was often preferred due to the congestion of the topics.

These confirmed the findings of the study by Jansoon et al (2009) stating that the students' mental models for chemical solutions vary, with more able students possessing more complete, relational mental models than their less able peers. It also confirmed the findings of Dori and Hameiri (2003) stating that the students also struggle to connect the symbolic level with submicroscopic level. This means that the students can observe things when doing experiments at the macroscopic level, but find it difficult to explain the nature of matter at the symbolic level. This less focus on the symbolic level of representation may be related to the mode of chemistry instruction at PSHS-CVisC wherein much of the instruction would be done using algorithms and mathematical representations rather than through the particulate nature approach.

Correlation Between General Chemistry 1 Grade and Mental Models Rating, Attitude and Mental Models Rating, and Prior Conceptions and Mental Models Rating

Table 6 shows the correlation between the variables (General Chemistry I grade, prior conceptions and attitudes towards chemistry as a subject) and the abilities of the respondents to depict mental models of chemical solutions.

Table 6. Correlation Between General Chemistry 1 Grade and Mental Models Rating, Attitude and Mental Models Rating, and Prior Conceptions and Mental Models Rating

Variables	n	Mean	SD	Computed r	Description	p-value
General Chemistry 1 Grade and Mental Models Rating	30	72.90 74.44	10.45 7.79	0.370*	slight	0.044
Attitude towards Chemistry and	30	3.06 74.44	0.25 7.79	0.380*	slight	0.038

Mental Models Rating						
Prior Conceptions Rating and Mental Models Rating	30	66.72 74.44	10.85 7.79	0.384*	slight	0.036

***** significant

Legend:

0.00	no correlation
± 0.01 – ± 0.20	negligible
± 0.21 – ± 0.40	low/slight
± 0.41 – ± 0.60	marked/substantial
± 0.61 – ± 0.80	high
± 0.81 – ± 0.99	very high
1.00	perfect correlation

It can be seen from the table that the correlation coefficient r between the variables General Chemistry 1 grade and mental models rating has a value of 0.370 which signifies a slight correlation. However, the p-value is 0.044 which is less than α=0.05, hence significant. Thus the respondents' grade in General Chemistry I has a slight significant correlation with their ability to depict mental models of chemical solutions.

Also in the same table, the variables attitude towards chemistry and the mental models rating has a computed r of 0.370 which signifies a slight correlation. The p-value is 0.038 which is less than α=0.05, hence significant. This leads to the significant correlation between the respondents' attitude towards Chemistry and their ability to develop mental models of chemical solutions.

Thirdly, it can be seen from Table 6 that the computed r for the variables prior conceptions rating and mental models rating is 0.384 which signifies a slight correlation. Also, the p-value is 0.036 which is less than α=0.05, hence significant. Thus there is a significant correlation between the respondents' ability to develop mental models of chemical solutions and their prior conceptions on chemical solutions.

From the above findings, it can be said that the abilities of the respondents to depict mental models of chemical solutions are affected by their performance in the chemistry subject, the level of prior understanding and their attitudes towards the subject. The findings of this study confirmed the findings of Pintrich and Schunk (1996) stating that the performance of the students is influenced by their motivation. Furthermore, in a study by Kan and Akbas (2006), it was stated that the attitude towards the chemistry course is a significant predictor of chemistry achievement. Also in a study by Jansoon, et al (2009), the students with higher chemistry aptitude were more able to depict correct mental models of solutions than those with lower chemistry aptitude. Finally, the findings of this study supported the findings of (Treagust, Chittleborough, & Mamiala, 2003) that the students' understanding of concepts at the three level of representation: macroscopic, submicroscopic and symbolic levels are influenced by factors such as how they regard chemistry as a subject, and how complete their understanding of the concepts is.

Comparison Between Male and Female Respondents in terms of their Mental Models Rating

Table 7 shows the comparison between the male and female respondents in terms of their mental models rating.

Table 7. Comparison Between Male and Female Respondents in terms of their Mental Models Rating

Sex	n	Mean	SD	Mean Difference	Computed *t*	*p*-value
Male	15	75.5553	7.85312	2.22200	0.775*	0.445
Female	15	73.3333	7.84207			

*not significant

It can be seen that the rating for the males (Mean =75.5553, SD =7.85312) has no significant difference compared to that of the females (Mean =73.3333, SD =7.84207), with a computed value of t =0.775, *p*-value = 0.445. This means that there is no significant difference between males and females in terms of their ability to depict mental models of chemical solutions. It may mean that sex has no bearing on one's ability to depict mental models of chemical solutions.

The findings of this study negated that of the study by Tenaw (2013) stating that there is a significant difference in the Chemistry achievement between sexes.

4. Conclusion

One's ability to depict mental models of scientific concepts can be enhanced by certain factors. In this study, the attitudes of students towards Chemistry, their prior conceptions of the subject matter and performance in prerequisite subjects are key determinants in their performance to depict mental models of chemical solutions.

Acknowledgments

The author wishes to thank Philippine Science High School-Central Visayas Campus and the Masters of Education Program of the University of the Philippines- Cebu Campus for their support.

References

[1] Bealle, H., & Prescott, S. (1994). Concepts and calculations in chemistry teaching and learning. *Journal of chemical education, 71*(2), 111-112.

[2] Bunce, D., Gabel, D., & Samuel, K. B. (1991). Enhancing chemistry problem-solving achievement using problem categorization. *Journal of Research in Science Teaching, 28*(6), 505-521.

[3] Calik, M. (2005). A Cross-Age Study of DIfferent Perspectives in Solution Chemistry from Junior to Senior High School. *International Journal of Science and Mathematics Education, 3*, 671-696.

[4] Calik, M., & Ayas, A. (2005). A Cross-age STudy on the UNderstanding of Chemical Solutions and their Components. *International Education Journal, 6*(1), 30-41.

[5] Calik, M., Ayas, A., & Coll, R. K. (2009). Investigating the Effectiveness of an Analogy Activity in Improving the Students' Conceptual Change for Solution Chemistry Concepts. *International Journal of Science and Mathematics Education*, *7*, 651-676.

[6] Calik, M., Ayas, A., & Coll, R. K. (2010). Investigating the Effectiveness of Teaching Methods Based on a Four-Step COnstructivist Strategy. *J Sci Educ Technol, 19*, 32-48.

[7] Calik, M., Ayas, A., Coll, R., Unal, S., & Costu, B. (2006). INvestigating the Effectiveness of a Constructivist-Based Teaching Model on tudent Understanding of the Dissolutionof Gases in Liquids. *Journal of Science Education and Technology, 16*(3), 256-270.

[8] Coll, R., & Treagust, D. (2003). Investigation of secondary school, undergraduate, and graduate learners' mental models of ionic bonding. *Journal of Research in Science Teaching, 40*(5), 464-486.

[9] Dahsah, C., & Coll, R. K. (2008). Thai Grade 10 and 11 students' understanding of stoichiometry and related concepts. *International Journal of Science and Mathematics Education, 25*(2), 573-600.

[10] Dori, Y. J. & Hameiri, M. (2003). Multidimensional analysis system for quantitative chemistry problems: Symbol, macro, micro and process aspects. *Journal of Research in Science Teaching, 40*(3), 278-302.

[11] Dunnivant, F. M., Simon, D. M., & Willson, S. (2002). The making of a solution: A simple but poorly understood concept in chemistry. *The Chemical educator, 7*(4), 207-210.

[12] Gabel, D. L. (1999). Improving teaching and learning through chemistry education research: A look to the future. *Journal of Chemical Education, 76*(4), 548-554.

[13] Gilbert, J., Watts, D., & Osborne, R. (2005). Eliciting student views using an interview-about-instances technique. In J.K.Gilbert, & J. Gilbert (Ed.), *Constructing wolrds through science education: the selected works of John K.Gilbert.* London: Routledge.

[14] Hinton, M. E., & Nakleh, M. B. (1999). Students' microscopic, macroscopic and symbolic representations of chemical reactions. *The Chemical Educator, 4*(4), 1-29.

[15] Jansoon, N. C. (2009). Understanding mental models of dilution in thai students. *International Journal of Environmental and Science Education, 4*(2), 147-168.

[16] Johnstone, A. H. (1993). The development of chemistry teaching: A changing response to changing demnad. *Journal of Chemical education, 70*(9), 701-705.

[17] Kan, A., Akbas, A. (2006). Affective Factor that Influence Chemistry Achievement (Attitude and Self Efficacy) and the Power of these Factorsto Predict Chemistry Achievement – I. *Journal of Turkish Science Education, 3*(1), 76-84.

[18] Lythcott, J. (1990). Problem solving and requisite knowledge of chemistry. *Journal of chemical education, 67*(3), 248-252.

[19] McElroy, L. J. (1996). Teaching dilutions. *Journal of Chemical Education, 73*(8), 765-766.

[20] Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International journal of Educational Research 31*. 459-470

[21] Rompayom, P., Tambunchong, C., & Dechsri, P. (2011). Using open-ended questions to diagnose students' understanding of inter- and intramolecular forces. *US-China Education Review, B*(1), 12-23.

[22] Salta, K., & Tzougaki, C. (2004, April 26). Attitudes Toward Chemistry Among 11th Grade Students in High Schools in Greece. *Wiley Periodicals, Inc.*

[23] Unal, S., Calik, M., Ayas, A., & Coll, R. K. (2006). A review of chemical bonding studeies: needs, aims, methods of exploring studnets' conceptions, general knowledge claims and students' alternative conceptions. *Research in Science and Technological education., 24*(2), 141-172.

[24] Wang, M. (2000). An introductory exercise on solution preparation: A rewarding experience. *Journal of Chemical Education, 77*(2), 249-250.

[25] Philippine Science High School Central Visayas Campus Website. http://cvisc.pshs.edu.ph. 2011. Accessed: 03 October 2013.