TÜRK FEN EĞİTİMİ DERGİSİ
Yıl 15, Sayı 1, Mart 2018

Journal of
TURKISH SCIENCE EDUCATION
Volume 15, Issue 1, March 2018

http://www.tused.org

Effectiveness of Concept Cartoons on 7th Grade Students' Understanding of "the Structure and Properties of Matter"

Fuat Serkan SAY[1], Haluk ÖZMEN [2]

[1] Asst. Prof. Dr., Mersin University, Mersin-TURKEY
[2] Prof. Dr., Karadeniz Technical University, Trabzon-TURKEY

Received: 03.11.2016 **Revised:** 13.06.2017 **Accepted:** 07.08.2017

The original language of article is English (v.15, n.1, March 2018, pp.1-24, doi: 10.12973/tused.10218a)

ABSTRACT

The aim of this study is to determine the effect of concept cartoons on 7th grade students' acquiring the concepts in "The Structure and Properties of Matter" chapter. To reach this aim concept cartoons involving students' preconceptions and alternative conceptions about the concepts in the unit were developed. The data of the research was collected via the Structure and Properties of Matter's Concept Test (SPMCT) and semi-structured interviews. The sample of the research consisted of 49 grade 7 students in total, 24 students in experimental group and 25 students in control group. SPMCT prepared by considering the alternative conceptions obtained via the outcome of literature analysis was applied as a pre-test. And then, the unit of "the structure and properties of matter" with prepared concept cartoons was studied. At the end of the study, SPMCT was applied to the students as a post-test. At the end of the research, it was ascertained that students had varied alternative conceptions about studied concept, some of them learned the concepts of the structure and properties of matter at a level of knowledge, but were inadequate in applying them. In addition, the students chosen from the experimental group were interviewed with the intent of promoting the test results. As a result of analyzing the test and interview, it was ascertained that the application decreased the alternative conceptions on the structure and properties of the matter existing in students, did not reveal new alternative conceptions and got the students comprehend the subjects better.

Keywords: Concept cartoon, the structure and properties of matter, alternative conception

INTRODUCTION

The abstract nature of science subjects may result with different alternative conceptions while constructing these subjects in students' mind. Students starting the science education at earlier ages are expected to be learning the abstract concepts in science, which are even difficult to be conceptualized by adults. Therefore, this higher expectation makes the science concepts relatively difficult for teachers to teach. (Amir & Tamir, 1994). Additionally, students describe science classes difficult due to more intellectual activity requirement (Çepni, Akdeniz & Keser, 2000). Chemistry included in science curriculum with a number of

Corresponding author e-mail: hozmen@ktu.edu.tr

basic concepts is one of the most important fields of science. Research studies investigating the understanding, comprehension and conceptions show that students at all levels struggle with chemistry concepts and cannot be successful in desired level. While students learn several alternative conceptions related to fundamental chemistry concepts, they face with several cognitive conflicts when dealing with these concepts and find them difficult to learn in chemistry (Kirkwood & Symington, 1996; Lorenzo, 2005; Özmen, 2007; Taber, 2000).

One of the basic and abstract subjects of chemistry is "*Structure and Properties of Matter*". Teaching microscopic nature of matter to students whose intellectual levels of development are not at the expected levels causes additional difficulty for students to clearly understand the relevant concepts. As a matter of fact that various alternative conceptions are observed about the subject when the studies in literature over the structure of matter are analyzed (Bektaş, 2003; Çakır, 2005; Griffiths & Preston, 1992; Harrison & Treagust, 1996; Nakhleh & Samarapungavan, 1999; Özmen, 2011a; Özmen, 2013; Tsai, 2001). Structure and properties of matter include fundamental concepts and correctly understanding these concepts affects the learning of other advanced level concepts (Özmen, Ayas & Coştu, 2002). In order to address problems in the learning and understanding fundamental concepts in chemistry, new and alternative teaching methods and materials are needed to be developed, which could enable students to understand these concepts easily and correctly.

Changing alternative conceptions is as important as teaching the concepts to the students correctly. Putting the conceptual change into practice requires students to realize that their prior knowledge was incorrect at first and then believe that the given knowledge is plausible and accurate (Chi & Roscoe, 2002; Ebenezer, Chacko, Kaya, Koya & Ebenezer, 2010; Piquette & Heikkinen, 2005; Posner, Strike, Hewson & Gertzog, 1982). And also, teachers should provide some opportunities for the students to make real conceptual change through various activities (Gooding & Metz, 2011). Literature reported that conceptual change strategies play a supportive role in promoting students' core understanding (Howe, Devine & Taylor Tavares, 2013).

It is seen in the literature that there are many teaching methods, techniques and materials being used to develop students' understanding and dispel the alternative conceptions (Chambers & Andre, 1997; Coll & Treagust, 2011; Guzzetti, Williams, Skeels & Wu, 1997; Huddle, White & Rogers, 2000; Keogh & Naylor, 1999; Özmen, Demircioğlu & Coll, 2009). In these studies it is stated that teaching methods and materials that activating the students have a positive effect on learning. Even though there are some studies in the literature investigating the effectiveness of different teaching materials on teaching the structure and the properties of matter (Akgün & Aydın, 2009; Balım, İnel & Evrekli, 2008; Chiu & Lin, 2005; Çepni, Akdeniz & Keser, 2000; İngeç, 2008; Özmen, 2011b), it is known that different materials being used in these studies are also mostly insufficient in concept teaching and correcting alternative conceptions. That most of the materials cannot meet the expectations sufficiently is one of the most important reasons for this. For example, it is stated that analogies could create new alternative conceptions (Huddle, White & Rogers, 2000; Orgill & Bodner, 2004; Thiele & Treagust, 1994), conceptual change texts could be boring and could create reading problems (Dole, 2000), and preparing worksheets is difficult and they could also be boring (Türk & Çalık, 2008). Therefore, along with the educational quality of the materials used in teaching process, it is also important that they should entertain the students during the implementation process. When considered for the primary education, we can talk about the attractiveness of the humorous approach in communicating the children. In this sense, cartoons are accepted to be an effective communication tools.

Concept cartoons were firstly introduced by Stuart Naylor and Brenda Keogh in 1991 (Karpudewan, MdZain & Chandrasegaran, 2017). They used them as a strategy to determine students' ideas, to challenge their nonscientific beliefs and to provide insights into how these

ideas are developed (Keogh & Naylor, 1999). Concept cartoons provide students with a constructivist learning environment to participate in classroom discussions enjoyably (Ekici, Ekici & Aydın, 2007) and to express their ideas freely, especially in science and technology courses (Saka, Akdeniz, Bayrak & Asilsoy, 2006).

Concept cartoons were presented the students with science concepts (Karpudewan, MdZain & Chandrasegaran, 2017) and include a visual representation of a few characters in settings familiar to students along with the use of written language in speech bubbles (Keogh & Naylor, 1999; Sexton, 2010). In these cartoons, students read the dialogues and decide which character's views they agree with. In such a process, students have the opportunity to compare own ideas with ones found in cartoons, to listen the other students' views about the concept (Naylor & Keogh, 2013; Karpudewan, MdZain & Chandrasegaran, 2017) and to investigate and reinterpret the ideas in the cartoons (Kabapınar, 2005). Such an application gives students opportunity to dispel their alternative conceptions and construct the correct science concepts.

It is possible to communicate in an easy but not a complicated way via cartoons. In addition, cartoons have a feature of being remarkable, amazing and catchy (Dabel, 2008; Keogh & Naylor, 1999; Stephenson & Warvick, 2002). Cartoons have great importance in teaching and learning in terms of being not only humorous but also their psychological effects (Uğurel & Moralı, 2006). Keogh and Naylor (1999) suggest using the concept cartoons as an original, encouraging, alternative and effective method providing a conceptual development in teaching and learning process.

Concept cartoons are often used by researchers as teaching and learning materials (Atasoy, Tekbıyık & Gülay, 2013; Chin & Teou, 2009; Dündar & Şentürk, 2012; İngeç, 2008; Kabapınar, 2005; Keogh & Naylor, 1999; Keogh, Naylor, Boo & Rosemary, 2002; Sexton, 2010; Taşlıdere, 2013). These studies report that concept cartoons have several benefits while using the educational purposes. For example, concept cartoons are effective in diagnosing and dispelling the alternative conceptions in science (Chin & Teou, 2009; Kabapınar, 2005; Keogh & Naylor, 1999). In addition, concept cartons are used for various purposes such as assessment tools (Chin & Teou, 2009; İngeç, 2008; Keogh et al., 2002), developing reading skills (Demetrulias, 1982), promoting investigations, motivation and involvement (Dündar & Şentürk, 2012; Kabapınar, 2005; Keogh & Naylor, 1996), solving problems (Jones, 1987), restructuring of ideas (Keogh & Naylor, 1996), promoting positive attitudes to science teaching and learning (Keogh et al., 2002), minimizing classroom management problems (Keogh & Naylor, 1999). Naylor and Keogh (2012) summarize some another benefits as developing language skills, engaging students in higher order thinking skills, creating interactive learning environments, auditing subject knowledge of student teachers, and effective stimuli for argumentation. And also, literature reports that concept cartoons are generally suitable for all ages of students (Karpudewan, MdZain & Chandrasegaran, 2017; Keogh & Naylor, 1999).

In the literature there are numerous studies stating that concept cartoons have a positive effect on learning and alternative conceptions (Kabapınar, 2005; Keogh & Naylor, 1999; Morris, Merritt, Fairclough, Birrell & Howitt, 2007; Stephenson & Warwick, 2002). Based on this data, we wondered in the present study that if the using of concept cartoons are effective way in teaching of the structure and the properties of matter. For this aim, a teaching material supported by concept cartoons was developed and its effect on learning was tried to be identified. In accordance with this aim, we tried to seek an answer for those two basic questions below:

1. Does the education supported by the concept cartoons have a statistically meaningful effect on learning?

2. To what degree could the concept cartoons have an effect on correcting the alternative conceptions?

METHODS

a) Research Method

A quasi-experimental design was used in the study. This method includes at least an experimental and a control group but the groups are not determined randomly. The points of each group from pre-test to post-test are compared and observed if there is a meaningful difference between the groups (Christensen, 2004).

b) Sample of the Study

It was used two different groups in this study. The first group is the one with 96 grade 7 students and also is the group on which the pilot study of the achievement test which is developed during the study was done. And the second group is composed of the students on whom the main study is conducted. The group is composed of two grade 7 classes consisting of 24 experimental and 25 control group's students attending to a primary school in Erdemli at Mersin.

c) Data Collection Tools

In this study the data were collected through The Structure and Properties of the Matter Concept Test (SPMCT) and semi-structured interviews. SPMCT consists of 19 two tier multiple-choice questions. The first tier of the test includes 2 or 3 answer choices and tests the students' knowledge as a multiple-choice format. And the second tier consists of 4 answer-choices asking students to justify their answers in the first phase. The second tier of the test involves multiple-choice options including students alternative conceptions determined from the findings obtained from the literature review. A literature survey has been done to prepare the test questions. All of the questions in the test were derived from the relevant literature (Çakmak, 2009; Çalık & Ayas, 2003; Ünal, 2007) and the 16^{th}, 17^{th}, 18^{th} and the 19^{th} questions were turned into two tier multiple-choice questions by the researchers. With the aim of checking the validity of SPCMT, the test was analyzed by three science teachers and an academic member who is an expert in chemistry education and corrections were made based on their view and suggestions. The reliability of the test was calculated with the SPSS 15.0 package software, Cronbach-Alpha method was used on the ground that the test consists of multiple grading questions and the reliability co-efficient of the test was found as r= 0.76. Two of the questions in the test are given as examples below.

Question 2. What do you think the structure of matter is like?

I-Continuous II- Particulate (*)

Which of the statements below could be the reason for your answer?

A. Because the matter is seen continuous when observed with naked-eyes
B. Because it is made up of little particles that are too small to be seen with naked-eyes (*)
C. Because the matter is seen as continuous when looked at through a microscope
D. Because the particles in matter are seen as continuous

Question 6. The gold is yellow. According to this, if we were able to separate an atom from a piece of golden wire by cracking it, would it be yellow too?

I- Yes II- No III- Atoms are colorless (*)

Which of the statements below could be the reason for your answer?

A. Because the atom of the matter would be the same color as the matter.
B. Because it is the atom that colors the matter.
C. Because the colorfulness of the matter depends on the matters' characteristics of absorb and reflect the light (*)
D. Because the atom would lose its color because of the fraction

*: true answer

A semi-structured interview consisting of 13 questions was also conducted for determining the students' conceptual understanding. Eleven of the questions used in interview were taken from the related literature (Çakmak, 2009; Çalık & Ayas, 2003; Ünal 2007) and being turned into interview questions. The 10th and the 13th questions were developed by the researchers. The interviews were carried out with 9 students from the experimental group that the main study is conducted on. Three successful students (S2, S7, and S16), three mid-level students (S4, S13and S24) and three unsuccessful students (S11, S20 and S21) were voluntarily chosen based on the concept test scores. The interviews were conducted by the first author of the study in the school's computer laboratory after applying the post-test. Each interview lasted 30 minutes and was type recorded. The interviews were analyzed by the three science teachers and an academic member who is an expert in chemistry education and essential changes in the test were done in accordance with their view and suggestions before implementing the interviews. The percentage of matches between experts was 89%. Subjects without a consensus were reassessed and finalized.

d) Developing the Concept Cartoons Used in the Study

Teacher's and the student's book were analyzed considering the learning outcomes in the unit before developing the concept cartoons. After that, the alternative conceptions regarding the subject were identified via the literature analysis. Concept cartoons were designed in accordance with the learning outcomes and the identified alternative conceptions. In making up the stories of the cartoons, we made use of the 7th grade teacher's guidebook of science, of the literature (URL1; URL2; Çakır, 2005; Çakmak, 2009) and of the views of the science teachers. On the phase of making up the stories of the cartoons, the views of the science teachers were considered and the concepts that they have difficulty in teaching were focused on. Concept cartoons consist of 6 series in which there are 20 frames in total. In preparing the 1st cartoon series, we were inspired by the metaphors in science teacher's guidebook and while teaching the abstract concepts such as atom, element and compound, onion cartoons were used to embody the abstractness of the concepts. In designing the 2nd cartoon series, we were inspired by the cartoons in the worksheets which were used in the study conducted by Çakmak (2009). In designing the 3rd cartoon series, we were inspired by the drawings and the pictures in the science teacher's guidebook. In preparing the 4th and the 5th series of cartoons, we were inspired by the animations on the net, demonstrating the atomic bonds. Concept cartoons which also included the alternative conceptions were developed to ensure the effective learning of the covalent bond and the ionic bond (URL1; URL2). Some of the cartoons developed by the researchers are given as an example below:

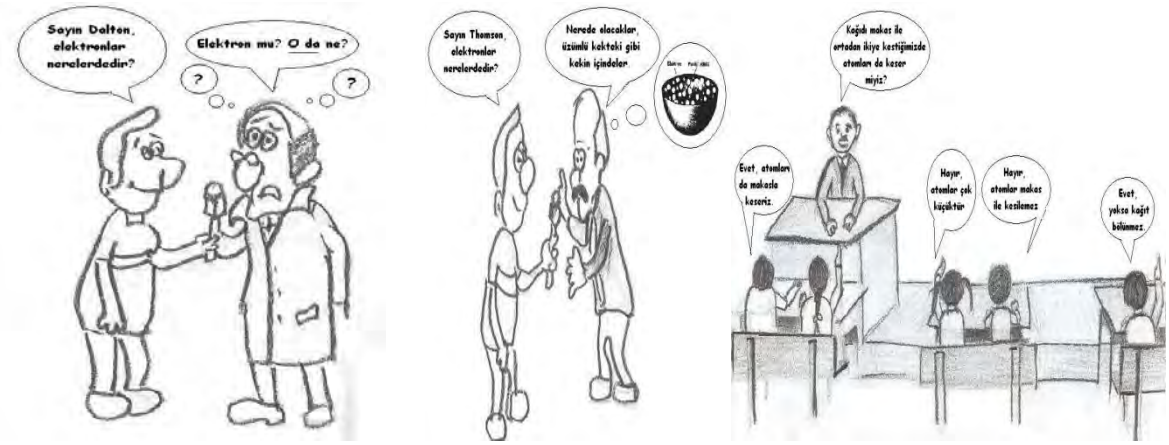


Figure 1. Samples of concept cartoons

e) Implementation Process

Both of the groups in the study were taught by the same science teacher. The teacher conducted text book and the teacher's guidebook-based instruction in the control group while he taught the same unit concept cartoon-based applications in experimental group. SPMCT was applied to both groups as pre-test before starting the implementation and as post-test a week after finishing the teaching of the unit. The application was completed by interviewing the 9 students after implementing the post-test. The teacher was informed before the main application about how to use the concept cartoons while teaching. What the aim to use of the concept cartoons is, what it is for, how it will affect the teaching and how to use it were explained to the teacher in detail. And then, the views and suggestions of the other science teachers were also taken by discussing with them related how to use the concept cartoons. As a result of these discussions, it was decided that it would be better to use the concept cartoons for discussions on the alternative ideas and for revealing the students' ideas on the subject. Finally, questions to assess the teaching at the end of the lesson were developed and it was decided to make the assessment through the concept cartoons. The teaching process in the control and the experimental groups is summarized on Appendix 1.

f) Data Analysis

SPMCT was applied to both groups at the beginning and at the end of the unit. In analysis, it was tried to be identified whether the students' answer were true at the first tier of the questions, and whether the reasons for the answers given at the first tier were true at the second tier. The points on table 1 were regarded in assessing the questions.

Table 1. *Points of Concept Test Questions*

The First Tier		The Second Tier		Total Score
Options	**Points**	**Options**	**Points**	
Correct Choice	3	Correct Reason	4	7
Wrong Choice	1	Correct Reason	4	5
Correct Choice	3	Wrong Reason	2	5
Not Answer	0	Correct Reason	4	4
Correct Choice	3	Not Answer	0	3
Wrong Choice	1	Wrong Reason	2	3
Not Answer	0	Wrong Reason	2	2
Wrong Choice	1	Not Answer	0	1
Not Answer	0	Not Answer	0	0

Even if it is wrong, the students' idea is always valuable, because the student has an idea about the concept. Therefore it is considered appropriate to give more points to the wrong answer than the question that is not answered. According to the table, the total score that a student could get is 113 when all the answers are correct. After that, the achievements of the experimental and control group students were compared to the independent t-test. Data obtained from the interviews were classified as "alternative conception", "partial understanding" and "correct understanding". In this classification, the scientifically correct explanations were accepted as correct understanding, the scientifically correct but deficient explanations as partial understanding and scientifically incorrect ones as alternative conception. These kinds of classifications are used in the literature (Abraham, Grzybowski, Renner & Marek, 1992; Çakmak, 2009).

FINDINGS

a) Results Obtained from the Test

SPCMT was applied to both groups as pre-test before the application and as post-test after the application in the study. It was observed with the independent t-test if there were any statistically significant difference between the groups. The results are presented below:

Table 2. *Statistical Results of Pre-test and Post-test between the Groups*

Application	Group	N	$\overline{X}$	ss	Sd	t	p
Pre-test	Experimental	24	39.96	4.1	47	.21	.83*
	Control	25	40.20	3.2			
Post-test	Experimental	24	120.08	3.53	47	7.38	.00**
	Control	25	109.64	6.54			

*p>.05; **p<.01

As is seen in table 2, before the application it was determined that there was not a statistically significant difference between the experimental and the control group (p>.05). However, it was observed that there was a statistically significant difference between the success of the groups after the comparison of the post-test results (p>.01). As seen in the table, there is a remarkable increase in both groups but the increase in the experimental group is much more than the control group.

In addition to the statistical analysis, both groups students' alternative conceptions were determined based on the analysis of the pre-test and post-test implementation of the SPMCT. According to the results of SPCMT, the percentage of the alternative conceptions of the students in both groups is demonstrated on table 3. As seen in the table, thirty alternative conceptions were identified in total under the ten topics in the pre-test in the study, and it is observed that the rates of the alternative conceptions in both groups are close to each other. And according to the assessments regarding post-test results, it was determined that there was a decrease in the rate of alternative conceptions of both groups however, the rate of the experimental group's alternative conceptions was determined to be far less than the control group's ones. While thirteen of the alternative conceptions were completely corrected in the control group, the number of the corrected alternative conceptions in the experimental group is nineteen. Some of the alternative conceptions were still present in both groups in post-test. While the alternative conceptions in the experimental group according to the post-test range from 4.2% to 8.2%, this percentage in the control group is between 4% and 16%.

Table 3. *Percentage of the Alternative Conceptions in Pre-Test and Post-Test*

Classification	Alternative conception	Control Group		Experimental Group	
		Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)
The atom is visible	Because the microscope enlarges the small particles	52	12	45.8	4.2
	Because the technology we have allows it	8	8	12	-
	Because there are the shapes of atoms in books	12	-	20.8	-
The atomic models are real	Because the scientists see atoms and draw their models	52	8	50	4.2
	Because the scientists explore the atomic models doing experimental researches	20	12	25	4.2
	Because the models are drawn with the help of microscope	16	-	12.5	-
If a matter is crushed, its atoms are also crushed	Because with the process of crashing atoms would get thinner and longer	20	-	12.5	-
	Because after the process of crashing, the volume of the atoms would decrease and their shapes would change	32	-	21.9	-
	Because after the process of crashing some of the atoms would be crashed and form different atoms	24	8	37.5	4.2
Atoms are circular	Because the shape of an atom likes sphere	56	12	62.5	4.2
	Because the shape of an atom is flat	20	4	12.5	-
	Because the shape of an atom likes a dot	16	-	12.5	-
All of the atoms are identical	Because all atoms of the elements are the same	36	12	33.3	-
	Because all of the matters in nature consist of the same atoms	24	-	16.7	-
	Because the atoms of the iron are harder than the ones in copper	24	-	25	-
The tap water is pure	Because it includes only one matter	64	16	53.8	4.2
	Because it consists of water atoms	12	4	16.7	-
	Because it is formed by the combination of pure matters	16	-	12.5	-
Whether the matters are mixture or not	Because they are formed by the combination of two different elements	12	-	16.7	4.2
	Because all the mixtures contain the same kind of particles	56	12	50	8.3
	Because they are pure matters	12	-	20.8	-
Whether the matters are compound or not	Because the smallest basic unit of the both models is atom	20	4	12.5	-
	Because the compound are formed by the combination of two identical atoms	40	4	50	8.3

	Because the compounds are formed by the combination of two matters	16	-	20.8	-
Mixtures	The solid powdered beverage melts because it will become liquid	48	4	41.7	-
	It would melt away because a new matter is formed	20	-	16.7	-
	The powdered drink would disappear	20	4	33.3	4.2
The ionic and the covalent bonding	Ionic bonding, because it is formed between two different atoms	28	4	12.5	4.2
	Ionic bonding, because there is an electron exchange among atoms	24	8	34.5	-
	Covalent bonding, because the electronegativity of the fluorine is more than the hydrogen	24	-	29.1	-

The most common alternative conception encountered in pre-test is that the tap water is pure because it includes only one matter. While 64% of the control group students have this alternative conception in pre-test, 53.8% of the experimental group students have this one. After the implementation process, 16% of the control group students have this alternative conception while 4.2% of the experimental group students have this one in post-test. Another most common alternative conception is that atoms are circular because the shape of an atom likes sphere. While 56% of the control group students have this alternative conception in pre-test, 62.5% of the experimental group students have this one. After the implementation process, 12% of the control group students have this alternative conception while 4.2% of the experimental group students have this one in post-test. The other common alternative conception encountered in pre-test is that the matters are mixtures because all the mixtures contain the same kind of particles. While 56% of the control group students have this alternative conception in pre-test, 50% of the experimental group students have this one. In post-test, 12% of the control group students have this alternative conception while 8.3% of the experimental group students have this one. One of the common alternative conceptions encountered in pre-test is that the atom is visible because the microscope enlarges the small particles. While 52% of the control group students have this alternative conception in pre-test, 45.8% of the experimental group students have this one. In post-test, 12% of the control group students have this alternative conception while 4.2% of the experimental group students have this one. Another common alternative conception found in pre-test is that the atomic models are real because the scientists see atoms and draw their models. While 52% of the control group students have this alternative conception in pre-test, 50% of the experimental group students have this one. In post-test, 8% of the control group students have this alternative conception while 4.2% of the experimental group students have this one. One of the alternative conceptions determined in pre-test is that the solid powdered beverage melts because it will become liquid. While 48% of the control group students have this alternative conception in pre-test, 41.7% of the experimental group students have this one. After the implementation process, 4% of the control group students have this alternative conception while the experimental group students dispel this alternative conception entirely in post-test. Another alternative conception is that all atoms are identical because all atoms of the elements are the same. While 36% of the control group students have this alternative conception in pre-test, 33.3% of the experimental group students have this one. After the implementation process, 12% of the control group students have this alternative conception while the experimental group students dispel this alternative conception entirely in post-test. One of the alternative conceptions found in pre-test is that if a matter is crushed, its atoms are also crushed because after the process of crashing, the volume of the atoms would decrease and their shapes would change. While 32% of the control group students have this alternative conception in pre-test, 21.9% of the experimental group students have this one. After the implementation process, both the control and the experimental group students dispel this alternative conception entirely in post-test.

Some of the alternative conceptions encountered in pre-test with lower rates dispelled entirely in post-test. For example, while 12% of the control group students and 20.8% of the experimental group students believe that the atom is visible because there are the shapes of atoms in books; both groups' students corrected this alternative conception entirely in post-test. Another is that, while 24% of the control group students and 16.7% of the experimental group students believe that all of the atoms are identical because all of the matters in nature consist of the same atoms; both groups' students dispelled this alternative conception entirely in post-test. Similarly, while 24% of the control group students and 25% of the experimental group students believe that all of the atoms are identical because the atoms of the iron are harder than the ones in copper; both groups' students dispelled this alternative conception

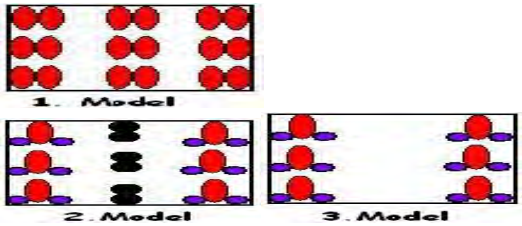
entirely in post-test. Another alternative conception dispelled entirely in post-test by both groups is that if a matter is crushed, its atoms are also crushed because with the process of crashing atoms would get thinner and longer. 20% of the control group students and 12.5% of the experimental group students have this alternative conception in pre-test. 16% of the control group students and 12.5 of the experimental group students have another alternative conception in pre-test, which atoms are circular because the shape of an atom likes a dot. Both groups' students dispelled this alternative conception in post-test. In pre-test 16% of the control group students and 12.5% of the experimental group students have the alternative conception that the atomic models are real because the models are drawn with the help of microscope. This alternative conception was dispelled entirely in post-test by both groups' students.

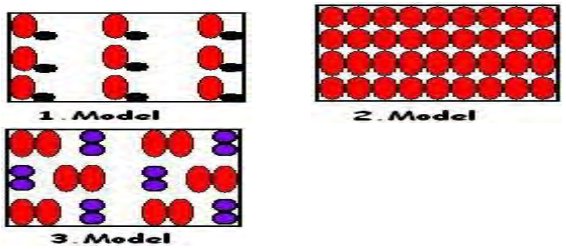
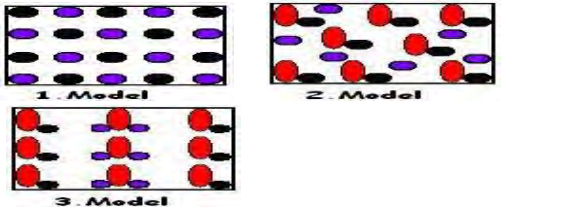
b) Results Obtained from the Interviews

Conceptions regarding the subjects in research were tried to be determined during the interviews conducted after the application with the students chosen from the experimental group, and by this way the findings of the test results were intended to be supported. The examples regarding the students' answers in three categories to the questions during the interview are presented in Table 4.

Table 4. *Examples Regarding the Students' Answers Organized in Three Categories*

Questions	Categories	Answer Samples
1. Matters are seen as a whole when looked at. How do you think the structure of matter is like? Why?	Alternative conception	Matters are in a single shape and therefore they look as a whole (S11)
	Partial understanding	There are atoms in matters, because they stand together, matters look as a whole (S21)
	Correct understanding	Matters consist of atoms. Because we cannot see the atoms through our eyes, we see matters as a whole (S2, S4, S7, S13, S16, S20, S24)
2. If we hammer an iron bar and flatten its shape, what kind of a change occurs in the atoms? For instance, is it possible that the atoms are smashed?	Alternative conception	As matters can be smashed so can atoms (S13)
	Partial understanding	As we do not know the shapes of the atoms, we cannot talk about their being smashed (S20)
	Correct understanding	Atoms cannot be smashed, if they could, there would be big explosions like atomic explosions (S2, S4, S7, S11, S16, S21, S24).
3. If we divided an aluminum plaque or a copper plate in two by scissors, is it possible that we could also divide the atoms there?	Alternative conception	We divide the matters in two by cutting them by scissors. We can also divide the atoms there (S11)
	Partial understanding	---
	Correct understanding	Atoms cannot be divided easily. If they could, there would be big explosions (S2, S4, S7, S13, S16, S20, S21, S24)
4. We know that some of the matters in our environment are soft and some of them are hard. Do atoms have the feature of being soft or hard? Why?	Alternative conception	---
	Partial understanding	We cannot know if the atoms are soft or hard because we cannot see them (S21, S24)
	Correct understanding	Atoms do not have physical features. Softness and hardness depend on atomic bonds and gaps (S2, S4, S7, S11, S13, S16, S20)
5. Imagine that you have two pieces of iron in different sizes. And assume that you take an atom from each of them. Would the size of the atoms you have taken be different too? How do you think the iron atoms are like in shape and size?	Alternative conception	We cannot see atoms. But the iron in bigger size is supposed to have bigger atoms (S21)
	Partial understanding	---
	Correct understanding	Because they are the same matter, the atoms are the same. The size and the shapes of the same atoms are the same (S2, S4, S7, S11, S13, S16, S20, S24)
6. Cell is the smallest unit of the living beings. A cell is like an atom with its nucleus in the middle and its movement. What can you say about an atom being living or not?	Alternative conception	---
	Partial understanding	Atoms are not alive because the matters that are formed by atoms are not alive (S11)
	Correct understanding	Atoms do not have the feature of being alive. They just move. Therefore atoms are not alive (S2, S4, S7, S13, S16, S20, S21, S24)

7. Matters are colorful. Are atoms also colorful? Why?	Alternative conception	It is the atom that gives a matter its color. Gold is yellow, because its atom is yellow (S4)
	Partial understanding	---
	Correct understanding	Atoms do not have colors. Color is related to the matter's reflecting the light, not to the atoms (S2, S7,S11, S13, S16, S20, S21, S24)
8. How is the structure of an atom?	Alternative conception	Atoms are in the shape of a sphere. Because they are demonstrated like that in books (S20)
	Partial understanding	---
	Correct understanding	Every atom is different from each other. As we cannot see atoms, we cannot have an idea about their shape (S2, S4, S7, S11, S13, S16, S21, S24)
9. What is ionic and covalent bonding? What kind of differences are there between them?	Alternative conception	---
	Partial understanding	Ionic and covalent bonds are inter-atomic bonds that hold the atoms together. Both of them hold the atoms together (S11, S24)
	Correct understanding	They are inter-atomic bonds. Ionic bonding takes place between a metal and non-metal via electron exchange. And the covalent bonding occurs by sharing of electrons of two non-metal (S2, S4, S7, S13, S16, S20, S21)
10. What is a homogenous or heterogeneous mixture? Do the chemical features of the matters change in mixtures?	Alternative conception	---
	Partial understanding	The mixtures that show the same features in each part of it are called homogenous mixtures. The mixtures in which the particles can be seen through naked eyes are called heterogeneous mixtures (S13, S20)
	Correct understanding	The mixtures that show the same features in each part of it are called homogenous and that shows different features are called heterogeneous. The matters in mixtures do not change their chemical features (S2, S4, S7, S11, S16, S21, S24)
11. Can you define the pure matter? Which model or models is/are pure matter/s? 	Alternative conception	Model 1 is pure matter. Because it consists of the same kind of atoms (S11)
	Partial understanding	Model 1 is pure matter. Because the pure matter is the one which does not include different kind of matters. In model 1 there is not any different kind of atom so it is a pure matter (S21)
	Correct understanding	Model 1 and Model 3 are pure matters. Because these models are formed by the same kind of atoms (S2, S4, S7, S13, S16, S20, S24)

12. What is a compound? Which model or models is/are compound/s? 	Alternative conception	Model 1 and model 3 are compounds, because there are different kinds of atoms (S11)
	Partial understanding	---
	Correct understanding	Model 1 is compound, because the compounds must include the same kind of molecules. Only in Model, there are the same kind of molecules (S2, S4, S7, S13, S16, S20, S21, S24)
13. Which model/s is/are mixture/s? 	Alternative conception	---
	Partial understanding	Model 2 and model 3 are mixtures. A mixture is formed by different matters' coexisting. In model 2 and model 3 different matters coexist so model 2 and model 3 are compounds (S13)
	Correct understanding	All of them are mixture. Different atoms and compounds' existing together is called a mixture. In each model different kinds of atoms and molecules coexist (S2, S4, S7, S11, S16, S20, S21, S24)

Data obtained from the interviews shows that while the rate of the answers given in the category of correct understanding by the experimental group is high, and the rate of the students' answers in partial understanding and alternative conception categories is low. The findings obtained both from the concept test and the interviews has shown that the teaching based on the concept cartoons in the experimental group was much more effective than the control group in students' understanding the concepts regarding the subject the structure and the properties of the matter. And also, experimental group students have better performance in altering the alternative conceptions.

In interviews, thirteen questions were asked to students related to structure and properties of matter after the implementation. The analysis of the interviews show that the rate of correct understanding of the students are generally high while some of the students have partial understanding and some of them still have alternative conceptions after the implementation. The first question of the interview was related to the holistic structure of the matter. In this question, while seven of the students have correct understanding, one student has partial understanding and one student has alternative conceptions. The second question was related to the interchangeability of the shapes of atoms with physical effects. While seven of the students responded the question correctly, one student has partial understanding and one student has alternative conception in this question. The third question was related to the divisibility of the atoms. In this question, eight of the students responded the question correctly stating that atoms cannot be divided. One student has alternative conception. This student believes that we divide the matters in two. We can divide the atoms by cutting them by scissors. The fourth question was related to hardness and softness of the atoms. While six of the students have correct understanding in this question, two students have partial understanding. These students think that we cannot know that they are soft or hard because we cannot see the atoms. There is no alternative conception in this question. The fifth question was related to the properties of the atoms of different sized species of the same matter. While eight students have correct understanding in this question, one student has alternative conception. This student believes that the atoms of the large-sized matters will also be large sized than the small-sized ones. The sixth question asked to the students that whether the atoms alive or not. While eight of the students responded the question in correct understanding category, one student had partial understanding. This student believes that atoms are not alive because the matters that are formed by atoms are not alive. The seventh question was related to colorfulness of the atoms. In this question, eight of the students have correct understanding, one student has alternative conception stating that if a matter is colorful, and its atoms are also colorful. The eighth question was related to the structure of atom. Eight of the students responded this question in correct understanding category while one student had alternative conception. This student believes that atoms are in the shape of sphere. The ninth question was related to the differences between ionic and covalent bonding. While seven of the students had correct understanding in this question, two students had partial understanding. The tenth question was related to homogenous and heterogeneous mixtures. In this question, seven of the students had correct understanding while two of them had partial understanding. These students defined the homogenous mixtures correctly, but they believed that the mixtures in which the particles can be seen through naked eyes are called heterogeneous mixtures. The eleventh question was related to the pure matter. In this question, students were given three different models and asked them to that which one of them represented the pure matter correctly. Seven of the students responded to the question in correct understanding category while one of them had partial understanding. One student had alternative conception in this question. The twelfth question was related to the compound. In this question, students were given three different models and asked them to that which one of them represented a compound correctly. Eight of the students responded to the question in

correct understanding category while one of them had alternative conception in this question. The thirteenth question was related to the mixture. In this question, students were given three different models and asked them to that which one of them represented a mixture correctly. Eight of the students responded to the question in correct understanding category while one of them had partial understanding in this question.

RESULTS, DISCUSSION AND CONCLUSION

The findings of the study show that the students in the grade 7 have some alternative conceptions regarding the subjects in the structure and the properties of the matter and that the concept cartoons are successful materials in identifying and correcting these alternative conceptions.

The leading alternative conceptions of the students are the ones related to atoms. It is observed by their answers in the test that both control and experimental group students think that atoms can be seen. The microscope's magnifying the objects that cannot be seen through naked eyes and making it possible for us to see the objects may be considered the reason of the alternative conceptions. One of the alternative conceptions seen in high rate in the pre-test both groups is related to the atomic models. Most of the students think that the atomic models are real. One of the most important reasons for this alternative conception may be considered as the text book's not including sufficient notice on the subject of atomic models. These models have been put forward to make atoms more comprehensible and they are not real but real-like suppositions. But in earlier studies, it is determined that most of the students described models as the copies of the originals (Bektaş, 2003; Çakmak, 2009; Harrison & Treagust, 1996).

Another alternative conception identified in the study is about the physical properties of atoms. Most of the students in both groups think that atoms have physical properties. The matters' being able to be crushed or cut, in other words, to be exposed to a physical phenomenon is considered as the reason why the students have this alternative conception. In addition, as atoms are the smallest units of matters, it may be considered that the shape of the matter changes because the shape of the atoms has changed. The studies encountered in the literature have also shown the similar results (Abraham, Grzybowski, Renner & Marek, 1992; Çakmak, 2009; Tezcan & Çelik, 2009).

Another alternative conception observed in students is about atoms being similar to each other. Because atoms are too tiny to see with naked eyes, these kinds of alternative conceptions come up about the size of atoms. And the studies in the literature have also shown the similar results (Çakmak, 2009; Griffiths & Preston, 1992; Yavuz, 2005; Yeğnidemir, 2000). Yegnidemir (2000) has tried to correct this alternative conception with the activities, but he couldn't completely correct it. And as a reason for this, he put forward the concepts' being abstract.

It is observed in the study that the students knew the subjects in theory or as definitions but they were not competent enough to use this knowledge. For instance, although the students could define the concepts as element, compound and mixture, they couldn't demonstrate it on models. This shows that the students are still in knowledge level and that the conceptual learning has not occurred. Most of the alternative conceptions in students results from the fact that they think of microscopic phenomenon in macroscopic level. These conceptions' being microscopic and requiring conceptual thinking has revealed incompetence in students. To overcome the incompetence and to correct the alternative conceptions, concept cartoons are found to be sufficient. This shows that using concept cartoons in the teaching process of abstract concepts may be an effective way.

The concept cartoons' being humorous (Keogh & Naylor, 1999; Uğurel & Moralı, 2006) and visual makes the teaching effective. Also, the cartoons' being enjoyable increases

the students' interests in the lesson and makes it easier for students to be motivated (Keogh & Naylor, 1996). Because the speeches in the cartoons are daily and humorous, students understand the concepts better, and they are affected positively during the learning process (Karpudewan, MdZain & Chandrasegaran, 2017). This shows that the lesson's being enjoyable is important in the effectiveness of the teaching process. Presenting the correct concept along with the alternative conceptions helped students to realize their alternative conceptions and prevented others to occur beforehand. And this has also shown that using the materials that shows and states the alternative conceptions is vital in the teaching process.

In addition, although the teaching that is conducted with concept cartoons alters the students' alternative conceptions in a certain level, it is observed that some of them were still present after the application. This supports the idea that even though the materials are prepared directly for the alternative conceptions, it is not easy to correct them and the students' ideas are resistant to change (Küçüközer & Kocakülah, 2007).

In conclusion, it is determined during the application process that the students had numerous alternative conceptions and they were tried to be corrected through concept cartoons. By means of the concept cartoons, the abstract concepts that gained visuality and tangibility were learned correctly by the students and owing to the fact that the cartoons include the alternative conceptions the students were prevented to have other ones. By this means, a more effective teaching was conducted in the experimental group. But preparing a cartoon for more than one learning outcome has affected the teaching negatively at the least. For instance, in the cartoon series in which the concept of the compound is also mentioned, mentioning the other concepts as well has prevented focusing on the conception of compound and teaching the "compound" to the students effectively. In addition, not mentioning about the pure matters sufficiently in the concept cartoons that are prepared about for the solutions caused not being able to correct the alternative conceptions of pure matter. This revealed that every concept cartoons to be prepared must serve for only one concept. By this means, the teaching is considered to be more effective. The informal observations on the experimental group's students by the researchers during the application have shown that the students enjoyed the teaching with the concept cartoons more. And this increased the students' attending the lesson. The cartoons being humorous and including the students' alternative conceptions encouraged the students to express their ideas and provided a good platform. By this means the students realized their alternative conceptions as well as realizing their peers'. The suggestions below could be made in accordance with the results obtained from this study:

- It may be possible to make the lesson enjoyable and make the students like it by means of the cartoons.
- One can benefit from the cartoons when preparing the textbook at a level that students could enjoy and be satisfied.
- Activity books can be prepared that includes cartoons teachers could benefit from.
- Concept cartoons could be used in embodying the abstract concepts and transferring them to the students.
- One can benefit from the concept cartoons when trying to encourage the shy students to attend the lesson and share their ideas.
- A comfortable platform is provided through the concept cartoons and by this means students become aware of the other students' ideas.

ACKNOWLEDGEMENT

This study constitutes a part of the first author's master thesis called "*Effect of concept cartoons on grade 7 students' understanding of the structure and properties of matter subject*" prepared with consultant of Assoc. Prof. Dr. Haluk ÖZMEN.

REFERENCES

Abraham, M. R., Grzybowski, E. B., Renner, J. W., & Marek, E. A. (1992). Understandings and misunderstandings of eighth graders of five chemistry concepts found in textbooks. *Journal of Research in Science Teaching*, *29*, 105–120.

Akgün, A., & Aydın, M. (2009). Erime ve çözünme konusundaki kavram yanılgılarının ve bilgi eksikliklerinin giderilmesinde yapılandırmacı öğrenme yaklaşımına dayalı grup çalışmalarının kullanılması. *Elektronik Sosyal Bilimler Dergisi*, *8*(27), 190-201.

Amir, R., & Tamir, P. (1994). In-depth analysis of misconceptions as a basis for developing research-based remedial instruction: the case of photosynthesis. *The American Biology Teacher*, *56*(2), 94-100.

Atasoy, Ş., Tekbıyık, A., & Gülay, A. (2013). The effect of concept cartoons on understanding of sound concept of fifth grade students. *Journal of Turkish Science Education,* 10(1), 176-196.

Balım, G. A., İnel, D., & Evrekli, E. (2008). Fen öğretiminde kavram karikatürü kullanımının öğrencilerin akademik başarılarına ve sorgulayıcı öğrenme becerileri algılarına etkisi. *İlköğretim Online*, *7*(1), 188-202.

Bektaş, O. (2003). *Maddenin tanecikli yapısı ile ilgili lise 1. sınıf öğrencilerinin yanlış kavramaları, nedenleri ve giderilmesi*, Yüksek Lisans Tezi, Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.

Chambers, S. K., & Andre, T. (1997). Gender prior knowledge, interest and experiences in electricity and conceptual change texts manipulations in learning about direct current. *Journal of Research in Science Teaching*, *34*(2), 107-123.

Chi, M. H., & Roscoe, R. (2002). The processes and challenges of conceptual change. In M. Limón & L. Mason (Eds.), Reconsidering conceptual change: Issues in theory and practice (pp. 3–27). Dordrecht: The Netherlands, Springer.

Chin, C., & Teou, L. Y. (2009). Using concept cartoons in formative assessment: Scaffolding students' argumentation. *International Journal of Science Education*, *31*(10), 1307–1332.

Chiu, M., & Lin, J. (2005). Promoting fourth graders' conceptual change of their understanding of electric current via multiple analogies. *Journal of Research in Science Teaching*, *42*(4), 429-464.

Christensen, L. (2004). *Experimental methodology*. USA: Pearson Education.

Coll, R. K., & Treagust, D. F. (2001). Learners' mental models of chemical bonding. *Research in Science Education*, *31*, 357-382

Çakır, Y. (2005). *İlköğretim öğrencilerinin sahip oldukları kavram yanılgılarının belirlenmesi*. Yüksek Lisans Tezi, Marmara Üniversitesi, Eğitim Bilimleri Enstitüsü, İstanbul.

Çakmak, G. (2009). *Altıncı sınıfta yer alan bazı temel kimya kavramlarının öğretimine yönelik hazırlanan yapılandırmacı temelli materyallerin etkinliğinin araştırılması*. Yüksek Lisans Tezi, Karadeniz Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Trabzon.

Çalık, M., & Ayas, A. (2003). Çözeltilerde kavram başarı testi hazırlama ve uygulama. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, *14*(2), 1-17.

Çepni, S., Akdeniz, A., & Keser, Ö. F. (2000). *Fen bilimleri öğretiminde bütünleştirici öğrenme kuramına uygun örnek materyallerin geliştirilmesi*. Türk Fizik Derneği, 19. Fizik Kongresi, Elazığ.

Dabell, J. (2008). Using concept cartoons. *Mathematics Teaching Incorporating Micromath. 209*, 34-46.

Demetrulias, D. (1982). Gags, giggles, guffaws: using cartoons in the classroom. *Journal of Reading*, *26*, 66-68.

Dole, J. A. (2000). Readers, texts and conceptual change learning. *Reading and Writing Quarterly, 16*, 99-118.

Dündar, H., & Şentürk, M. L. (2012). Concept cartoons and their using in life studies lesson. Uşak Üniversitesi Sosyal Bilimler Dergisi, Güz (5/3), 44-58.

Ebenezer, J., Chacko, S., Kaya, O. N., Koya, S. K., & Ebenezer, D. L. (2010). The effects of common knowledge construction model sequence of lessons on science achievement and relational conceptual change. *Journal of Research in Science Teaching*, *47*(1), 25–46.

Ekici, F., Ekici, E., & Aydın, F. (2007). Utility of concept cartoons in diagnosing and overcoming misconceptions related to photosynthesis. *International Journal of Environmental & Science Education*, *2*(4), 111–124.

Gooding, J., & Metz, B. (2011). From misconceptions to conceptual change. *The Science Teacher*, *78*(4), 34–37.

Griffiths, A.K., & Preston, K.R. (1992). Grade-12 students' misconceptions relating to fundamental characteristics of atoms and molecules. *Journal of Research in Science Teaching*, *29*(6), 611-628.

Guzzetti, B. J., Williams, W. O., Skeels, S. A., & Wu, S. M. (1997). Influence of text structure on learning counterintuitive physics concepts. *Journal of Research in Science Teaching*, *34*(7), 701-719

Harrison, A.G., & Treagust, D.F. (1996). Secondary students' mental models of atoms and molecules: Implications for teaching chemistry. *Science Education*, *80*(5), 509-534.

Howe, C., Devine, A., & Taylor Tavares, J. (2013). Supporting conceptual change in school science: A possible role for tacit understanding. *International Journal of Science Education*, *35*(5), 864–883.

Huddle P.A., White M.W., & Rogers F. (2000). Simulations for teaching chemical equilibrium. *Journal of Chemical Education*, *77*(7), 920-926.

İngeç, Ş. K. (2008). Use of concept cartoons as an assessment tool in physics education, *US-China Education Review, 5*(11), 47-54.

Jones, D. (1987). *Problem solving through cartoon drawing*. In R. Fisher (ed.), Problem Solving in Primary schools (Oxford: Basil Blackwell).

Kabapınar, F. (2005). Effectiveness of teaching via concept cartoons from the point of view of constructivist approach. *Educational Sciences: Theory and Practice*, *5*(1), 135–146.

Karpudewan, M., MdZain, A. N., & Chandrasegaran, A. L. (Eds). (2017). Overcoming students' misconceptions in science: Strategies and perspectives from Malaysia. Springer: Singapoure.

Keogh, B., & Naylor, S. (1996). Teaching and learning in science: a new perspective. Paper presented at the BERA Conference, Lancaster, UK.

Keogh, B., & Naylor, S. (1999). Concept cartoons, teaching and learning in science: An evaluation. *International Journal of Science Education*, *21*(4), 431-466.

Keogh, B., Naylor, S., de Boo, M., & Rosemary, F. (2002). Formative assessment using concept cartoons: Initial teacher training in the UK. In H. Behrendt, H. Dahncke, R. Duit, W. Gräber, M. Komorek, A. Kross, & P. Reiska (Eds.), Research in science education—Past, present, and future (pp. 137–142). New York: Kluwer Academic Publishers.

Kirkwood, V., & Symington, D. (1996). Lecturer perceptions of student difficulties in a first-year chemistry course. *Journal of Chemical Education*, 73, 339–343.

Küçüközer, H., & Kocakülah, S. (2007). Secondary school students' misconceptions about simple electric circuits. *Journal of Turkish Science Education*, *4*(1), 101–115.

Lorenzo, M. (2005). The development, implementation and evaluation of a problem solving heuristic. *International Journal of Science and Mathematics Education*, *3*(1), 33–58.

Morris, M., Merritt, M., Fairclough, S., Birrell, N., & Howitt, C. (2007). Trialing concept cartoons in early childhood teaching and learning of science. *Teaching Science*, *53*(2), 42-45.

Nakhleh, M. B., & Samarapungavan, A. (1999). Elementary school children's' beliefs about matter. *Journal of Research in Science Teaching*, *36*(7), 777-805.

Naylor, S., & Keogh, B. (2012). Concept cartoons: What have we learnt? Paper presented at the Fibonacci Project European Conference, Leicester, UK.

Naylor, S., & Keogh, B. (2013). Concept cartoons: what have we learnt? *Journal of Turkish Science Education,* 10(1), 3 – 11.

Orgill, M., & Bodner, G. (2004). What research tells us about using analogies to teach chemistry. *Chemistry Education: Research and Practice*, *5*(1), 15–32.

Özmen, H. (2007). The effectiveness of conceptual change texts in remediating high school students' alternative conceptions concerning chemical equilibrium. *Asia Pacific Education Review*, *8*(3), 413-425.

Özmen, H. (2011a). Turkish primary students' conceptions about the particulate nature of matter. *International Journal of Environmental and Science Education, 6*(1), 99-121.

Özmen, H. (2011b). Effect of animation enhanced conceptual change texts on 6th grade students' understanding of the particulate nature of matter and transformation during phase changes. *Computers and Education*, *57*, 1114-1126.

Özmen, H. (2013). A cross-national review of the studies on the particulate nature of matter and related concepts. *Eurasian Journal of Physics and Chemistry Education*, *5*(2), 81-110.

Özmen, H., Ayas, A., & Coştu, B. (2002). Fen bilgisi öğretmen adaylarının maddenin tanecikli yapısı hakkındaki anlama seviyelerinin ve yanılgılarının belirlenmesi. *Kuram ve Uygulamada Eğitim Bilimleri*, *2*(2), 507-529.

Özmen H., Demircioğlu G., & Coll, R. K. (2009). A comparative study of the effects of a concept mapping enhanced laboratory experience on Turkish high school students' understanding of acid-base chemistry. *International Journal Science and Mathematics Education*, *7*, 1-24.

Piquette J. S., & Heikkinen H. W. (2005). Strategies reported used by instructors to address student alternate conceptions in chemical equilibrium. *Journal of Research in Science Teaching, 42*, 1112-1134.

Posner, G., Strike, K., Hewson, D., & Gertzog, W. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, *66*(2), 211-227.

Saka, A., Akdeniz, A. R., Bayrak, R., & Asilsoy, Ö. (2006). "Energy conversion in living" impact of the elimination of errors faced in unit concept cartoon (Trans.). Paper presented in National Science and Mathematics Education Congress 6–8 September 2006, Ankara, Turkey.

Sexton, M. (2010). Using concept cartoons to access student beliefs about preferred approaches to mathematics learning and teaching. Freemantle, Australia: Paper presented at the MERGA conference.

Stephenson, P., & Warwick, P. (2002). Using concept cartoons to support progression in students' understanding of light, ERIC, Document Reproduction Service No. EJ647907.

Taber, K. S. (2000). Chemistry lessons for universities: a review of constructivist ideas. *University Chemistry Education*, *4*(2), 26-35.

Taşlıdere, E. (2013). Effect of conceptual change oriented instruction on students' conceptual understanding and decreasing their misconceptions in DC electric circuits. *Creative Education*, *4*(4), 273–282.

Tezcan, H., & Çelik, T. (2009). Kimya öğretmen adaylarının atomla ilgili bazı kavramları anlama derecelerinin belirlenmesi. *Türk Eğitim Bilimleri Dergisi*, *7*(1), 49-67.

Thiele, R. B., & Treagust, D. F. (1994). An interpretive examination of high school chemistry teachers' analogical explanations. *Journal of Research in Science Teaching*, *31*, 227–242.

Tsai, C. C. (2001). Probing students' cognitive structure in science: the use of a flow map method coupled with a meta-listening technique. *Studies in Educational Evaluation*, *27*, 257-268.

Türk, F., & Çalık, M. (2008). Using different conceptual change methods embedded within 5E model: A sample teaching of endothermic-exothermic reactions. *Asia-Pasific Forum on Science Learning and Teaching*, *9*(1), 1-10.

Uğurel, I., & Moralı, S. (2006). Karikatürler ve matematik öğretimi. *Milli Eğitim Dergisi*, *170,* 32-46.

Ünal, S. (2007). *Atom ve molekülleri bir arada tutan kuvvetler konularının öğretiminde yeni bir yaklaşım: BDÖ ve KDM'nin birlikte kullanımının kavramsal değişime etkisi*. Doktora Tezi, Karadeniz Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Trabzon.

URL1:http://www.fenokulu.net/portal/Sayfa.php?Git=KonuKategorileri&Sayfa=KonuDeneyListesi&baslikid=43&DeneyNo=169.

URL2:http://www.fenokulu.net/portal/Sayfa.php?Git=KonuKategorileri&Sayfa=KonuDeneyListesi&baslikid=43&DeneyNo=154.

Yavuz, A. (2005). *Öğrencilerin madde kavramlarını anlamalarında, gösteri deneyleri ve bilgisayar destekli kavram haritalarıyla desteklenen kavramsal değişim metodunun etkileri*. Doktora Tezi, Orta Doğu Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Ankara.

Yeğnidemir, D. (2000). *Temel eğitim 8. sınıf öğrencilerinde madde ve maddenin tanecikli-boşluklu-hareketli yapısı ile ilgili yanlış kavramaların tespiti ve giderilmesi*. Yüksek Lisans Tezi, Gazi Üniversitesi, Fen Bilimleri Enstitüsü, Ankara.

Experimental Group		Control Group	
Teacher's role	**Students' role**	**Teacher's role**	**Students' role**
❖ The teacher reflected the first cartoon series on the blackboard through the OHP. ❖ After reading and summarizing the cases in the cartoons, he wanted students to find the right concepts ❖ He explained the concepts; atom, element and compound and gave examples ❖ After that, he asked the reason why the right concepts are right, and the wrong ones are wrong on the 1st cartoon series	❖ They read the 1st cartoon series ❖ They tried to find the right and the wrong concepts through discussion ❖ After that, they discussed the reason why they are right or wrong.	❖ The teacher came into the class with salt (NaCl) in his hand and asked the students what it is made up and how it is made up. ❖ He wrote the definitions of atom, element and compound on the blackboard and gave examples. ❖ He asked students to give examples of matters they experience in daily life and tell if they are element or compound. ❖ He asked the difference between an element and a compound.	❖ They tried to find out what the salt is made up through discussion. ❖ They gave examples of element and compound from daily life. ❖ They tried to find out the difference between an element and a compound.
❖ The teacher reflected the second cartoon series on the blackboard through the OHP. ❖ After reading the cases in the cartoons, he asked students to decide which students gave the right answer. ❖ He explained the inter-atomic bond and that they cannot dispel it with physical process. He stated that the atoms of different matters that are made up of the same atoms would be the same and gave examples. ❖ He asked students to explain the reason why the wrong answers are wrong.	❖ They read the 2nd cartoon series. ❖ They tried to imagine the cases in the cartoons ❖ They tried to find the right concept through discussing ❖ After that they discussed the reason why the concepts are right and wrong	❖ The teacher cut the paper in two and asked "How did it divide into two? Have I cut the atoms of the paper?" ❖ He talked about the inter-atomic bond briefly and explained that they cannot be divided by physical intervention ❖ He gave the example that when they mash the salt (NaCl), it doesn't turn into Na and Cl. ❖ And after that he asked the students whether all the atoms are the same or not. ❖ He mentioned that the same types of atoms are the same and asked the students to summarize the lesson.	❖ They tried to tell how the paper is divided into two with the help of their prior knowledge. ❖ Discussing, they tried to find out that even if their shapes are different, the same matters have the same kind of atoms. ❖ They tried to summarize what they have learned about this subject.

❖ The teacher reflected the third cartoon series on the blackboard through the OHP. ❖ He introduced the cartoons and read the speech on the cartoons. ❖ He explained the historical development of the atomic model and how it was found. ❖ He asked students to tell the deficiencies of models with the help of the statements on the cartoons.	❖ They read the third cartoon series ❖ They tried to figure out how the atomic models became evident. ❖ Discussing, they tried to find out the deficiencies in the models	❖ The teacher drew the atomic models on the board according to their historical order. ❖ After that, he explained which atomic model was found by whom and how it was found. ❖ He sorted the deficiencies of the atomic models as items ❖ He asked students to take notes of these deficiencies	❖ Students took notes of the atomic models and their deficiencies according to their historical order.
❖ The teacher reflected the fourth cartoon series on the blackboard through the OHP. ❖ He read the speeches and summarized the case in the cartoon. ❖ He drew two atoms making ionic bond and explained what it is, and he asked students to associate it with the case in the cartoon. ❖ After that, he asked students to find the student in the cartoon who has explained the concept correctly. ❖ He explained the ionic bond on the cartoons and he likened students' giving money to each other to atoms' giving electrons. ❖ He gave daily examples	❖ They read the 4th cartoon series. ❖ They tried to associate the ionic bond with the case on the cartoons. ❖ They tried to find out which student's idea in the cartoon is correct through discussing.	❖ He drew on the blackboard how the water (H_2O) makes bond. ❖ After that, he explained to the students that atoms could make bonds giving their electron to each other and added that was called the ionic bond. ❖ He talked about the metallic and non-metallic bonds and stated that metallic and non-metallic compounds are stable with ionic bond ❖ He gave examples of ionic-bonded compounds from daily life. ❖ Summarizing the subject, he made the students write it down.	❖ They tried to figure out what the ionic bond was. ❖ They learned which of the compounds from the daily life were formed by ionic bond. ❖ They took notes.
❖ The teacher reflected the fifth cartoon series on the blackboard through the OHP. ❖ He read the speeches and summarized the case in the cartoon. ❖ He drew two atoms making covalent	❖ They read the 5th cartoon series. ❖ They tried to associate the covalent bond with the case on the cartoons. ❖ They tried to find out which student's idea in the cartoon is correct through discussing.	❖ The teacher summarized the ionic bond. ❖ After that, he added that atoms could be in conjunction with each other sharing their electrons commonly.	❖ They tried to understand what the covalent bonding was. ❖ They learned the compounds formed by covalent bonding and how they were formed. ❖ They took notes.

bond and illustrated the covalent bonding and asked students to associate it with the case in the cartoon. ❖ After that, he asked students to find the student in the cartoon who has explained the concept correctly. ❖ He explained the covalent bond on cartoons and likened students' sharing their money to buy a ball to atoms' sharing their electrons. ❖ He gave daily examples.		❖ He drew a compound on the black boars as an example for cooperation of electrons and illustrated the covalent bonding. ❖ He summarized the subject and asked students to take notes. ❖ He asked students to tell the difference between the covalent and the ionic bond.	❖ They tried to tell the difference between the covalent and ionic bond.
❖ The teacher reflected the sixth cartoon series on the blackboard through the OHP. ❖ He summarized the case in the cartoon and read the speeches. ❖ He asked students' idea about the homogenous and heterogeneous mixtures and then explained the homogenous and the heterogeneous mixtures. ❖ After that, turning back to the cartoons, he asked which students tell the truth. ❖ He asked students to give daily examples.	❖ They read the 6th cartoon series. ❖ They shared their idea on the homogenous and the heterogeneous mixtures. ❖ They tried to find out which students' ideas in the cartoon were correct through discussing. ❖ They gave examples of homogenous and heterogeneous mixtures.	❖ The teacher explained the mixtures and gave examples. ❖ He stated that there were different kinds of mixtures, two of which were homogenous and heterogeneous. ❖ He explained how homogenous and heterogeneous mixtures were formed. ❖ He asked the students to tell the difference between the homogenous and the heterogeneous mixtures. ❖ He asked students to give examples of homogenous and heterogeneous mixtures.	❖ They tried to understand how homogenous and heterogeneous mixtures were formed. ❖ They tried to tell the difference between the homogenous and heterogeneous mixtures. ❖ They tried to give examples of homogenous and heterogeneous mixtures from daily life.