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Problem Solving Ability of High School Chemistry Students

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Abstract

Problem solving is defined as important abilities for students in quantitative chemistry. The literature suggests that many high school students faced difficulty in learning quantitative chemistry due to the lack of problem solving abilities. There are three main components of problem solving which are; 1) ability to understand the problem; 2) ability to connect the related concepts; and 3) ability to solve the problem and find correct the answer. However, a little literature indicated which components of problem solving that most challenge for the high school chemistry students, and rarely research studied about the topic of solution. Thus, this study aimed to explore students problem solving ability in each component using concepts of solution. The participants were 50 high school chemistry students (Grade 11) who had learned solution topic. The research instrument was open-ended problem solving test, 16 items, that constructed by the researchers. The chemistry concepts include concentration and preparation of solution. The test were validated by three experts. The results indicated that many students faced difficulty in all components of problem solving abilities which were at needs improvement level. There were 30, 30, and 54 percent, respectively. The most challenge component was ability to solve problem and find correct answer since no student in the strength level. In addition, the findings pointed out that the students faced more difficulty in solving problems in the concepts of mole fraction, preparation of solution, molarity, and molality. The finding of this study suggested that to be successful in the teaching quantitative chemistry, the instructors need to take more consideration about students problem solving abilities, especially the ability to solve the problem and find the answer, and scaffold them using variety of techniques to improve their problem solving abilities until they are able to solve quantitative chemistry effectively.

1. Introduction

Problem solving is a process of finding solution to difficulty or complex problems or issues, which is a kind of thinking ability [1,2]. In learning chemistry, problem solving is an essential ability for students, especially, in quantitative chemistry where most curriculums and examinations focus on numerical answers. The development of such abilities requires systematic and clear process, and need to be easy to identify students' abilities in solving problems. The literature suggested that the problem solving abilities include three components: 1) ability to understand the problem, 2) ability to connect the related concepts, theory, formulae and equations, 3) ability to solve the problem scientifically or mathematically in order to get correct answers [3,4]. Chemistry is a complicated subject especially in quantitative chemistry that involved both conceptual understanding and numerical problem solving such as stoichiometry, rate of chemical reaction, chemical equilibrium, acid-base, and solution topic [5,6,7].

The solution is a fundamental topic of many topics in chemistry, for example, rate of chemical reaction in which students should be able to calculate concentration at a specific time; chemical equilibrium that students should be able to determine the concentration of reactants and products at the equilibrium; and acid-base where students should be able to prepare solution for titration.

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However, rarely research done about problem solving in solution concepts, except, the study by researchers while studying students problem solving in stoichiometry [8].
The research study pointed out that students were incapable of solving problems in solution topic because students tend to memorize and use formulae to calculate the chemical concentration instead of comprehending each unit of solution concentration. Also, students could not explain symbols in formulae they used, leading to miscalculation. Thus, this research aims to examine the problem solving abilities of high school students in the topic of solution.

2. Research Methodology

2.1 Participants

The participants were 50 eleventh-grader students who are in a science program and had studied solution topic in the first semester of 2016. They were from an all-boys high school in Bangkok where one of the researcher teaches chemistry.

2.2 Research Instrument

The research instrument used in this study was an open-ended written test. The open-ended question allows students to freely express their ideas and understanding toward a particular concept; enables researchers to evaluate them in precise way. The process of developing this instrument was as follows:

1) Constructed the learning objectives based on high school science textbooks [8].
2) Studied the relevant documents about problem solving abilities, and their evaluation and assessment.
3) Developed the item specification table, items prompt and its scope which covers six topics of solution, namely, percent (percent by mass, by volume, and by mass/volume), parts per million and billion (ppm and ppb), molarity (mol/dm^3), molality (mole/kg), mole fraction, and solution preparation.
4) Proposed to the thesis advisor for validity and appropriation of the instrument and each item prompt.
5) Checked validity and appropriateness of the items prompt by three experts using an Index of Item-Objective Congruence (IOC). The IOC of each items equals to 1.0. It indicated that all items could be used.
6) Tried out the items with 50 high school students to check language comprehension of each items and appropriate time for testing. Reliability of the instrument is 0.785.
7) The final version of the instrument includes 16 items and the time to complete all items is 60 minutes.

2.3 Data collection

The data was collected from the 50 eleventh-graders students in a science program who had studied solution topic in a chemistry classroom in the first semester of 2016. The test lasted for 60 minutes where 50 (equals to 100 percent) of the test were returned.

2.4 Data Analysis

Each response was analyzed carefully through three components of the problem solving ability: 1) ability to understand the problem; 2) ability to connect the related concepts; and 3) ability to solve the problem and find correct the answer. The answers were categorized into three levels; 1) Needs Improvement (0-2 score): signified no answer or partial relevant data, 2) Competent (2.1-4.0 score): signified an answer and objective while showing partial or all relevant concepts; the problem may not be solved or completely solved, 3) Strength (4.1-6.0 score) signified an answer covering all the required material and relevant concepts, formulae, and got the correct answers. Each component was taken into account and evaluated of total 32 score; Needs Improvement (0-11 score), Competent (12-22 score), and Strength (23-32 score).

3. Result

The results of problem solving abilities of the students were justified in three level of competence and sorted by the three components including 1) ability to understand the problem; 2) ability to connect the related concepts; and 3) ability to solve the problem and find correct the answer, as shown in Table1**.** The problem solving abilities for each solution topic (percentage, parts per million and billion, molarity, molality, and solution preparation) are elaborated in Table 2**.**

Table 1. Levels of Competence in Three Components of Problem Soving Abilities.

Topic	Number of Students [percent] (N = 50)		
	Needs Improvement	Competent	Strength
Ability to understand the problem	15 [30.00]	29 [58.00]	6 [12.00]
Ability to connect the related concepts	15 [30.00]	19 [38.00]	16 [32.00]
Ability to solve the problem and find correct the answer	27 [54.00]	23 [46.00]	0 [0.00]

Table 2. Level of Competence in Problem Dolving in Solution Topic Problem Solving.

Topic	Number of Student [percent] (N = 50)		
	Needs Improvement	Competent	Strength
Percent by Mass, Volume, or Mass/Volume	17 [34.00]	27 [54.00]	6 [12.00]
Parts per million and Part per billion	19 [38.00]	19 [38.00]	12 [24.00]
Molarity	19 [38.00]	28 [56.00]	3 [6.00]
Molality	20 [40.00]	26 [52.00]	4 [8.00]
Mole fraction	35 [70.00]	15 [30.00]	0 [0.00]
Solution Preparation	29[58.00]	13 [26.00]	8 [16.00]

4. Conclusion

The results suggest that the majority of the students were able to understand and identify a given problem including its objective, and 58% of the students were in strength level. However, the majority struggled with an ability in solve problems scientifically or mathematically in order to get correct answers. Fifty four percent of the students were in needs improvement level and none reached the strength level. Regarding to another component; ability to connect the related concepts, the result was varied. Thirty percent of the students were in needs improvement level, 38% in competent level, and 32% in strength level.

The data provided in Table 2 regarding each topic in solution indicated that students struggled in mole fraction concept the most, which is 70% of the students in needs improvement level. The other concepts that challenge to most of the students were solution preparation which 58% of the students in needs improvement level. The concepts that most of the students were in competent level were solution percent (54%), molarity (56%), and molality (52%). Only few students were in strength level in all topic, especially, the mole fraction which none of students was in strength level.

The results implied that the students who have studied solution had difficulty in solving the given problems because they could only understand the problems but could not identify related concepts or theories to solve the problems; agreeing with the previous work by the researcher [2,4,7]. It is saying that students cannot solve solution problems as they had lack of an understanding of solution

concepts and focused only on using formula to get correct answers instead of understanding the meaning of each symbols in the formula. As a result, they could not explain these symbols which contributed to miscalculation. Due to the fact that the students struggled with calculation and confusion over symbols, teaching that focuses on drilling without proper understanding of its core would lead students to miscalculation, misconception, and hinder the problem solving abilities in relevant topics [6,7]. The results of this study suggest that teachers need to take into consideration about the importance of improving students' problem solving abilities while teaching solution topic, and related topics.

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References

[1] Su, K.D., "Strengthening strategic applications of problem solving skills for taiwan students' chemistry understanding", Journal of Baltic Science Education, 2016, 662-679.
[2] Criswell, B.A. & Greg, T.R., "Activity structures and the unfolding of problem solving actions in high- school chemistry classrooms", Journal of Research in Science Education, 2014, 155-188.
[3] Duran, M., "An academic survey concerning high school and university students' attitudes and approacher to problem solving in chemistry", International Journal of Environmental & Science Education, 2016, 819-837.
[4] Krause, S. & Tasoji, A., "Diagnosing students' misconceptions on solubility and saturation for understanding of phase diagrams", Journal of Amarica Society for Engineering Education, 2007, 1-12.
[5] Gok, T. & Ozge, G., "Peer instruction in chemistry education assesment of students' learning strategies, conceptual learning and problem solving", Journal of Asia-Pacific Forum on Science Learning and Teaching, 2016, 1-21.
[6] Dahsah, C. & Richard, K.C., "Thai grade 10 and 11 students' understanding of stoichiometry and related concepts", Internationnal Journal of Science and Mathematics Education, 2008, 573-600.
[7] Dahsah, C. et al., "Enhancing grade 10 Thai students' stoichiometry understanding and ability to solve nummerical problems via a conceptual change perspective", Journal of Science and Mathematics Education in Southeast Asia, 2008, 1-43.
[8] The Institute for the Promotion of Teaching Science and Technology, Chemistry 2 Teacher' s Manual, Office of the Welfare Promotion Commission for Teachers and Education Personal Publisher, Bangkok, 2013.