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MISCONCEPTIONS ABOUT PERIODICITY IN SECONDARY CHEMISTRY EDUCATION: THE CASE OF KAZAKHSTAN

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ABSTRACT

Determining students' misconceptions in chemistry is important for an effective teaching and learning chemistry. In this study we determine misconception about periodicity and help students to prevent developing erroneous ideas about periodicity. The sample of this study consists of 137 questionnaires who were secondary school`s students and the test was developed after two step application on questionnaires. A questionnaire, including multiple choice and true-false format with 7 items was applied to total of 116 eight-year and nine-year secondary school`s students who attended at gymnasium schools. The collected data was analyzed using data analysis technique in six categories (the meaning of periodicity, the determinative factors of periodic properties or periodicity, the relation between periodic properties and the number of subatomic particles, the meaning of period, periodic properties and the forms of periodic table). According to the all results, main reasons of erroneous ideas are the lack of teaching method that presenting only Mendeleev`s periodic table (short form), no exercises about periodic properties and the meaning of periodicity cannot be focused as a subject during the teaching process.

Keywords: Teaching Secondary Chemistry, Misconception, Periodicity, Periodic Propertie.

Teaching of concept has great importance for an effective learning of chemistry. Nevertheless, it has some difficulty to determine students' misconceptions and learning meaningfully in secondary chemistry education. For this, the introduction of each new concept in education should be performed by connecting it with other concepts of different levels of generality (Sisovic & Bojovic, 2000); the concepts developed for organizing and arranging our knowledge (Beck, 1991); constructing new and more powerful meaning (Novak&Gowin,1984) are main ways of helping students for meaningful learning. Educational experiences of students as a result, if they not install the semantic relationship in the brain, the learning process is unable that an adequate level of understanding and some misconceptions or errorneous ideas occur in students' mind. Researchers has expressed the lack of students' understanding and perceptions in some terms; misunderstanding (Taber, 2001: Spada, 1994), misconception (Disessa & Sherin, 1998: Nakhleh, 1992: Pfundt, 1982: Herron, 1996), school-made misconceptions (Barke, 2009), conceptual misunderstandings, erroneous concepts and erroneous ideas. Many of misconceptions about chemistry subjects which are commonly taught in chemistry have been researched. One of these subjects is about periodicity and periodic system. Many studies have been done about instructional methods or techniques about periodic table or system and periodicity. Bolmgren (1995) simulate Mendeleev's development of the periodic table by organizing colored cardboard circles to increase level of understanding of students on periodicity. Goh and Chia (1989) used the learning cycle model used to teach the periodic table periodicity. This study indicates that students found card game a very interesting and meaningful and increased to understand their understanding levels of periodicity. Lehman et al. (1984) explored the effects of various structural modifications of the periodic table on learning. They used three different periodic tables in their study and proved to teach better using the modified tables than the traditional table on learning periodic system. Tejada and Palacios (1995) play a game which is Chemical Elements Bingo (CEB) to facilitate the learning-teaching process of periodicity in high school level. This game was designed to teach periodic classification and indicate that it was difficult to deduce properties with periodic classification for average student. Dreyfuss (2000) tried to teach elements in the periodic table with

very interesting technique that is likened an old car needs to paint to the periodic table. Knight (2003) use the pictorial periodic table and graphic technique of data mapping as inquiry-based methods to change high school chemistry students' understandings of the elements, structure, and periodicity of the Periodic table. Abraham et all (1992) researched about periodicity, learning periodicity and misconceptions on periodic law. They studied eighth-grade students' understanding of five chemistry concepts that chemical change, dissolution, conservation of atoms, periodicity, and phase change. They deduced the results of three questions: (a) what misconceptions do eighth grade students have concerning the chemistry concepts from their textbooks. (b) How is reasoning ability related to misconceptions concerning chemistry concepts? (c) How effective are textbooks in teaching an understanding of chemistry concepts? As a result, they indicated a general failure of textbooks as barrier to understand the five chemistry concepts and the nature of the misconceptions held by students teach a reasonable understanding of chemistry concepts. Although there is plenty of information on chemistry teaching in the international literature, there are few studies focused on determining errorneous ideas and students' misconceptions at all levels on concept of periodicity.

Method

The Purpose of the research

The aim of this study is to determine and categorize misconceptions or erroneous ideas and their causes in secondary chemistry teaching. This research has two steps; first step is related to misconceptions that occur during learning of periodic system in Kazakhstan. Second is to compare between findings of first step and misconceptions of the teaching in innovative way of modern periodic system.

The Universe and the Sample

This study is applied on secondary students who participate at gymnasium schools which are 175th and 113th gymnasium in Almaty region of Kazakhstan. Secondary education is given at vary type of schools, one of these schools are gymnasiums in the Kazakh educational system. Students attended gymnasium school have high level than normal secondary schools. The periodic law is taught first at age 14 year in Grades 8 at all schools of Kazakhstan. This topic is repeated to teach again shortly at age 15 year in Grade 9 in gymnasium school. The sample of this study consists of 137 questionnaires who were secondary school students and the test developed by the author. After pilot application on questionnaires, the test was developed with decreasing item number to 7 items and applied to total of 116 eight-year secondary school's students.

Instruments. Periodicity Conceptual Test (PCT) consisting of seven main items was developed in order to determine the misconceptions or erroneous ideas. These are related to periodicity and grouped in six categories (Table I). The PCT is a pencil reading test consisting three multiple–choice, three true/false and one open-ended test items. It is applied one hundred sixteen students who were participants of the main study. The reliability of PCT showed satisfactory internal consistency (Cronbach $\alpha = 0.76$). The difficulty indices of test is 0.31.

Data collection and analysis. PCT was applied to participants. PCT was administered in groups at the end of the unit of periodic law in chemistry course in eight class in accordance with standard curriculum. In PCT, the choices of each item were given as statement having ready knowledge as statements. The choices were scored as correct or incorrect response. If it is correct it equals 1 and incorrect equals 0 point. PCT was evaluated for both correct and incorrect responses for each student. Some misconceptions or errorous ideas were determined in accordance of the given responces of the each item. The students' answers were analyzed in six categories (the meaning of periodicity,

the determinative factors of periodic properties or periodicity, the relation between periodic properties and the number of subatomic particles, the meaning of period, periodic properties and the forms of periodic table). Frequencies and proportions of responses for each category were found. The relations of each category was shown.

Table I
Structure of Periodicity Conceptual Test (PCT)

Categories	Item number
1. Meaning of periodicity	2, 5
2. Determinative factors of periodic properties or periodicity	1, 4
3. Relation between periodic properties and the number of subatomic particles	3, 4
4. Meaning of period	3
5. Periodic properties	6
6. Forms of periodic table	7

Results and discussion

Periodicity is a difficult and abstract concept in which students have erroneous ideas. Fourteen misconceptions or erroneous ideas (Table 2) were identified through analysis of items on the PCT. These were categorized under the headings: the meaning of periodicity, the determinative factors of periodic properties or periodicity, the relation between periodic properties and the number of subatomic particles, the meaning of period, periodic properties and the forms of periodic table. These are discussed below in detail. In category first; There are two items which are "Why is the system of elements is called periodic?" and second one is "Note the following proposals, which help to understand the word "periodic"?". These two items are related to the meaning of periodicity as a concept. In accordance to first question two erroneous ideas which are “the relative atomic masses increase periodically and the atomic number increases periodically” are deduced (Table II). The true proposal should that the elements are listed in order of atomic number. Students have confused these two words; “orderly” and “periodically”. In accordance to second question, 26.7 % of students choice the following proposal “The elements are arranged in accordance with the increase of the relative atomic mass in the periodic table” as an answer of understanding the meaning of "periodic". So, students think that “arrangement of elements by relative atomic mass” means periodic.

In second category; there are two items; first one is related to determinative factor of periodic properties. 54.3 % of students predict that if the numbers of energy level of atoms are the same, the property of elements similar to each other. However the number of energy level of electrons gives period number. Periodic properties are not similar over the periods exactly. Students believe that elements have similar chemical property in the same period of the periodic table. Trifonov (1971) predicted that ‘it can be seen that the lengths of the rows (periods) in the periodic table are different and equal to 2,8,8,18,18 and 32. A mathematician would claim that there is no exact periodicity, since the period itself is not of constant value’. Thus, it is stressed on groups not only periods to understand periodic properties of elements. In accordance the next question "Which following factors change periodic properties?", 40.5 % of students answer as "When the total number of electron of an atom is changed, periodic properties don’t change". This result shows that it is stressed on only atomic mass number to change the properties of an atom. Students can’t know the effect of electron number or the number of other subatomic particles. They need to be taught electronic configuration effectively and how to relate periodic properties with electron configuration.

In third category; most of students erroneously (59.5 % and 66.4% of students) think that atomic number of an atom or proton number do not characterizes the chemical property of the element. We think that students place relative mass number instead of atomic number in their mind. The other

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erroneous idea is "There are no elements arranged oppositely ascending relatively average atomic mass in short form of periodic table" that is shown by 62.9% of students. In short form of periodic table (Mendeleev's periodic table) there seemed to be irregularities in the increase of atomic mass from element to element. Most of the students incorrectly learn the difference between relative atomic mass number and atomic number. The meaning of relative atomic mass number should be taught with relating isotopes of elements. As we know that the greater the number of isotopes, the more average mass of an element. So the relative mass number is changeable but proton number or atomic number is characteristic.

Table II
Percentages of students' misconceptions or erroneous ideas (N=116)

Misconceptions or erroneous ideas	f	%
Meaning of periodicity		
Why the system of elements is called periodic? Because the relative atomic masses increase periodically	39	33.6
Why the system of elements is called periodic? Because the atomic number increases periodically	23	19.8
The elements in the periodic table are arranged in accordance with the increase of the relative atomic mass	31	26.7
Determinative factors of periodic properties or periodicity		
If the numbers of energy level of atoms are the same, the property of elements similar to each other	61	54.3
When the total number of electrons are changed in the atom, periodic properties do not change	57	40.5
Relation between periodic properties and the number of subatomic particles		
Atomic number of an atom do not characterizes the chemical property of the element	69	59.5
The number of protons an atom do not characterizes the chemical property of the element	77	66.4
There are no elements arranged oppositely ascending relatively average mass in short form of periodic table	73	62.9
Meaning of period		
Period is a series of elements arranged in increasing relative average atomic mass (decided by students as correct)	33	28.4
Period is a series of elements arranged in ascending order of atomic number (decided by students as incorrect)	49	42.2
Periodic properties		
Atomic radius of an atom is the periodic property of elements of an atom (decided as correct)	7	6
Ionization energy of an atom is the periodic property of elements of an atom (decided as correct)	15	12.9
Forms of periodic table		
There is no different form of periodic table	61	52.3
In the periodic table by increasing atomic number increases relatively average masses of the atoms	71	61.2

In category four; two erroneous ideas; 'Period is a series of elements arranged in increasing relative average atomic mass' decided correctly by the 28.4% of students as a first. The second was 'Period is a series of elements arranged in ascending order of atomic number' decided incorrectly by the 42.2 % of students. The both ideas were deduced as result of learning to be one way arrangement

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of elements that is arrangement in increasing relative average atomic mass in periodic table. The modern periodic table should be shown and taught clearly difference the definitions of relative average atomic mass number and atomic number. In category five; the less students show atomic radius and ionization energy as periodic properties of an element. Only 6 % and 12.9 % of students answered that atomic radius and ionization energy of an atom are the periodic properties of elements respectively. As a reason, the periodic properties are not explained sufficiently during chemistry teaching process and there are no adequate exercises on chemistry textbooks. In category six; 61.2 % of students said the by increasing atomic number increases relatively average masses of the atoms in short form of periodic table. There are cases in which an element with a lower atomic number has a higher atomic weight than an element with a higher atomic number (see argon (Ar), and potassium (K)). Students confuse atomic number and relative mass number due to the short-form of table which is based on an increase relative atomic mass. The next erroneous idea was produced as an answer of question:"Is there another form of the periodic table, except Mendeleyev periodic table?" 52.3% of students believed that there is no different form of periodic table. The reason of this erroneous idea is the perception of students as only one way to arrange elements. It is need the correlation table to be better understanding the relationship between all categories except four. Category four is related to the meaning of period that causes to confuse with the meaning of periodicity. Thus, we thought no relation with each other. In accordance of Table III, we see there is no significant relationship between meaning of periodicity in which first category along with other categories. Nevertheless, it appears to be significant relationship between other categories. The relationship between second and third categories is positive that can be meant the proportion of learning determinative factors of periodic properties increases, students' knowledge about the relation the periodic properties and the number of subatomic particles are high. In addition, it is significant relationship between the categories 5, 6 and 2, 3 show that while students with the interests of understanding periodic table and periodic properties is positive, a progressive increase shows in learning of determinative factors of periodic properties and relation between number of subatomic particles and periodic properties. As a result, the relationship between all categories except first is proportional to the learning them but unable to understand by the meaning of periodicity.

Table III

Correlations between Categories (Pearson Correlation, N=116)

	Categories	Category 1 Meaning Periodicity	Category 2 Determinative Factors of Periodic Properties	Category 3 Relation between Periodic Properties and Number of Subatomic Particles	Category 5 Periodic Properties	Category 6 Periodic Table
1	Meaning Periodicity	1.000	.177	.139	.149	.222
2	Determinative Factors of Periodic Properties	.177	1.000	.763**	.501**	.368**
3	Relation between Periodic Properties and Number of Subatomic Particles	.139	.763**	1.000	.389**	.316*
5	Periodic Properties	.149	.501**	.389**	1.000	.274*
6	Periodic Table	.222	.368**	.316*	.274*	1.000

*Correlation is significant at the 0.05 level (2-. tailed). **. Correlation is significant at the 0.01 level (2-tailed).

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Conclusions and implications for education

It was deduced that students have some misconceptions and erroneous ideas with the lack of instruction methods. As main reasons; using only one format of periodic table, no comparative exercises about periodic properties on table, inadequate expression of the concept of periodicity during the secondary chemistry education could be predicted. It should be considered in more depth on the description the periodicity in courses. We could foresee that students understand the meaning of periodicity while they learn the periodic system in traditional way. This indicates that the definition of periodicity should be placed apart on curriculum during the teaching process.

Teaching should be done in modern table efficiently and used different forms of periodic table. The concept of periodicity has objectified for better understanding the relations between elements. The meaning of periodicity should be focused as a subject during the teaching process and given examples about the periodic processes from nature. The some particular exercises on the modern periodic table like comparing properties of elements with each other and grouping elements in accordance of their properties should be taught that it helps student to learn better the concept of periodicity clearly. It should be concentrated on groups not only periods on periodic table while students learn the concept of periodicity.

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