Determination Of Middle School Students' Misconceptions Related To The Unit Of "Structure And Properties Of Matter" Using A Two-Tier Diagnostic Test

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ABSTRACT
Studies on science education show that students have many misunderstandings and misconceptions related to chemistry concepts. Many techniques have been used to determine those misconceptions such as multiple choice tests, interviews, drawing, etc. Two-tier diagnostic test is one of these techniques for using to determine misconceptions and their reasons. For this reason, in this study, it was aimed to determine middle school students' misconceptions related to the unit of "Structure and Properties of Matter" using a Two-Tier Diagnostic Test. The study was conducted with two hundred twenty five 7th grade students, who had already learned the unit of "Structure and Properties of Matter" and studied at three different middle schools in İstanbul. In this study "Structure and Properties of Matter Achievement Test", which was developed by the researchers and ensured validity and reliability, was used to collect data. The test was a two-tier diagnostic test that consists 32 items. Reliability coefficient was found to be 0.90. According to the results, it was found that students had high level of misconceptions about the topics "Stable Atom, Ion, Anion, Cation, Ionic Bond, Covalent Bond, Compound, Homogenous and Heterogeneous Mixtures, Concentrated and Dilute Solutions".

INTRODUCTION
Today, learning takes place based on conceptual basis. This is why, it's very important that students learn concepts in a correct and effective way and make sense of them. The fact that learning basic concepts well, help students to learn further topics has been pointed out by researchers (Briggs and Holding, 1986; Griffiths and Preston ,1992). Although concept learning is important, a lot of problems are faced with in the teaching process. One of them is misconceptions (Alım, 2008, p.177). Misconceptions, can be defined as the information, derived as a result of personal experiences contrary to scientific facts that prevent teaching of scientifically proven facts (Chi and Roscoe, 2002; Koray et al. 2007). One of the most important issue in learning Science and Technology lesson has been regarded as students' misconceptions. In order to ensure meaningful and permanent learning, misconceptions should be identified and be remedied (Osborne and Freyberk, 1996; Baysarı, 2007). There are many studies addressing misconceptions in science in the literature. Research address that students have some misconceptions about the basic concepts of chemistry, such as "The Electron Array and Chemical Properties ", "Chemical Compounds", "Bonds and formulas" and "Mixtures" (Abraham et. al., 1992, 1994; Akgün and Aydın, 2009; Barker, 2000; Bayrak, 2005; Coştu et. al., 2005; Çalık and Ayas, 2005; Dindar et. al., 2010; Goodwin, 2002; Kabapınar, 2001; Lee et. al. 1993; Nicoll, 2010; Ozmen, 2004; Papageorgıou and Sakka, 2000; Say, 2011; Stavy ,1990; Taber, 1998; Tezcan and Salmaz, 2005; Uzun, 2010; Uzuntiryaki and Geban, 2005; Urek and Tarhan, 2005; Valanides, 2000).

Different techniques have been used in order to determine students' misconceptions. Techniques often used are; concept maps (Ross and Munby,1991), conversation (Osborne and Gilbert, 1980; Coll and Taylor, 2001; open-ended questions (Glazar and Vrtacnic, 1992) and multiple choice tests (Nakipoglu and Tekin , 2006 ; İnce, Acar Sesen and Kirbaslar, 2012). While techniques used in determining the students' misconceptions, help to define what misconceptions students have, it is not possible to have an idea about the causes of these misconceptions. So, in order to define misconceptions, and their reasons , two-tier diagnostic tests have been used (Garnett and Treagust, 1992; Odom and Barrow, 1995; Tan, Goh, Chia and Treagust, 2002). The first section of two-tier tests includes information assumptions similar to multiple choice tests. Here, there is a question item called a root agent, or an information assumption with various number of choices that follow (Chen, Lin and Lin, 2002; Karataş, Köse and Çoştu,2003; Treagust and Haslam, 1986). The second section that differentiates two-stage tests from multiple choice tests, can be made up of open ended questions that require students to justify their reasons for marking the choices in the first section, or multiple choice options again (Tan and Treagust, 1999; Peterson et al., 1989). The second part of the research is prepared depending on, the literature study, the results from interviews and open-ended questions or already defined students misconceptions (Jang, 2003).

THE STUDY

In this study, it was aimed to determine middle school students' misconceptions related to the subjects of "The Electron Array and Chemical Properties", "Chemical Bonds"," Compounds and Formulas", "Mixtures" in the unit of "Structure and Properties of Matter" by using a Two-Tier Diagnostic Test. This study was conducted with two hundred twenty-five 7th grade students, who had already learned the unit of "Structure and Properties of Matter" and studied at three different middle schools in İstanbul in 2013-2014 academic year. As data collection tools, "Structure and Properties of Matter Achievement Test" which have been designed by the researcher and tested in terms of validity and reliability were used. The test was a two-tier diagnostic test that consists 32 items. Reliability coefficient was found to be 0.90. Lertap 5 was used to analyse students' misconceptions.

FINDINGS

Results of students' misconceptions related to "Electron Sequence and Chemical Properties" under the unit of "Structure and Properties of Matter Achievement Test" and their percentages and frequencies are given in Table 1.

Table 1: Students' misconceptions about "Electron Sequence and Chemical Properties " defined as a result of "Structure and Properties of Matter Achievement Test".

	Concept	Misconceptions	f	%
Electron Sequence and Chemical Properties	Stable Atom	Stable atoms tend to give out electrons.	33	15
		Atoms containing only eight electrons in the last layer may participate in formation of links.	27	12
	Ion	When an electron is disconnected from any atom, anions are formed.	68	30
		When an electron is disconnected from any atom, an electron is disconnected, and loses its energy.	23	10
		Cation is formed when a neutral atom receives an electron.	27	12
	Atom Model	An neutral atom with 2 electrons in its last orbit, is expected to form a (-2) anion.	43	19
		For an atom, to be chemically determined, it has to have 2 electrons in its outmost energy level.	18	8
	Cation and Anion	In order to have noble gas structure, cations (+) by accepting electrons and anions by giving electrons are formed.	38	17
		Atoms become anion by accepting proton, and become cation by giving protons.	27	12
		Polyatomic ions are in form of cations.	25	11
		There is only one kind of atom in the structure of polyatomic ions.	25	11
		During bond-formation, all electrons of both atoms play the most active role.	32	14
		There is electron sharing in NaCI, and electron exchange in H_2O.	43	19

As shown in Table 1, it was detected that, students had misconceptions about "Stable atom" approximately 12-15%, about "Ion" in ratio of 10-30%, about "Atom Model" in ratio of 8-19%, about "Cation and Anion" concept approximately in ratio of 11-19%.

Table 2: Students' misconceptions about "Chemical Bonds" defined as a result of "Structure and Properties of Matter Achievement Test"

	Concept	Misconception	f	%
Chemical Bonds	Ionic Bond	The bond that keeps Na and Cl atoms together is the metallic bond.	23	10
		A single Cl atom makes only ionic bond with a different atom.	32	14
		Salt (NaCl) and water (H2O) both have Ionic structure.	29	13
	Covalent Bonds	Salt (NaCI) and water (H2O), both have covalent structure.	50	22
		Covalent structures consist of electron exchange.	38	17
		In covalent structures, as anion and cation have opposite loads, they attract each other.	36	16
		When covalent bond is formed, the electrons in the last layer of the atoms change places.	25	11
	Covalent Bond Made up of Different Elements (HCI)	Made bond with the Cl atom of the H atom; It is ionic bonds.	56	25
		Made bond with the Cl atom of the H atom; It is metallic bond.	27	12
		HC l compound is formed with ionic bonds.	63	28

As shown in Table 2, it was detected that, students had misconceptions about "Ionic Bond" in ratio of 10-14%, about "Covalent Bond" in ratio of 11-22%. Approximately 12-28% of them had misconception about "Covalent Bond Made Up of Different Elements (HCI)" concept.

Table 3: Students' misconceptions about "Compounds and Formulas" defined as a result of "Structure and Properties of Matter Achievement Test".

	Concept	Misconception	f	%
Compounds and Formulas	Compound	Compounds are divided into components physically.	27	12
		There is no specific ratio between the compounds and components.	23	10
		Water is solution.	68	30
		Water is mixture.	34	15
		The compound is formed as oxygen atoms make chemical bonds.	81	36
	Ionic and Molecular Compound	When atoms form the compound, they don't lose their features.	25	11
		Compound, is the smallest unit that different type of atoms form by means of ionic bond.	34	15
		Molecular structure compounds are formed only by common use of same type of atoms	54	24

As shown in Table 3, it was detected that, students, under the heading of " Compounds and Formulas ", have misconceptions about "Compound" in ratio 10-36%, about " Ionic and Molecular Compound " concept approximately in ratio 11-24%.

Table 4: Students' misconceptions about "Mixtures" defined as a result of "Structure and Properties of Matter Achievement Test".

	Concept	Misconception	f	%
Mixtures	Mixture	Salt dissolves homogeneously both in water and oil.	23	10
		Materials that make up the heterogeneous mixture, dissolve evenly to each part of the mixture.	46	20
		Salty water is a heterogeneous mixture.	54	24
	Dissolution Event	Salt,melts in water.	23	10
		When we put edible salt to a glass of water, a new compound is formed as the salt ions are combined with water.	29	13
		When a little bit of sugar is added to water, the concrete sugar, becomes fluid.	65	29
		When sugar is added in water, sugar disappears.	43	19
	Dissolution Rate	Granulated sugar and sugar cubes dissolve at the same rate when put into two different container with water at the same temperature.	47	21
		Equal amounts of crushed sugar dissolves more than cube sugar .	29	13
	Dilute Concentrated Solution	Adding water to the solution is a process of increasing its concentration	41	18
		When sugar is added in water, it dissolves to its ions.	32	14
	Conductivity Solution	Pure water and sugar water transmit electricity.	23	10

As shown in Table 4, it was detected that, students, under the heading of "Mixtures", have misconceptions about "Mixture" in ratio 10-24 %, about "Dissolution Event" in ratio 10-29 %, about "Dissolution Rate" in ratio 13-21 %, about " Dilute Concentrated Solution " in ratio 14-18 %, about "Conductivity Solution" concept approximately in ratio 10%.

CONCLUSIONS

As a result of "Structure and Properties of Matter Achievement Test" applied within the scope of this study, it was detected that, students, among the concepts under the heading of "Electron Array and Chemical Properties" have the highest misconception with "*When an electron is disconnected from any atom, anions are formed."* It was also detected that students have misconceptions such as; "*Stable atoms tend to give out electrons.*", "*Atoms containing only eight electrons in the last layer may participate in formation of bonds*.", "When an electron is disconnected from any atom, an electron is disconnected, and loses its energy.", "Polyatomic ions are in form of cations." In this study, it was detected that students are confused about stable atom and neutral atom concepts in a way similar to the misconception about stable atom concept indicated by Uslu (2011); as "*If the number of protons and electrons are equal, if there is no need for proton and electron, the atom is stable."* Similar findings to misconceptions detected within the scope of the study as in, *"Cation is formed when a neutral atom receives an electron.", "For an atom, to be chemically determined, it has to have 2 electrons in its outmost energy level.", "An neutral atom with 2 electrons in its last orbit, is expected to form a (-2) anion.", In order to have noble gas structure, cations (+) by accepting electrons and anions by giving electrons are formed.", "Atoms become anion by accepting proton, and become cation by giving protons."* have been indicated by other researchers as well. (Kara and Ergül, 2012; Uzun, 2010; Uzuntiryaki, 2003). The misconceptions detected as in *"There is electron sharing in NaCI, and electron exchange in H_2O."* coin with the results of Butts and Smith (1987). When misconceptions related to concepts under the heading of "Chemical bond" were studied, it was detected that, misconceptions of the students were at a high rate about concepts such as "Ionic Bond", "Covalent Bond", and "Covalent Bond Made Up of Different Elements (HCI)", and the highest rate of misconception was in "*HCl compound is formed with ionic bond."* Students' misconceptions as in, "*A single Cl atom makes only ionic bond with a different atom"* was detected by the researcher, within the scope of this study. Besides, the misconception as in "*The bond that keeps Na and Cl atoms together is the metallic bond", "Salt (NaCl) and water (H_2O) both have Ionic structure."* were detected by other researchers. (Nicoll, 2010; Taber, 1998). It was also indicated that; misconceptions that were detected in this study as in " *Salt (NaCI) and water (H_2O), both have covalent structure", "Covalent structures consist of electron exchange", " In covalent structures, as anion and cation have opposite loads, they attract each other." ,"When covalent bond is formed, the electrons in the last layer of the atoms change places.", " Made bond with the Cl atom of the H atom; It is ionic bonds.", " Made bond with the Cl atom of the H atom; It is metallic bond.", "During bond-formation, all electrons of both atoms play the*

most active role" are similar to other studies (Nicoll, 2010; Taber, 1998; Urek and Tarhan, 2005; Altınyuzuk, 2008; Uzun, 2010). Other misconceptions showing that students are confused about ionic and covalent bond such as; *"Ionic bond is the bond among molecules.", "Covalent bond is common usage of electrons by different metals"(*Butts and Smith, 1987; Altınyüzük, 2008), *"Covalent bond is the strength of attraction between the negative and positive ends of atom*"(Nicoll, 2010), *"NaCI is a covalent bonded compound."* (Butts and Smith, 1987), "*Covalent bond, is formed as a result of electron exchange between two metals."* (Urek and Tarhan, 2005), "*There is intermolecular bond in ionic compounds."* (Taber, 1998) have been detected in other researches as well. With regards to the concepts under the heading of "Compounds and Formulas"; a high misconception rate was detected about "Compound" and " Ionic and Molecular Compound " concepts. It was detected that the students had the highest rate with misconceptions such as; "*The compound is formed as oxygen atoms make chemical bonds.", "Water is a solution."* It was also detected that students had misconceptions such as; "*Compounds are divided into components physically.", "There is no specific ratio between the compounds and components. ", "Water is a mixture."* The detected misconceptions correspond to the results of researches conducted by Uzun (2010), Konur and Ayas (2008), Uzuntiryaki and Geban (2005), and Meseci, Tekin and Karamustafaoglu (2013). Misconceptions such as; *" When atoms form the compound, they don't lose their features.", "Compound, is the smallest unit that different type of atoms form by means of ionic bond.", " Molecular structure compounds are formed only by common use of same type of atoms "* were indicated by Urek and Tarhan (2005), Novick and Nussbaum (1978) as well. It was detected that with regards to the concepts under the heading of "Mixtures"; students had high rate of misconceptions such as, "Mixture", "Dissolution Event ", "Dissolution Rate ", " Dilute Concentrated Solution " and " Conductivity Solution ". It was found that the highest misconception students had was as *"When a little bit of sugar is added to water, the concrete sugar, becomes fluid."* Another misconception as; *"Salt dissolves homogeneously both in water and oil"* was also indicated within the scope of the study. The misconceptions such as "Materials that make up the heterogeneous mixture, dissolve evenly to each part of the mixture." , "Salty water is a heterogeneous mixture." parallel to the results of the research conducted by Kalın (2008), Kalın and Arıkıl (2010). The misconception that *"Salt,melts in water ."* also show similar results to the results of different researchers (Uzun, 2010; Akgun and Aydin, 2009; Kalın and Arıkıl, 2010; Valanides, 2000; Kabapınar, 2001; Kuşakcıekim, 2007; Lee.et.al. 1993; Say, 2011). The misconception that *"When we put edible salt to a glass of water, a new compound is formed as the salt ions are combined with water."* corresponds to the results of Coştu et al. (2005), Papageorgıou and Sakka (2000), Ebenezer and Fraser (2001), Kabapınar (2001). The misconception; *"When sugar is added in water, sugar disappears"* correspond to Uzun (2010), Akgün ve Aydın (2009),Uzuntiryaki and Geban (2005), Ebenezer and Erickson (1996), Abraham et. al. (1994), Lee et al. (1993). The misconception that "*Granulated sugar and sugar cubes dissolve at the same rate when put into two different container with water at the same temperature "* is similar to the misconception defined by Uzun that; "*There is no relation between the grain size and dissolution."* The misconception "*Adding water to the solution is a process of increasing its concentration."* is similar to Meşeci, Tekin and Karamustafaoglu's (2012) studies. The misconception detected among the students; "*When sugar is added in water, it dissolves to its ions."* is similar to the results of the study conducted by Sen and Yilmaz (2012). Also the misconception, "*Pure water and sugar water transmit electricity."* is similar to the results of the study conducted by Uzun (2010). In order to ensure meaningful and permanent learning, it is very important to realize learning process by defining the misconceptions of students. It is therefore, believed that, students' misconceptions found as a results of this study about subjects within "Structure and Properties of Matter " unit will be helpful to educationalists, in planning the educational program and implementing it.

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