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Research Article

The Impact of Content Materials on Students Alternative Conceptions About Periodicity in Teaching Chemistry

Satilmis Y, Bekenova G, Zhumakayeva BD and Aidos AA*

SDU University, Natural Science Pedagogy Department, Kaskelen, Kazakhstan

***Corresponding author**: Aidos AA, SDU University, Natural Science Pedagogy Department, Kaskelen, Kazakhstan

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Abstract

This study empowers to investigate and compare the student's alternative conceptions on the concept of periodicity which was reasoned from teaching the Modern and the Mendeleyev periodic systems (the MPS and the MEPS) and find out the impacts on students' conceptions taught with two contents` knowledge and only one type of the periodic table. In this study, 96 secondary school students were involved including 39 Kazakh-Turkish high school students and 57 Gymnasium students. The Periodical Conceptual Question Paper (PSQP) was developed and composed of six major questions; true-false propositions; and one question was open ended. The reliability tests demonstrated satisfactory internal consistency (KR-20 = 0.71.) The study results showed that P <0.05 was statistically significant for the ratio of alternative concepts (AC1, AC2, AC6) of both the MPS and the MEPS contents and the students` achievements. Three alternative conceptions were found by the students, and it was proved that alternative conceptions of students were decreasing while students were taught with comparing alternative two contents in the teaching process. Finally, teaching with various content knowledge and periodic tables enables students to better understand the periodicity concept.

Keywords: Alternative conception; Mendeleyev and modern periodic system; Periodicity; Teaching secondary chemistry

Introduction

The periodicity concept - when elements are arranged in order to increase atomic number, there is a periodic repetition of elements with similar properties [1]. Some scientists in their research provide us with the opportunities to view general chemical trends directly related to the periodic table. They specified the importance of the periodic table in determining periodic trends and behaviors of elements. The end of the periodic table relativistic effects plays an important role in determining atomic characteristics such as binding energies, atomic (ionic) radii, and etc. [2]. Chemical Periodicity provides to belabor the links between electronic structure and chemical behavior so it should be an integral part of our chemical thinking within summary [3].

Students develop new or revised concepts based on their interpretation of new information from the viewpoint of their existing ideas and beliefs. Their concepts that are not consistent with the consensus of the scientific community are called

alternate conceptions [4]. One of the alternative conceptions is about periodicity in schools. Students struggle to understand the "Chemical Periodicity '' due to some reasons: first would be teaching theory more than practice; second would be memorizing periodicity of the periodic table; third one would be the use of inaccurate instructional methods in chemistry class. This issue can be solved and minimize alternative conceptions by an impact of sufficient experience of instruction, teaching responsively and effectively for meaningful learning. The researchers reported on misconceptions caused by instructional processes. It was specified that `Students build concepts in their minds by acknowledging their own observations as scientific truth in a meaningful and coherent way [5] and also defined as school-made misconceptions [6]. Additionally, it was determined by Koballa & Chiappetta that there is a strong consensus that students possess alternative conception about the natural world prior, during, and after school science instruction." They also wrote "For some of the most important concepts, alternative conceptions persist beyond formal instruction [7].

Scientists have studied better instruction and teaching methods of periodicity. It was explored by Lehman et al. the effects of various structural modifications of the periodic table on learning themed research [8]. They used three different periodic tables in their study and proved to teach better by using the modified tables than the traditional table on learning the periodic system. It was researched about teaching of 'Chemical Periodicity' using concept maps for meaningful learning [9]. It was also researched about pictorial periodic table and graphic technique of data mapping used to change students' understanding. Researcher specifies that the school students who continue to use traditional instruction (lecture and textbook activities) have a very limited understanding on the periodic table and deduced to enhance students understanding of the patterns of the physical properties of the elements on the periodic table by using the pictorial periodic table [10].

According to the insights drawn from above scholarly literature, a few studies reported on instructing with various content or knowledge about periodicity. In this context, it is worthwhile to consider varied content instruction about periodicity to measure effectiveness of teaching with the MPS (Modern Periodic System) and the MEPS (Mendeleev Periodic System) contents in order to diminish alternative conceptions of students. It is specified at this point and concluded by Garnett and colleagues that the use of multiple definitions and models may all contribute to students lack of understanding of chemistry concepts [11].

The Difference of the MPS and the MEPS Contents

The first major difference is about the shaping used in periodic tables. It is known that elements in the periodic table are arranged into groups and periods by repeating chemical and physical properties. As we know, two forms of the periodic table exist: the short and the long form of the table. These two forms have different shapes. The short form is used in the MEPS content and the long form is used in the MPS content. It was emphasized by Petrucci that Mendeleyev`s periodic table is called as a "short" one; it consists of eight groups [12]. The most modern periodic tables arrange the elements in 18 groups, referred to as a "long" form. In the long form, each period has one row but, the first three and the seventh periods have one row, while the fourth, the fifth and the sixth periods have twice rows. The rows or periods are divided and invisible. However, the existing Mendeleyev periodic table is accepted as an original table while the others are ineffective by the MEPS students. The MEPS content includes more knowledge about the historical development of the periodic table and Mendeleev's periodic law than the MPS content.

The second difference is related to teaching objectives. In the MEPS content, the Mendeleev table in which elements were displayed according to their atomic masses. In the MPS content, the modern periodic table is used, and the periodic table is organized according to increasing atomic number. In the MPS content, students understand that the atomic number is a characteristic number and the main number on each element is called the atomic number that equals the proton number. However, teaching has focused on atomic mass during learning of periodicity in the MEPS content. It is confusing that the atomic mass number and the atomic number are used together, and it is thought that the periodic table is only arranged by increasing atomic mass and it is hard to understand for students.

The third difference is about the relevant themes of periodicity. The history of atomic theories and models, electronic configuration and periodic properties; atomic radius; ionization energy; electronegativity; metallic and nonmetallic properties have been taught in the MPS. The MEPS content consists of the importance of the Mendeleev Periodic Law and teaching of oxide and hydride compounds of each group is different. Therefore, some exercises should be given; comparing and contrasting the chemical properties within the group's elements, and within the period's elements, investigating physical properties elements in each region on periodic table have been taught in the MPS rather than the MEPS.

The purpose of research is to compare and find out the results of the students' conceptual understanding by teaching both the MPS and the MEPS contents in chemistry. The objective of this study is to determine alternative conceptions reasoned from teaching of both contents; using only one type of the periodic table on teaching process and to see how student's alternative conceptions can be changed while two types of the periodic table and content knowledge are taught.

Materials and Methods

This research study is an exploratory investigation of how students learned the concept of `periodicity`. Two different types of secondary schools: Gymnasium and Kazakh-Turkish high school were the medium of our research. 96 participants were the students from a Gymnasium and a Kazakh-Turkish high school, Almaty region. The type of gymnasium is known better among other government schools and has a high educational performance since it has a strong base for instruction. A Kazakh-Turkish high school is also successful and has a good performance in the education process in

Kazakhstan. The periodicity subject was taught first in grade 8 and then in grade 9 at all schools of Kazakhstan. The Periodicity concept is taught with the MEPS content in Gymnasium and the number of participants was 57. In Kazakh-Turkish high school, the periodicity was also taught both to students of grades 8 and 9 with the MPS content and the number of participants were 39.

The MPS and the MEPS groups had 39 and 57 students accordingly and they participated in this study. Prior to conducting the study, the achievements of both groups` students were determined by examining their gained achievements at school. The achievements of both groups' students were evaluated. Therefore, both groups have a great performance and equal success. After the application of the SPPS 15.0 statistical program, (Significance) values in the column of 0.05 appear to be small in independent samples from the test table. So, p <0.05 is statistically significant. The student's achievements don't differ because of a positive meaning relation (see Table 1).

Table 1: Statistics of both MPS and MEPS Group.

MPS=1 MEPS=2	N	Mean (over 5.00)	F	Sig.	t	df	Sig. (2-tailed)
1	39	4,92	1,502	,224	8,1	8	,000
2	57	4,09					
							p <0.05

The Periodicity Conceptual Question Paper (PCQP) was developed by the author and implemented successfully as a pilot study a year ago at secondary schools. The PCQP consists of eight questions to identify alternative conceptions. The PCQP was composed of five multiple-choice questions and one question was open ended (see Table 2) Two of eight questions were not related to the study. Multiple-choice questions were prepared using the chemistry textbooks actively used in the Gymnasium and the Kazakh-Turkish high schools. It was decided that multiple-choice exams are often used to identify alternative conceptions. It is written by Herron that "Although a great deal of information about student misconceptions can be obtained from incorrect choices on carefully prepared multiple-choice exams' [13]. The reliability of the PCQP showed satisfactory internal consistency (KR-20 = 0.71).

Table 2: Structure of Periodicity Conceptual Question Paper (PCQP).

Questions	Question Type	Item number
"Why is the system of elements called periodic?	Multiple choice	1
Do you know any different forms of periodic table? Explain?	Open end question	2
Do you agree with the following opinions about chemical properties?	Multiple choice	3,4
"Periodicity means"	Multiple choice	5,6

The PCQP was implemented in groups at the end of the unit of periodicity subject in chemistry course in the eighth and the ninth grades aligned with the standard curriculum. The choices were scored according to correct or incorrect response as an equality of 1 and 0 respectively. For the second question about the periodic table form (long and short), if the explanatory answers were given by the students, these were scored also as 1 point. Alternative conceptions were identified in compliance with the given responses of each item for both groups of students. To understand the alternative conceptions held by the students, the relations between student's achievements and their conceptions were investigated by the crosstab`s method analytically.

Results

One of alternative concepts is about periodicity. Determining alternative concepts held by students and changing them are very important for improving learning science. It is hard to change students' alternative conceptions. Nevertheless, for all conditions, it should be predicted alternative conceptions and try to change them. Studies have shown that alternative conceptions can be resistant to change and prevent students from learning new scientific knowledge. Thus, educators should work on how to handle students' alternative conceptions [14]. For identifying some alternative conceptions about periodicity, PCQP was applied, and some alternative conceptions were predicted. They were ordered in accordance with relevant themes (see Table 3).

Percentages of correct answers for alternative conceptions for each group are presented on Table 4. According to the application of PCQP results, 22 % - 41 % of students have less success for conceptual understanding. The less one AC1 (22%) was about periodic properties and the more one AC2 (41%) was about periodicity concept (see Table 4).

Table 3: Alternative Conceptions (AC).

Themes	Alternative Conceptions	No of (AC)
Periodicity	Atomic mass increases periodically	AC 1
	Periodicity means "Arranging elements in seven periods on the periodic table"	AC 6
	Periodicity means "Arranging elements in increasing of atomic number on the periodic table"	AC 5
Periodic table	There is no different form of periodic table	AC 2
Periodic Properties	Atomic mass characterizes the properties of chemical element	AC 3
	Neutron number characterizes the properties of chemical element	AC 4

Table 4: Percentages of Correct Answers for Student's Alternative Conceptions.

Alternative Conceptions	Groups				Total for Both Groups	
	MPS		MEPS			
	N (f)	Percent %	N (f)	Percent %	Total N (f)	Percent %
AC1	2	5.20%	19	33.30%	21	22%
AC2	10	25.60%	29	50.90%	39	41%
AC3*	9	23%	20	35%	29	30%
AC4*	9	23%	18	32%	27	28%
AC5*	11	28%	16	32%	27	28%
AC6	19	48.70%	8	14%	27	28%

We compared the achievements of students on alternative conceptions for each group (MPS-MEPS) which were taught with different contents by crosstab method. The achievements of students for alternative conceptions; AC3, AC4, AC5 were the same or near in accordance with the crosstab. The crosstab revealed certain results, thus, as a result of this study, there is a meaningful relation between student's achievements for both groups and their alternative conceptions; AC1, AC2 and AC6. According to the results, there is no meaningful relation between student's achievements and other alternative conceptions; AC3, AC4 and AC5, so these three alternative conceptions can be neglected. As noted earlier, this research is based on investigation of impact of content on diminishing alternative conceptions held by students, so AC3, AC4 and AC5 are negligible.

Discussion

Different instructional content and materials used in schools tend to produce alternative conceptions AC1, AC2 and AC6. It was predicted that the main reason for misconceptions is due to inappropriate teaching methods and materials in his research, called school-made misconceptions [6]. The probable alternative concepts caused by three themes; atomic mass, types of periodic table, and arrangement of atoms on table, are investigated in accordance with the results from the PCQP. By comparing the two groups` results, some alternative conceptions can be decreased by instructional content; MEPS content produces alternative conception AC6 and diminish other conceptions; AC1, AC2. MPS content produces alternative conceptions; AC1, AC2 but diminishes AC6.

Alternative conception (AC1) relevant atomic mass

Table 5 illustrates the links between AC1 and students' achievements. Based on the revealed outcomes of the study it was seen that the significant relationship between students' achievements and AC1 in both group members. Students had responses as correct about this proposition that is alternative conception `Atomic mass increases periodically. However, 38 of MEPS (66.7%) and 37 of MPS (94.8%) students determined the above proposition as correct. This means that the MPS content than MEPS had a higher impact to produce alternative conceptions about atomic mass. Another meaning was what MEPS content helps to diminish alternative conception about atomic mass.

The proposition atomic mass increases periodically` is incorrect because of some exceptions of atoms on the periodic table. Atomic mass is not a characteristic property of an atom. Atomic mass is changing in accordance with the absence of the ratio of isotopes of elements. The reason for this outcome is the MEPS instructional content was based on the Mendeleyev system and the periodic table (short form) is arranged of elements in terms of atomic mass or weight (Table 5).

Table 5: The Relationship Between Groups and AC1.

		mps=1, MEPS=2		Total	Nominal by Nominal	
		1	2		Value	Approx. Sig.
AC1	0	37	38	75		
	1	2	19	21		
N of Valid Cases		39	57	96		
Phi					,335	,001
Cramer's V					,335	,001
						p <0.05

The Mendeleev periodic table is constructed to increase atomic mass. The AC1 specified that the students have perceived as increasing atomic weights properly and respectively but observed the exception for elements such as Ar - K; Te - I and some actinide series of elements on the periodic table. Therefore, there are except elements arranged while increasing relatively average masses in short form of the periodic table. Thus, the highlighting of teaching content knowledge tends to produce alternative conceptions. Therefore, the alternative conception about atomic mass can be improved using the MPS content which is based on the atomic number that is characteristic property of an element. Atomic number is a more fundamental means to finalize the classification of the elements, a process begun by classical chemistry by concentrating on the macroscopic properties of the elements and their compounds [15].

Alternative conception (AC2) relevant type of periodic table

The AC2 proposition is about using only one type of periodic table form. The AC2 was called "There is no different form of periodic table." It was answered as incorrect by 29 of the MPS and 28 of the MEPS students. This means that more of the MPS and the MEPS students have a higher impact to produce alternative conceptions about different forms of periodic table, but a higher percentage of the MPS students than the MEPS ones produce as incorrect. This is the result of more focusing on the historical approach of the Mendeleev periodic table for the MEPS while the only modern periodic table is presented during the teaching process for the MPS. Why did students answer the proposition as an alternative conception? The reason is the traditional contents, no presentation of alternative or different periodic tables at schools. It was specified by Roddy that the students have a very limited understanding of instruction from traditional schools left on the periodic table [10]. He/she proved that the pictorial periodic table and graphic technique of data mapping should be used as inquiry-based methods to change high school chemistry students' understandings of the elements, structure, and periodicity of the periodic table. It was also proved by Lehman that it's better to teach using the modified tables than the traditional table on learning periodic systems [8]. Thus, the teaching with traditional content and only one type of periodic table increased the alternative conception AC2 (Table 6).

Table 6: The Relationship Between Groups and AC2.

		mps=1, MEPS=2		Total	Nominal by Nominal	
		1	2		Value	Approx. Sig.
AC2	0	29	28	57		
	1	10	29	39		
N of Valid Cases		39	57	96		
Phi					,252	,013
Cramer's V					,252	,013
						p <0.05

This study signifies the effect of using different Periodic table's forms on the change of alternative conception. MEPS students accepted AC2 as less percent because the existing Mendeleyev periodic table is decided as the original table and the knowledge about later developments of construction of periodic table (short form, long form and others) was taught during the teaching process. However, MPS content included less knowledge of historical development of periodic tables. Therefore, MEPS content can diminish the alternative conception because of the significant relationship between AC2 and achievements of students as shown on Table 6. The combination of MEPS and MPS contents can diminish the AC2 when students are taught by using effectively different forms of periodic table in both teaching processes.

Alternative conception (AC6) relevant elements arrangement

For AC6, MEPS and MPS students had understanding correctness about the meaning of periodicity concept in accordance with the answers to be as correct but that is "the arrangement of elements in seven periods on the table" was an incorrect proposition, so this was an alternative conception. This proposition is incorrect because the "periodicity" concept cannot be used as meaning of "arrangement in seven periods". It is determined that 49 of MEPS (86%) students and 20 of MPS students (51%) had not identified the incorrectness of the above proposition. It may seem that the main reason is lack of explanation about the periodic law. In traditional instruction, teachers are demonstrating the table, but additional activity is not done. Thus, students accept knowledge by only observing tables and so, they may build misconceptions and alternative conceptions. In this respect, when it explained more, represented the different forms of the periodic tables, and built periodic table studies, not only student's observations, but it also increased meaningful understanding and decreased mistakes about AC6.

Results also show us the MEPS content had a higher impact to produce alternative conception than the MPS about the AC6. The MPS content includes the application of electronic configuration in teaching process and atomic theory; the arrangement of elements in group forms by their similarities in their chemical properties; periods or rows form the arrangement of elements which have similarities in the electronic configurations. The periodic table includes seven periods in the MPS table, and it is long, and periods seem clear. The MPS students can understand the "periodicity" concept as "arrangement in seven periods" because of the regular period and meaning sequence as seven regular rows. However, the MEPS table has ten small and big rows and short periods and is divided into two short rows, so it is hard to be understood by students without extra information. The MEPS students can misunderstand the visually presented periodic table without any extra explanation. The positive significant relationship between the AC6 and achievements provides understanding that the MPS content can diminish the alternative concept (AC6) that is `Periodicity means arranging elements in seven periods on the periodic table (see Table 7).

Table 7: The Relationship between Groups and AC6.

1		mps=1, MEPS=2		Total	Nominal by Nominal	
		2		Value	Value	Approx. Sig.
AC6	0	20	49	69		
	1	19	8	27		
N of Valid Cases		39	57	96		
Phi					-,379	,000
Cramer's V					,379	,000
						p <0.05

Conclusion

This study concluded that some alternative conceptions could be diminished by using various contents during the instruction process. The combination of two contents was used in the study and became effective for students' understanding and diminishing alternative conceptions about 'periodicity' concept. According to the results, the MPS content diminishes the AC6 while the MEPS content diminishes the AC1 and the AC2.

If knowledge or information is emphasized more during the teaching process, students may hold alternative conceptions. These are the teacher made conceptions. We suggest advantages of various contents and strategies should be taken to prevent alternative conceptions about periodicity concept. Educators can develop teaching strategies that help students identify their preconceptions and change their alternative conceptions [14]. Once traditional teaching methods are used in teaching science subjects, students understand subjects at knowledge level, and they usually memorize the science concepts without understanding the real meaning [16]. They suggested alternative teaching approaches needed to teach difficult concepts in science education. These should be taken into account during the curriculum design process. It suggested that "Students` alternative conceptions are extensive and tenacious but also possible curriculum and pedagogical factors contributing to their formation [11]. Furthermore, it should be enough to design content knowledge about periodicity in the curriculum. Given this orientation, this study showed that there is a great benefit to prevent misunderstandings on the meaning of the periodicity with the help of making comparisons between the different didactic contents, representing the different forms of the periodic tables, building periodic table studies, more explaining, and training exercises about properties of atoms on tables during the instructing process. This paper also emphasizes that for chemistry instruction to be effective, teachers and learners will need to be educated about how knowledge is acquired in the discipline that they are teaching and learning.

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Conflict of Interest

No conflict of Interest.

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