Views of solubility of pre-service science teachers

İ. Afşin Kariper
Erciyes University, Faculty of Education, Department of Primary Education, 38039, Kayseri, Turkey.

E-mail: akariper@gmail.com

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Abstract

The purpose of this study is to learn how the pre-service science education students understand solubility concept, how are they imagining solubility at their mind and how we can help for their understanding. The students strained imagining in their mind about matter molecules, ions and so do not understanding of solubility. Solubility is one of the themes in primary schools in Turkey. The pre-service science education students will educate primary school students. If a teacher do not know to explain a subject, he/she will not transfer own knowledge. Because of this problem, their students have misconception, erroneous learning, etc… Semi-structured interviews and written exams are used to explore students' ideas and mental models about solubility. This investigation is applied at laboratory lesson for pre-service science education students. The students' contribution was 22 male and 49 female. The implications and recommendations for pedagogy are discussed as conclusion of this paper.

Keywords: Solubility, Mental models, Pre-service science education students.

Resumen

El propósito de este estudio es conocer cómo los estudiantes de pre-servicio de educación científica comprenden el concepto de solubilidad como se imaginan la solubilidad en su mente y cómo podemos ayudar a su comprensión. Los estudiantes se mantienen en tensión en su mente mientras se imaginan las moléculas de la material, y los iones, por lo que esto no representa la comprensión de la solubilidad. La solubilidad es uno de los temas de comprensión en las escuelas primarias en Turquía. Los estudiantes de pre-servicio de educación en ciencias irán a educar a estudiantes de escuelas primarias. Si un maestro no sabe explicar el tema él/ella no va a transferir el conocimiento propio. Debido a este problema, los estudiantes captan una idea falsa de aprendizaje, etc. Las entrevistas semiestructuradas y exámenes escritos se utilizan para explorar las ideas de los estudiantes y los modelos mentales acerca de la solubilidad. Esta investigación se aplica durante el curso de laboratorio para los estudiantes de pre-servicio en educación científica. La contribución de los estudiantes fue de 22 varones y 49 mujeres. Las implicaciones y recomendaciones para la pedagogía se discuten como conclusión de este trabajo.

Palabras clave: Solubilidad, modelos mentales, estudiantes de pre-servicio en educación de ciencias.

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I. INTRODUCTION

There are many ways of gathering information about students' understandings of scientific phenomena [1, 2]. Although many methods were applied to students by science educators, but the fundamental problem is always that the students do not understand science lessons or courses. A model is a representation of a phenomenon, an object or an idea [3]. The model can only relate to some properties of the target. Some aspects of the target must be excluded from the model [4].

There are different types of models in science education. Based on the literature [5];

1. Conceptual Models
   a) Mathematical Models
   b) Computer Models
   c) Physics Models
2. Mental Models

The term 'mental model' has been ascribed to the Scottish psychologist, Kenneth Craik. He mentioned that the mind constructs "small-scale models" of reality to foresee events, and to construct explanations [6]. According to Craik's view, mental models are dynamic and create representations of external world. Johnson-Laird [7] developed a theory of mental models that can explain a wide variety of phenomena in reasoning. The mental models are grounded in the way the world is represented. It is not the logical structure (such as in propositions) or some artificial constructions (such as circles standing for sets) that are represented, but rather single objects taking part in a situation and the relations among them. Of course, this very basic idea must be extended, for sets must be representable. However, the advantage of this account is that the world is represented in a simple and natural way. Johnson-

Laird showed that reasoning with mental models lead to logically valid conclusions when no limit of capacity was assumed. Also, Franco has described that mental models are psychological representations of real or imaginary situations. They occur in a person's mind as that person perceives and conceptualizes the situations happening in the world [8]. Gentner and Stevens conclude that mental models, like prior knowledge, influence our perceptions of phenomena and our understanding of information. Interactions with phenomena and representations, in turn, influence our mental models [7, 9]. The other studies, researchers have suggested that mental models are the internal representation of knowledge about the world [7, 9, 10].

The importance of mental and conceptual models can be shown in many fields, such as in physical and chemical concepts to explore complex and difficult subjects. This is the well-known that if a student don't have mental and conceptual models about an issue, he or she don't understand of this issue. Also, the students have misconceptions and don't understand of next issues.

II. WHAT IS PROBLEM AND AIM OF THIS STUDY?

Many researchers investigated understanding solubility of students. They deduced very strange. Çalık and Ayas studied misconception of mixing and solutions at grade of 7-10 [11]. They investigated preservation of mass, affect of mixed in solubility, solubility and physical changing. The students did not answer especially, natural of solubility. They understood that students understood shallow and they did not develop interrelationship between macroscopic and microscopic level. This means that students did not imagine of solubility on their mind. Kalın and Arıkıl also investigated misconception in solutions [12]. Their aims at found out how undergraduate students expressed dissolution in macroscopic level and particulate level and also tried to determine their misconceptions about the topic "solutions". They wanted to student shown structure and drawing of pure matter and solutions. % 3 and 0,5 of students could be drawing geometry or formulas of molecules and besides, they retained misconceptions. Tezcan and Bilgin studied about "Affects of Laboratory Method and Other Factors on the Student Success in the Teaching of the Solvation Subject at the High Schools" [13]. They divided the students as control and experimental groups. They strived to prove student success with laboratory education in solutions and solubility subject.

Therefore, this study aims at understanding how students imagine solubility and how it affects their understanding level and what are they have misconception about solubility and solubility concepts. Moreover, the laboratory education affected their understanding level in solubility subject?

III. METHOD

22 male and 49 female students were contributed in this study. Those students are pre-service students of education faculty in Erciyes University. Those students were to taken lesson from General Chemistry I/II in first class. The general chemistry lessons were sufficient for understanding solubility subject. In addition, their high school experience was taken into account their knowledge about solubility. Because they taken solubility subject from primary school to university. Just in case, a pre-exam was applied to students and then post exam and semi-interview.

IV. RESEARCH DESIGN

A. First Step

The study was applied a laboratory class which was expelled eight hour (four + four hour). Firstly, a pre-written exam (written exam) was applied for knowledge level of students about solubility subject. The educators were assigned in this study and they exchanged the students' written exam. The determination of exam papers was averaged given points by educators. The written exam divided two which were including of solubility, solutions and their concepts (Table I) and the other was a solubility table (Table II). The questions were easy and simple terms about solubility and terms in Table I.

Table I. Subject and distribution of scores pre-written exam.

Subjects	**Scores (points)**
Classify of Mixings	10
Solubility	6
Solutions	2
Solubility test (in Table 2)	16
Total Score	**34**

We want to understanding of students' knowledge about solubility and what they known about this subject. Then, the students were given a table about which matter solvable which solvent. This was a simple solubility test, in Table II.

Table II. Solubility test of matters in solvents.

Matters	**CCl_4**	**Water**	**Ethanol**	**HNO_3**
Salt (Solid powder)	-	+	+	+
Sulfur (Solid powder)	+	-	-	-
İodine (Solid grains)	+	-	+	-
Sugar (Solid powder)	-	+	+	+

In this step, students were not do this test with experimental. At this table, Salt dissolved water, ethanol and nitric acid. If the students wrote every "+" and "-", they would be given 1 point. At the totally, the students were given 16 points when they answered fully true answers. Partially solubility was

accepted in this score. We wanted that the students prospected the table II in first step. In the second step, they applied this solubility test and filled the table II, after they did solubility test in laboratory. We requested that if the students will not know anything about questions, they do not write anything in paper and in table. Because they did not take any point for lessons and didn't write their name and class.

B. Second Step

The students were applied solubility test to given table II with experimental. Tubes, tube holders, droppers and the other laboratory tools were distributed to students for applied solubility test experiment and explain step by step.

1. Please, take a little amount salt a spatula (for example 0.1 g) and put into tubes.
2. Then, Added water in tube until salt dissolved in water.
3. The water was added until end of volume of tubes.
4. Please, record your observation in table II.
5. Applied same things for other matters and solvents, try again.

The table II of first step and second step determined, separately. The students were given 16 points at this level. Then, we want to imagine dissolving of this matters and drawing empty papers. After the students drawn their figures on their mind, we did interview about their figures. Also, we asked them that diluted solution, concentrated solution and supersaturated solution and want to prepare to those solutions. All this study was applied two educators and determined did with interactively, so the educators were changing the students and exam papers, again.

V. RESULTS AND DISCUSSION

Firstly, we wondered that were students distinguished the mixings? They need to know homogenous and heterogeneous mixings, because of understanding solubility and solutions subject. They must distinguish solvable mixings and unsolvable mixings.

Our expectation that the students classified of mixings in pre-written exam that was ten points, totally; like as Table III and IV.

Table IV. Classify of mixings.

Mixings	Solid	Liquid	Gas
In solid	Alloys	Sponge	Solid foam
	Granite		
In liquid		Solutions	
	Suspensions	Emulsions	Detergent foam
In gas		Aerosols	Mixing of pure gasses

The red boxes were heterogeneous mixings, green boxes were homogenous mixing.

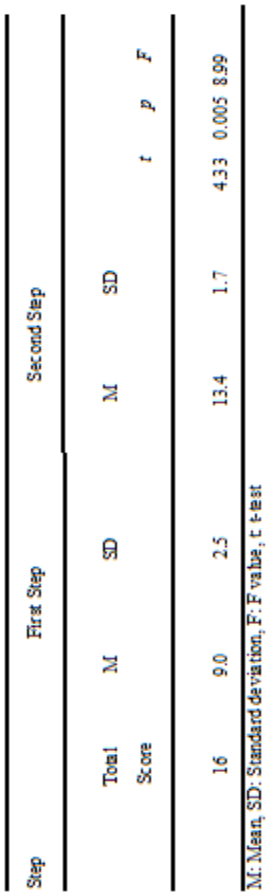
Table V. The student's scores, mean and standard deviation in pre-written exam and table II.

Subjects	M	SD
Classify of Mixings	5.7	1.1
Solubility and solutions	7.1	0.8
Solubility test of matters in different solvents (in Table II)	9.0	2.3
Total Score	**21.8**	

M is mean of students' score; SD is standard deviation of students' score.

The students obtained 5.7 point based on 10 point in classify of mixings section and the value of the 1.1 standard deviation was a little big value on 10 points. Because of this point, they were not answer about liquid-in solid, gas-in solid. The points of solubility and solutions (M: 7.1), which was based on 8 points, were higher than points of classify of mixings section. So, the standard deviation of solubility and solutions (SD: 0.8) was lower than classify of mixing sections. Nevertheless, those results showed that students had known some knowledge at intermediate level. The students taken 9 points based on 16 points on solubility test at first step. We understood that they did not have very big experience about solubility of matters when we asked at interview. However, they knew main concepts about solubility and solutions. The taken mean 21.8 points at 34 points.

TABLE VI. Determination of solubility test according to first and second step.



In the second step, the students were applied the solubility test and requested complete the table II. The results were very good according to first step. We determined to these results in Table V.

In the second step, the students did not make only two tests, actually, they did not decide to solvable or unsolvable of sulfur in CCl_4, iodine in HNO_3 and sulfur in HNO_3. The educators only shown an example relative to experiments, which was salt in water and carbon tetrachloride, they were very simple samples. Then the educators did not interfere anything, so the students decided to own decisions. According to table 5, the results shown that significant diversity occurred to the students, because of p value was lower than 0.05. According to Tezcan and Bilgin, this statistics sufficed and the students were successful with laboratory education [13]. It was true when we considered table 5. The answer was very easy at this situation? But sometimes, these statistical values did not suffice some measurements.

End of the second step, we asked some questions to the students for semi-interview. These some questions are listed at below:

- Why is the NaCl solubility in the water?
- Why is not the NaCl solubility in the CCl_4?
- Why is not the sulfur solubility in the water?
- Why are you deciding to solubility of sulfur to which solvent?
- What is the insolubility of sulfur to these solvents?

Then we raised the questions according to student's answers. We realized that the students well known solubility of some matters in aqua media. They answered;

- The water molecules surrounded of the salts and picked cat ions and anions when added a salt in the water. These anions scattered in the water, so this is solubility phenomena of salts in aqua media.

But they were not answer to solubility of sulfur in CCl_4 media. We asked them why sulfur was dissolving in the CCl_4. They answered;

- The sulfur was not decomposing with ions in CCl_4 media.

We understood their misconception phenomena about solubility. Then we continued the questions, we were to be sure about this problem. The students only imagined solubility that the solubility occurred with scattered of ions of matters in a solvent. Kalın and Arıkıl are to be right that the students were suffer to lack of mental concept and was not imagine solubility [12]. The students claimed that they only directed about on solubility phenomena in the aqua media. They were not known to how a matter behaved in the other Medias.

VI. CONCLUSION

We understand that the students have misconceptions about solubility. They think that the solubility is only about scattering of ions of matters and occurring. Some researchers were to emphasize these problems who are Kalın & Arıkılı [12] and Çalık & Ayas [11]. The students believed that scattering of ions phenomena affected the only important role in solubility. Also, we observed that they were not having some knowledge about solubility of matters in the other Medias. This problem occurred to understand of next issues of chemistry. For example, if a student does not understand of solubility, he or she will not prepare of a solution. This problem may be dissolve with develop to their mental and conceptual models or do with laboratory experiments very much as suggest of Tezcan & Bilgin [13] and Kariper [14].

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