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MENTAL MODELS OF PRE-SERVICE SCIENCE TEACHERS ABOUT BASIC CONCEPTS IN CHEMISTRY

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Abstract

The aim of this study was to investigate mental models of pre-service science teachers about basic concepts in chemistry. Cross-sectional research design was used in this study. The sample of the study consisted of 60 pre-service science teachers which were 15 freshmen, 15 sophomores, 16 junior, 14 senior. The drawings and the writing of the students about the basic concepts of chemistry, which we have asked to the participants as 5 open-ended questions, composed of the research data. The students are asked to answer these open-ended questions on the first page, and they were asked to draw their imaginations about the questions on the second page so that their mental images can be learned about these concepts of chemistry. Responses of questions and the students' mental models were compared with scientific answers/models, and were evaluated under five categories which were 'there is no drawing/expression', 'wrong or irrelevant drawing/ expression of question', 'partially correct drawing/ expression', 'the drawing/ expression that has some deficiencies', 'completely correct and complete drawing/ expression'. Tables including frequency were used analysis of data. The results of study indicated that relationship between levels of writing and drawings were interpreted according to class level.

Keywords: *mental models, pre-service science teachers, basic concepts in chemistry*

INTRODUCTION

Each other very closely related to the basic concepts in chemistry. Concepts in everyday language can easily be used interchangeably, although there are distinct differences between them as scientific. One of the biggest challenges the school day passed misperceptions and misconceptions of our daily lives (Yürümezoğlu and Çökelez, 2010). Students' misconceptions are known to cause difficulties for their learning of chemistry concepts (Bekiroğlu, 2007).

The latter part of last century witnessed a huge research effort into learners understanding of scientific concepts and overcoming misconception of basic scientific concepts (Coll, 2008). Much of the this research has been concerned with perceptions of learner's in abilities to understand scientific concepts or to develop conceptual understanding about mental models that are in accord with scientific or teaching models (Garnett et al., 1995; Pfundt and Duit, 1994,1997,2000). Theory-making and practice of chemistry and science is dominated by the use of mental models (Coll, 2008). This it is argued by many authors occurs since when scientists seek to understand macroscopic properties they inevitably need to consider what is happening at the microscopic level (Oversby, 2000). Because we cannot see what happens at the microscopic level we need to develop mental images or mental models of what happens at the microscopic level we need to develop mental images or mental models of what matter and its changes might be like at this level (Coll, 2008). The establishment of systematic links between concepts, but it is possible with the process of teaching a scientific. So, fact that abstract concepts and misconceptions in chemistry education is taught in this course requires the use of the model. (Treagust et.al., 2002).

The concept of mental model for the first time in the Gentner and Stevens (1983) faced by the students in the physical world, meanings and interpretations of daily events to create mental representations used to describe event. According to Norman (1983), Gilbert and Boulter (1998) these models are a special and personal models which the students created they had acquired earlier on the basis of the information. These are usually neither the specific of nor the scientific. Addition to being inadequate in some respects may contain completely the opposite, wrong, and unnecessary concepts (Norman, 1983; Hafner and Steward, 1995, Yürümezoğlu and Çökelez, 2010).

Mental models are one form of mental images, and as such represent personal mental constructions (Johnson-laird, 1983). Writers such as Piaget and Inhelder (1974) and Ausubel (1968) have stressed that mental construction depends strongly on what mental images individuals possess at the time they are attempting to learn new concepts (Coll, 2008). The literature then suggests that mental models represent personal mental constructions, although the process of construction may be mediated by a variety of factors. The personal nature of mental models means that they are intrinsically difficult to investigate (Coll, 2008).

While the importance of mental models has been raised in many fields, it is still considered a complex and difficult subject to explore. However, while it may be hard to explore individuals' mental models, it is still important in order to reveal individuals' thoughts about key concepts (Chang, 2007).

Information instead of memorizing the basic concepts of chemistry, the right mental models must be created for effective learning (Uzunkavak, 2009). Given that the concepts formed the basis of the issues would affect student achievement is occurring misconceptions. (Kara et.al., 2009).

Purpose and significant of study

Knowledge of basic concepts in chemistry is of great importance for chemistry education. Learning of chemistry issues, it is therefore important to distinguish between these basicconcepts. Therefore, students' beliefs about the topic to reveal this, you must determine the methods. In the literature, there are studies demonstrating ways of developing the wrong concepts (Halloun and Hestenes, 1985; Meyer, 1993; Krishman and Howe, 1994; Eryılmaz and Tatlı, 1999; Mustafa et al., 2003; Koray and Tatar, 2003; Can and Mansur, 2004; Ekiz and Akbaş, 2005). In addition, many methods for removing and preventing formation of incorrect conceptsdiscussed (Abimbola, 1988; Watts and Pope, 1989; Pearsall et al.,1997; Pines and West, 1986; Rowel et al., 1990; Cleminson, 1990; Büyükkasap and Samancı, 1998; Ertekin and Sulak, 2004; Wessel, 1999; Koray and Bal, 2002).

Using the method of drawing is able to determine conceptual changes in students' knowledge and misconceptions, is frequently used in recent years (White and Gunstone, 1992; Rennie and Jarvis, 1995; Şahin et al., 2008). By this method, students found out the hidden knowledge and beliefs without being dependent on words (Ayas, 2006). Students, by painting, the ability to use the information provided about metallic bonds, are much lighter than other measurement tools that were excised (Acar and Tarhan, 2008).

Purpose of this study was to compare basic knowledge level of students about the basic concept in chemistry using drawing method and turn out misconceptions on basic concept in chemistry.

METHOD

Research design

Cross-sectional study, which is a developmental research method, was used in this study. Groups are thought to be followed by the sample selected; the data is interpreted as a single sample collected.

Working group

The sample of the study consisted of 60 pre-service science teachers which were 15 freshmen, 15 sophomores, 16 junior, 14 senior. Data collection tool was applied students who volunteered to obtain in-depth knowledge and to achieve right result.

Data collection tool

The drawings and the answers of the students about the basic concepts of chemistry, which we have asked to the participants as 5 questions, composed of the research data. The students are asked to answer these open-ended questions on the first page, and they were asked to draw their imaginations about the questions on the second page so that their mental images can be learned about these concepts of chemistry. Responses of questions and the students' mental models were compared with scientific answers/models, and were evaluated under five categories (Table 2).

Table 1. Open-ended questions on the first page

Questions	Expression
1	What is the matter? Egg, table, chicken... Is it a matter and why?
2	When thrown into water-souble salt, salt is not visible. What do you thik the salt?
3	Even a thick sweater on a cold day can drain. What do you think the water which in a sweater?
4	When you set fire to wood turns black. What do you think that the wood its hardness?
5	Would you expect the formation of bubles in the water for macoroni throw into the water? This refers to what occurs in the bubles? What do you think at the time?

Analysis of data

Evaluation of the data takes into account levels given in table 2. Each grade level are evaluated separately, the levels presented frequency tables.

Table 2. Five-stage evaluation table which used assess levels of writing and drawing on basic concept in chemistry

Levels	Statement	Expression	Drawing
Level 1	there is no drawing/expression	E1	D1

Level 2	wrong or irrelevant drawing/ expression of question	E2	D2
Level 3	partially correct drawing/ expression	E3	D3
Level 4	the drawing/ expression that has some deficiencies	E4	D4
Level 5	completely correct and complete drawing/ expression	E5	D5

FINDINGS AND DISCUSSION

Students about the basic concept in chemistry by analyzing the expression and drawings, misconceptions and the level of information have been uncovered about concepts. To evaluate information and draw, five-stage evaluation grid established. Students' theoretical knowledge on the subject and drawing levels, scaled up from 1 to 5. The selected sample drawings in accordance with levels, seen in figure 1, figure 2, figure 3 and figure 4.

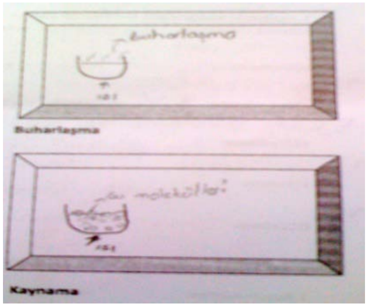

Figure 1. Partially correct drawing (sophomore)

In the example selected in accordance to level 3, the student interpreted as the boil at every point, and stated that the transition from liquid into gas. Also reduce evaporation by saying that only the surface, his expression was determined according to E3.

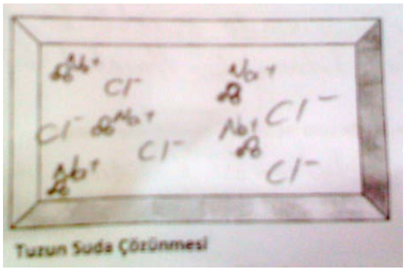

Figure 2. The drawing that has some deficiencies (senior)

In the example selected in accordance to level 4, the student interpreted as the dissolution of substance solubility in the solvent not see it as E4 level appropriate an expression.

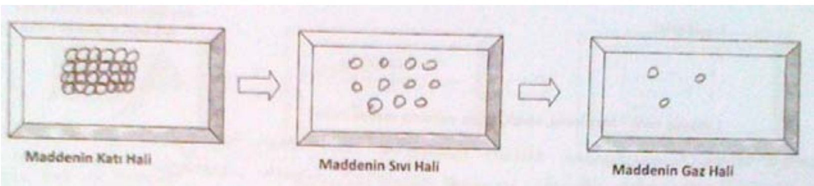

Figure 3. Wrong or irrelevant drawing of question (freshmen)

In the example selected in accordance to level 2, the student interpreted as matter is everything, in fact, nothing.

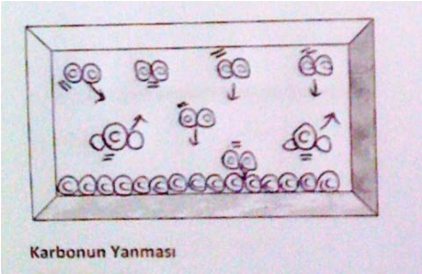

Figure 4. Completely correct and complete drawing (junior)

In the example selected in accordance to level 5, the student interpreted as for combustion of carbon, carbon reacts with oxygen to form carbon dioxide.

Students' responses were analyzed; writing and drawing levels were tabled for each question. Distribution of these levels according to the class we can see the tables below.

Table. 3 Distribution of class levels as matter concept

	Freshmen					Sophomore					Junior					Senior				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
D1																				
D2		12	2	1			2	4					3	2					3	
D3								9					4	7				5	6	
D4																				
D5																				

We can look Table 3, we can say as matter concept in terms of level collected the majority that freshmen know wrong and misconfigured in mind, sophomore partially the right to know and partially correct configured in mind, there are some missing in information and partially correct configured in mind for junior and senior.

Table 4.Distribution of class levels as dissolution

	Freshmen					Sophomore					Junior					Senior				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
D1																				
D2		9	2				3	8				2	4						4	
D3		2	2				4					10						1	9	
D4																				
D5																				

We can look table 4, we can say as dissolution concept in terms of level collected the majority that freshmen know wrong and misconfigured in mind, sophomore partially the right to know and misconfigured in mind, junior know wrong and partially correct configured in mind, senior partially the right to know and there are some missing in information .

Table 5. Distribution of class levels as evaporation

	Freshmen					Sophomore					Junior					Senior				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
D1																				
D2			9	2			1						1	5					5	
D3				4			4	10					2	8				2	7	
D4																				
D5																				

We can look table 5, we can say as evaporation concept in terms of level collected the majority that freshmen know wrong and misconfigured in mind, sophomore partially the right to know and partially correct configured in mind, there are some missing in information and partially correct configured in mind for junior and senior.

Table 6. Distribution of class levels as combustion

	Freshmen					Sophomore					Junior					Senior				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
D1																				
D2		11	3				5						4	5				1	3	
D3			1					10						7				1	9	
D4																				
D5																				

We can look table 6, we can say as combustion concept in terms of level collected the majority that freshmen know wrong and misconfigured in mind, sophomore partially the right to know and partially correct configured in mind, there are some missing in information and partially correct configured in mind for junior and senior.

Table 7. Distribution of class levels as boil

	Freshmen					Sophomore					Junior					Senior				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
D1		4																2		
D2		11					10						5				4	7		
D3							2	3					6	5				2		
D4																				
D5																				

We can look table 7, we can say as boil concept in terms of level collected the majority that freshmen know wrong and misconfigured in mind, sophomore know wrong and misconfigured in mind, junior partially the right to know and partially correct configured in mind, senior know wrong and misconfigured in mind.

CONCLUSION AND SUGGESTIONS

Results which turned out discussion of students' writing and drawing levels can be summarized as follows.

- ✓ Grade level increases, were seen expressed more accurate, more accurate configured in their minds for matter, evaporation and combustion concepts.
- ✓ It is not showed that difference between know and draw of the dissolution concept with class levels. But, we can say that for the concept of dissolution, even if students' knew the wrong, the correct configure their minds or vice versa.
- ✓ It is not showed that difference between know and draw of the boil concept with class levels. But, we can say that most of the students are wrong know and configured in correctly.

In addition, when we look at the results of the study, according to class level and students can see how that knowledge and misconceptions on this subject can see that. Therefore, the method of drawing is seen to be effective in revealing students' misconceptions about basic concepts in chemistry. Misconceptions about basic concepts in chemistry can be listed as follows:

As freshmen:

1. Evaporation and boiling is the same thing.
2. Dissolution is only ionic.
3. Dissolution of solid and liquid is just.
4. Solid-state, the molecules do not move because it is very cramped.
5. Combustion is the change of state.

As sophomores:

1. Evaporation is then boils.
2. Melting and dissolving the same thing.
3. Solids and liquids in volatility are due to only the election movement.
4. Molecules in the solid do not move.

As junior:

1. Melting and dissolving the same thing.
2. Solid- state, the molecules do not move.
3. Evaporation happens only at high temperatures.

4. When water evaporated, breaks down the oxygen and hydrogen atoms.
As senior:
1. Solid-state, the molecules do not move much because the molecules are trapped state.
2. Solid-liquid-gas case is the movement of vibration.
3. Dissolution and melting is the same thing.
4. Boiling happens on the surface.
5. Evaporation and boiling is the same thing.
6. Gas phrase will not matter.

REFERENCES

Abimbola, I. O., (1988). The Problem of Terminology in The Study of Students Conceptions in Science. *Science Education*, 72, 175–184.

Acar, B. and Tarhan, L., (2008). Effects of Cooperative Learning on Students' Understanding of Metallic Bonding. *Resarch in Science Education*, 38, 401–420.

Ausubel, D.P. (1968). *Educational psychology: A cognitive view.* New York: Holt, Rinehart & Winston.

Ayas, A., (2006). *Kavram Öğrenimi, Fen ve Teknoloji Öğretimi* (Edt: S. Çepni). PegemaYayıncılık, Ankara.

Bekiroğlu, F. (2007). Effects of model-based teaching on pre-service physics teachers' conceptions of the moon, moon phrases, and other lunar phenomena. *International Journal of Science Education*, 29(5), 555-593.

Büyükkasap, E. and Samancı, O., (1998). İlköğretim Öğrencilerinin Işık Hakkındaki Yanlış Kavramları. *Kastamonu Eğitim Dergisi*, 4(5), 109-120.

Can, Ş. and Mansur, H., (2004). Fen Bilgisi Öğretmenliği ve Sınıf Öğretmenliği Öğrencilerinin Kimyasal Bağlar Konusundaki Kavramsal Yanılgıları. *İ.Ü Eğitim Fakültesi Dergisi*, 5(8).

Chang, S. (2007). Externalising Students' Mental Models Through Concept Maps. *Journal of Biological Education*, 41(3), 107-112.

Cleminson, A., (1990). Establishing and Epistemological Base for Science Teaching in The Light of Contemporary Nations of The Nature of Science and of How Children LearnScience. *Journal of Research in Science Teaching*, 27(5), 429-445.

Coll, R.(2008). Chemistry Learners' Prefered Mental Models for Chemical Bonding. *Journal of Science Education*, 5(1), 22-47.

Ekiz, D. and Akbaş, Y. (2005). İlköğretim 6.Sınıf Öğrencilerinin Astronomi ile İlgili Anlama Düzeyi ve Kavram Yanılgıları. *Milli Eğitim Üç Aylık Eğitim ve Sosyal Bilimler Dergisi*, 32(165), 61-78.

Ertekin, E. and Sulak, H., (2004). Denklem Kurmadaki Hata ve Yanılgıların Teşhisi ve Alınması Gereken Tedbirler. *Selçuk Üniversitesi Eğitim Fakültesi Dergisi*, 18, 163-170.

Eryılmaz, A. and Tatlı, A., (1999). *ODTÜ Öğrencilerinin Mekanik Konusundaki KavramYanılgıları*. III. Fen Bilimleri Eğitimi Sempozyumu. 23-25 Eylül 1998, KTÜ, Trabzon,M.E.B. ÖYGM, 103-108.

Garnett, P.J., Garnett, P.J., & Hackling. M.W. (1995). Learners' alternative conceptions in chemistry: A review of research and implications for teaching and learning. *Studies in Science Education,* 25, 69-95.

Gentner, D. & Stevens, A. L. (Eds.). (1983). *Mental models*. Hillsdale, NJ: Erlbaum.

Gilbert, J. K. & Boulter, C. (1998). Models in explanations, Part 2: Whose voice? Whose ears?. *International Journal of Science Education*, 20 (2), 187-203.

Hafner, R. & Steward, J. (1995). Revising explanatory models to accommodate genetic phenomena: Problem solving in the "context of discovery". *Science Education*, 79 (2), 111-146.

Halloun, I. A. and Hestenes, D. (1985). Common Sense Concepts About Motion. *American Journal of Physics*, 53(11), 1056-1065.

Johnson-Laird, P. (1983). *Mental models: Towards a cognitive science of language, inference and consciousness*. Cambridge, MA: Harvard University Press.

Koray, Ö. and Bal, Ş., (2002), Fen Öğretiminde Kavram Yanılgıları ve Kavramsal Değişim Stratejisi, G.Ü. *Kastamonu Eğitim Fakültesi Dergisi*, 10(1), 83-90.

Koray, Ö. and Tatar, N., (2003). İlköğretim Öğrencilerinin Kütle ve Ağırlık ile İlgili Kavram Yanılgıları ve Bu Yanılgıların 6.,7. ve 8. Sınıf Düzeylerine Göre Dağılımı. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, 13, 187-198.

Krishman, S. R. and Howe, A. C. (1994). The Mole Concept: Developing An Instrument To Assess Conceptual Understanding. *Journal of Chemical Education*, 71(8), 653–655.

Meyer, D. K., (1993). Recognizing and Changing Students' Misconceptions, An InstructuralPerspective. *College Teaching*, 41(3), 104-109.

Mustafa, K., Uygar, K., and Rahmi, Y., (2003). Lise 3. Sınıf Öğrencilerinin Işık ve Optik ile İlgili Anlamakta Güçlük Çektikleri Kavramların Tespiti ve Sebepleri. *Milli Eğitim Dergisi*, 158.

Norman, D. N. (1983). *Some observations on mental models.* In D. Genterve Stevens, A.L. (Eds.) Mental models (pp. 7-14). Hillsdale, NJ: Erlbaum.

Oversby, J. (2000). *Models in explanations of chemistry*. In J.K. Gilbert & C.J. Boulter (Eds.),Developing models in science education (pp. 227-251). Dordrecht, Kluwer.

Pearsall, R. N., Skipper, J. E. J. and Mintzes, J. (1997). Knowledge Restructuring in The LifeSciences: Alongitudional Study of Conceptual Change in Biology. *Science Education*, 81,193-215.

Pfundt, H., & Duit, R. (1994). *Bibliography: Student's alternative frameworks and science education* (3rd ed.). Kiel, Germany: University of Kiel.

Pfundt, H., & Duit, R. (1997). *Bibliography: Student's alternative frameworks and science education* (4th ed.). Kiel, Germany: University of Kiel.

Pfundt, H., & Duit, R. (2000). *Bibliography: Student's alternative frameworks and science education* (5th ed.). Kiel, Germany: University of Kiel.

Piaget, J., & Inhelder, B. (1974). *The child's construction of quantities*. London: Routledge Kegan Paul.

Pines, A. L. and West, L. H. T., (1986). Conceptual Understanding and Science Learning: AnInterpretation of Research Within A Sourses of Knowledge Framework. *Science Education*, 70(5), 583-604.

Rennie, L. J. and Jarvis, T., (1995). Childrens Choice of Drawings To Communicate TheirIdeas About Technology. *Research in Science Education*, 25(3), 239-252.

Rowel, A.J., Dawson, C.J. and Harry, L., (1990). Changing Misconcepetions: A Challenge ToScience Education. *International Journal of Science Education*, 12(2), 167-175.

Şahin, Ç., İpek, H and Ayas, A., (2008). Student Understanding of Light Concept Primary Schools: A Cross-Age Study. *Asia-Pacific Forum on Science Learning and Teaching*, 9(1),Art:7

Treagust, D. F., Chittleborough, G., Mamila, T. L. (2002). Students' understanding of the role of scientific models in learning science. *International Journal of Science Education*, 24 (4): 357- 68.

Uzunkavak, M. (2009). Revealing discrimination skills of students between positive and negative work by writing and drawing method. *International Journal of Technologic Sciences*, 1(2), 10-20.

Wessel, W., (1999). *Knowledge Construction in High School Physics: A Student Teacher Interactio*, Saskatchewan School Trustees Association Research Center Report.

White, R.T. and Gunstone, R. F., (1992). *Probing Understanding*, The Falmer Press, London.

Yürümezoğlu, K. & Çökelez, A. (2010). Transmitting current a simple electric circuit students' opinions about what is happening. *Journal of Turkish Science Education*, 7(3), 147-166.