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Kavram Karikatürlerinin Fen Bilgisi Öğretmen Adaylarının Organik Kimyadaki Kavramsal Anlamaları Üzerindeki Etkililiği

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Öz

Alkoller konusunun organik kimyadaki pek çok konu ile ilişkili olması, bu konunun organik kimyada önemli bir yere sahip olmasını sağlamıştır. Bu çalışmada, kavram karikatürüne dayalı öğretimin, öğretmen adaylarının alkoller ile ilgili sahip oldukları alternatif kavramları gidermedeki etkisinin araştırılması amaçlanmıştır. Bu amaç doğrultusunda, yarı-deneysel desen olarak yürütülen çalışma, Türkiye'deki bir fen eğitimi anabilim dalında öğrenim gören öğretmen adayları ile yürütülmüştür. Çalışmada, bir sınıf rastgele olarak deney grubu (N = 38), diğeri ise kontrol (N = 42) grubu olarak seçilmiştir. Her iki gruba ön ve son-test olarak Alkol Kavram Testi (AKT) uygulanmıştır. Deney grubunda, alkoller konusu kavram karikatürüne dayalı öğretim ile işlenirken, kontrol grubunda geleneksel öğretim uygulanmıştır. Araştırma sonuçları, ön-test puanlarına göre deney ve kontrol gruplar arasında anlamlı bir fark bulunmadığını; ancak son-test puanlarında deney grubunu lehine anlamlı bir farkın olduğu göstermiştir. Sonuç olarak, kavram karikatürüne dayalı öğretimin, fen bilgisi öğretmen adaylarının istenen kavramsal anlama düzeyine ulaşmalarında geleneksel öğretimden daha etkili olduğu belirlenmiştir.

Effectiveness of Concept Cartoons on Pre-service Science Teachers' Conceptual Understandings in Organic Chemistry

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Abstract

The fact that the topic of alcohols is related to many topics in organic chemistry has enabled this subject to have an important place in organic chemistry. This study aimed at analyzing the effect of concept cartoon-based teaching on eliminating the alternative conceptions pre-service teachers have about alcohols. Toward this aim, the study, based on a quasi-experimental design, was conducted with pre-service science teachers studying in science education department in Turkey. In the study, one class was randomly selected as the experimental group (N=38), the other as a control (N=42). Both groups were administered Alcohol Concept Test (ACT) as a pre- and post-test. While the concept cartoon-based teaching was implemented in the experimental group, traditional teaching was followed in the control group. The results of the research revealed no significant difference between the groups according to the pre-test scores, but a significant difference favoring the experimental group was noted in the post-test scores. It was consequently found that concept cartoon-based teaching was more effective than traditional teaching in the desired level of conceptual understanding.

Introduction

Organic chemistry is a course required not only in chemistry, chemical engineering or chemistry education programs, but also in the undergraduate curriculums of a diversity of disciplines such as science, biology education, biochemistry, pharmacy, and nanotechnology (Cruz Ramirez-de Allenano & Towns, 2014). Understanding something about organic chemistry is important for learning about different disciplines, because many of them involve studying organic molecules. When considered in this light, it is clear that the understanding undergraduate students gain in their organic chemistry courses will also affect their understanding in other related courses (Szu, Nandagopal, Shavelson et al.,2011). Because of this, it is of great importance that teaching techniques designed to contribute to the ability of especially undergraduate students to improve their understanding of the concepts of organic chemistry are implemented and the effectiveness of such techniques is explored.

Research on teaching organic chemistry has indicated that students at varying levels perceive this course to be a difficult one and that many find it hard to understand some of its concepts and for this reason have alternative conceptions in their minds (Ratcliffe, 2002; Flynn, 2015; O'Dwyer & Childs, 2017). It is reported that the main reasons for the difficulty experienced with organic chemistry are that organic molecular reactivity is dependent upon many variables, symbolic representations are frequently used, and these representations are not completely understood (Duffy, 2006; Ferguson& Bodner, 2008; Grove, Cooper & Rush, 2012; Cruz Ramirez-de Allenano and Towns, 2014). In fact, Anderson and Bodner (2008) have reported that in the face of these difficulties in organic chemistry, students tend to memorize without completely understanding the rules or principles of basic concepts and consequently are led to make mistakes in their applications. In this context, teaching techniques that will contribute to helping students understand organic chemistry content and allow them to learn meaningfully have a major job to fulfill.

One of the methods may be used in attaining learning goals of students is concept cartoons. Concept cartoons are drawn materials that are offered to students to encourage them to engage in active thinking, whet their curiosity, and help them to generate and discuss ideas (Long & Marson, 2003). Concept cartoons are widely used in education to uncover students' notions, determine their alternative conceptions, attain conceptual change and support their efforts to learn meaningfully (Naylor & Keogh, 2013). Gafoor & Vevaremmal (2013) have stated that many concepts in chemistry are abstract and students have difficulty learning new concepts, suggesting that concept cartoons are an effective means of helping students overcome their learning difficulties. According to researchers, concept cartoons can easily draw the attention of students to concepts in chemistry, leading them into participating in class discussions and providing teachers with important information on the level of understanding that the students have reached. In fact, there are many articles in the literature that assert that the use of concept cartoons has a positive impact on eliminating alternative conceptions (Keogh & Naylor, 1999; Stephenson, & Warwick, 2002; Kabapınar, 2005).

On the other hand, when studies in chemistry education were investigated, it was determined that some of this

research is limited to primary or secondary school-level topics such as the structure and properties of matter, changes in state, atom radius, covalent bonds, chemistry and energy, buffer solution (Kabapınar, 2005; Özyalçın-Oskay &Efil, 2016; Kusumaningrum, Ashadi & Indriyanti, 2018; Say & Özmen, 2018; Karakırık & Kabapınar, 2019). It can also be seen that there is a group of articles that assert that concept cartoons have remained a part of teaching approaches such as context-based learning, argumentation, laboratory activities, conceptual change text (Şahin & Çepni, 2011; Özmen, Demircioğlu, Burhan et. al, 2012; Steininger, 2013; Ültay, 2015). Considering this perspective, it is clear that concept cartoon-based teaching particularly needs to be implemented and its effectiveness assessed in Organic Chemistry, where students are conceptually challenged and there is a concentration in their minds of alternative conceptions.

The topic of alcohols that is a part of the organic chemistry course content has become a central part of organic chemistry as these substances contribute to the synthesis and reactions of organic molecules of functional groups such as aldehydes, ketones, ether and carboxylic acids. Because of this, the alternative concepts that students may have about the properties of alcohols, their reactions and products, can cause them to feel challenged in related subjects, both conceptually and also in forming meaningful associations. In fact, in studies conducted on alcohols, it has been shown that students have difficulty with conceptualizing topics and exhibit many alternative conceptions (Hassan, Hill & Reid , 2004; Chiu ; 2007, Potgietera & Davidowitz , 2011; Şendur & Toprak, 2013). This holds true and is of vital importance not only for secondary school students but also for teacher candidates in the areas of science and chemistry. Thus, when the content of the General Chemistry-4 course in which the research was conducted is examined, it is seen that the subject of alcohols is important part of this course

Although Education Faculties in Turkey have adopted a renewed undergraduate science education program in the academic year 2018-2019 limiting the content of Organic Chemistry, the topic of alcohols still remains in the General Chemistry III course. At the same time, as the topic of alcohols is a multidisciplinary subject related especially to biological systems, it is clear that pre-service teachers planning to be science teachers need to have a meaningful grasp of the concepts related to alcohols. On the other hand, a review of the field literature indicates that only few studies have been conducted on the matter of improving pre-service teachers' conceptual understanding of alcohols (Sevinç, 2008; Ratniyom, Boonphadung & Unnanantn, 2016).These studies are narrowly framed since they treat the topic of alcohols together with other classes of organic molecules. Because of this, it can be said that there is a need for studies focused on improving pre-service teachers' conceptual understanding of the properties of alcohol content, their nomenclature, and their reactions and synthesis.

Another weakness of the studies in the literature is that while a variety of teaching methods, techniques and approaches such as concept mapping and context-based learning have been covered, there is no mention of a concept cartoon-based teaching technique (Karslı & Yiğit, 2015;Dönmez-Usta& Ultay, 2016; Hanson, 2017). When considering the matter from this perspective, it is believed that this study will make an important contribution to the literature in its attempt to explore how and to what degree pre-service science teachers can improve their levels of conceptual understanding and eliminate their alternative conceptions of alcohols through

the use of concept cartoons as well as in its aim of determining the effectiveness of this method. The study may also contribute to raising awareness among science and chemistry teachers as well as students about what kind of alternative conceptions are rampant and how a concept cartoon-based teaching program can be implemented.

Aim of the Study and Sub-problems

In the light of previous researches, the aim of this study was to analyze the effect of concept cartoon-based teaching on eliminating the alternative conceptions pre-service teachers have about alcohols and on developing their conceptual understanding. Toward this aim, answers were sought to the following sub-problems:

1) Is there a significant difference between the pre-test scores of the experimental and control group?
2) Is there a significant difference between the post-test scores of the experimental and control group?
3) How effective concept cartoon-based teaching compared to the traditional teaching in achieving conceptual change?

Method

The study was conducted by quasi-experimental design using a pre-test-post-test with control group. This type of design is appropriate for situations where the participants cannot be randomly assigned to experimental and control groups but the experimental methods or treatments can be randomly assigned to groups (Hinkle et al., 1998; Gravetter & Wallnau, 2000). Accordingly, one of the classes in this study was randomly chosen as the experimental group (n=38), another as a control group (n=42). The experimental group followed the lessons on the basis of concept cartoons while traditional teaching was applied to the control group. This study took place in General Chemistry-IV Courses offered to pre-service science students. General Chemistry-IV was a one-semester compulsory course which includes the concepts of Organic Chemistry. This course is instructed in two lecture sessions per week. The study were completed in 4 weeks.

Participants

The participants in the study comprised 80 pre-service teachers who were enrolled in the 2nd-year classes of the Science Education Department of a state university in Turkey during the spring term of the 2015-2016 academic year. All of the pre-service teachers had voluntarily consented to participating. The ages of the teacher candidates were in the range of 20-22 and most came from middle-income families. At the same time, all of the pre-service teachers had similar backgrounds, as could be discerned from their admittance into the department via the university entrance exams.

Data Collection Instrument

The Alcohol Concept Test (ACT) was used in the study as a data collection instrument. Consisting of 16 multiple-choice questions, the ACT was developed by Şendur and Toprak (2013) to determine the level of

understanding of pre-service teachers and their alternative conceptions. Each choice calls for a response and a reason for the response. The choices on the test were set up in accordance with the categories of "sound understanding, partial understanding with alternative conceptions, and alternative conceptions." Abraham et al. (1992), Çalık (2005) and Ünal et al. (2010) used similar categories, containing the following:

- Sound understanding (SU): This involves responses and explanations that are scientifically accepted as true.
- Partial understanding with alternative conceptions (PUAC): This involves responses and explanations that are scientifically accepted as true but are not actually correct.
- Alternative Conceptions (AC): This involves responses and explanations that are not completely accepted as scientifically true.

All of the questions contain one choice that represents sound understanding (the right answer), one that represents partial understanding with alternative conceptions (as a distractor), and three alternative conceptions (as distractors). At the end of the pilot testing, the reliability coefficient (Cronbach's alpha) was calculated as 0.74. The question content of the ACT is shown in Table 1. All of the data in this study were collected in the Turkish language and translated into English by the first researcher.

Table 1. The Question Content of the ACT

Question	Content
Question 1	General properties of alcohols
Question 2	Nomenclature of alcohols
Question 3	Conditions for being alcohol
Question 4	Physical properties of alcohols (solubility)
Question 5	Structural isomers of alcohols
Question 6	Physical properties of alcohols (solubility)
Question 7	Reactions of alcohols (reactions with sodium)
Question 8	Synthesis of alcohols (reduction of ketone)
Question 9	Reactions of alcohols (oxidation reactions)
Question 10	Synthesis of alcohols (reduction of carboxylic acid)
Question 11	Reactions of alcohols (reactions with Lucas reagent)
Question 12	Reactions of alcohols (oxidation reactions)
Question 13	Synthesis of alcohols (from alkyl halides)
Question 14	Classification of alcohols
Question 15	Physical properties of alcohols (boiling point)
Question 16	Reactions of alcohols (dehydration of alcohol)

One of the questions on the ACT can be seen in Figure 1. ACT was administered simultaneously to the experimental and control groups 2 weeks before the start of the instruction on alcohols in order to determine the prior knowledge and alternative conceptions of the pre-service teachers. The same test was also administered,

this time as a post-test, 2 weeks following the completion of the instruction in both groups. There were 6 weeks between the administration of the ACT as a pre-test and as a post-test. This period is considered enough time to ensure that pre-service teachers have forgotten the questions (Yürük, 2007).

I: 3-methyl-2-butanol
II: 3-methyl-1-butanol
III: 2-methyl-2-butanol

Which of the statements below is true about the reaction of these compounds with metallic sodium?

A) *Each of the three compounds enters into a reaction with metallic sodium and sodium alkoxide forms with H_2 gas because all alcohols produce this reaction

B) Each of the three compounds enters into a reaction with metallic sodium and sodium alkoxide forms with H_2 gas because only five/six-carbons alcohols produce this reaction.

C) Only the 1st compound enters into a reaction with metallic sodium and sodium alkoxide forms with H_2 gas because only secondary alcohols produce this reaction.

D) Only the 2nd compound enters into a reaction with metallic sodium and sodium alkoxide forms with H_2 gas because only primary alcohols produce this reaction.

E) Only the 3rd compound enters into a reaction with metallic sodium and sodium alkoxide forms with H_2 gas because only tertiary alcohols produce this reaction.

*Correct Answer

Figure 1. One of the Questions on the ACT

Treatment

The implementation of the study was conducted in the Spring term of the academic year 2015-2016. Two weeks after the simultaneous administration to both the experimental and control groups of the pre-tests, the lessons were presented to the experimental group in the form of concept cartoon-based teaching and to the control group as traditional teaching. The lessons were completed in 4 weeks (2 class hours a week) in both the experimental and control groups; the same instructor taught the lessons in both groups.

Preparation of the Concept Cartoons

The alternative conceptions appearing in the literature were considered in the preparation of the concept cartons about alcohols, and 11 worksheets were drawn up. Various organic chemistry textbooks were employed in the preparation of the concept cartoons to ensure priorities and content validity (Solomons, 1988; McMurry, 1995; Fessenden & Fessenden, 1998; Atkins & Carey, 2002). Subsequently, the alternative conceptions mentioned in studies in the literature conducted on the subject of alcohols were identified (Hassan, Hill & Reid, 2004; Chiu, 2007; Potgietera & Davidowitz, 2011; Şendur & Toprak, 2013) and the concept cartoons were drawn up to

show both these alternative conceptions and the scientifically correct thoughts the students had in their minds.

The concept cartoons were drawn up containing at least 3 that were given names and on the worksheets appeared the question, "Whose thought do you think is right? Mark the box you think is right with ✓." and a blank space under the words, "Why do you think so?". All of the characters in the concept cartoons represent students. In the last stage, the concept cartoons were given to two experts in organic chemistry who were asked to provide their views. The cartoons were given their final form after revisions were made accordingly. The concept cartoons were administered as a pilot study to 15 pre-service teachers who had studied the topic of alcohols but were outside of the sample group. The concept cartoons and their contents, as shown in Table 2, were handed out to these pre-service teachers and the concept cartoon shown in Figure 2 was provided to the experimental group.

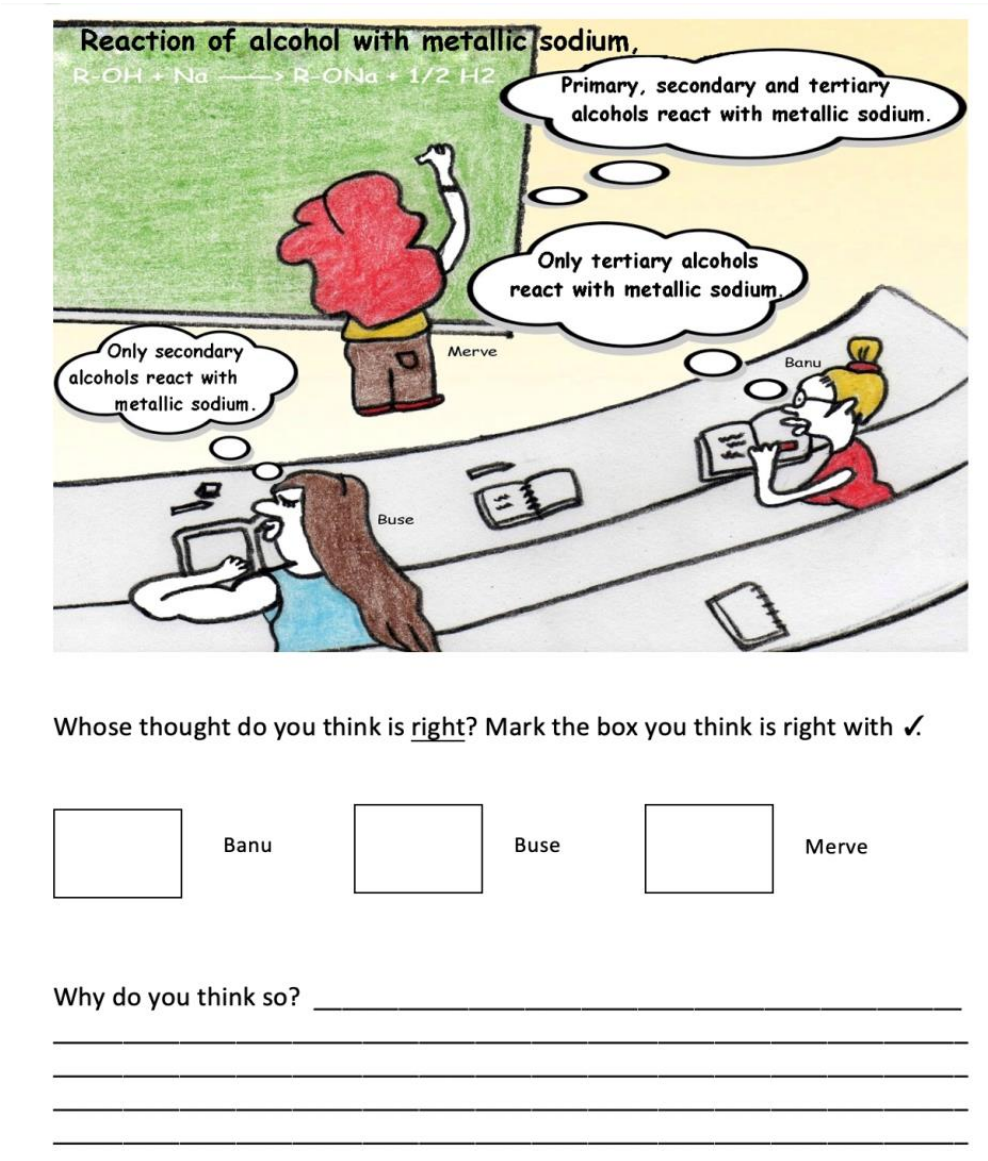

Figure 2. Example of the Concept Cartoons Used in the Study

Table 2. Concept Cartoons and Their Content

Concept Cartoon	Content
Concept Cartoon-1	Conditions for being alcohol
Concept Cartoon-2	Classification of alcohols
Concept Cartoon-3	Nomenclature of alcohols
Concept Cartoon-4	Physical properties of alcohols (boiling point)
Concept Cartoon-5	Physical properties of alcohols (solubility)
Concept Cartoon-6	Reactions of alcohols (dehydration)
Concept Cartoon-7	Reactions of alcohols (reactions with Lucas reagent)
Concept Cartoon-8	Reactions of alcohols(with Metallic sodium)
Concept Cartoon-9	Reactions of alcohols (oxidation reactions)
Concept Cartoon-10	Synthesis of alcohols (reduction reactions)
Concept Cartoon-11	Synthesis of alcohols (from alkyl halides)

Concept Carton-Based Teaching

During this time, groups of 5-6 individuals were formed and the concept cartoons were discussed first individually and then in the form of a group discussion. What was aimed in this process was to first of all activate the individuals own prior knowledge and then to encourage them to open up their thoughts to their peers. After this group participation, the group was asked to share their thoughts in the classroom setting. At this point, the instructor made note of the scientifically correct and incorrect thoughts of the groups as the individuals expressed their ideas. For example, some of the groups were able to correctly state that primary, secondary and tertiary alcohols would react with metallic sodium. Some groups however said that only secondary or only tertiary alcohols reacted with metallic sodium. This process helped the pre-service teachers both to activate their prior knowledge and also to expose their alternative conceptions, allowing them to become aware of the knowledge they were lacking. Following this, the instructor (first author) explained which of the answers was scientifically correct and also pointed to the alternative conceptions the pre-service teachers had expressed.

At this stage, the pre-service teachers were nudged into becoming unhappy with the extent of their knowledge. Following this, worksheets containing explanations about the scientific knowledge on the subject were distributed to the pre-service teachers. These worksheets clarified why the alternative conceptions the pre-service teachers harbored were wrong and expounded on this with scientific information and examples. The aim of this stage of the implementation was to ensure that the pre-service teachers believed in the intelligibility and plausibility of scientific knowledge. In the last stage of attaining fruitfulness, different examples were given to give the pre-service teachers practice in learning about the concepts and reactions related to alcohols, which was supported with classroom discussion. Here, the aim was to instill in the pre-service teachers the belief in the usefulness of new knowledge.

Traditional Teaching

Traditional teaching was conducted with the method of lecturing, supported by questions and answers and classroom discussion. In this process, the instructor started off by first introducing the topic to the pre-service teachers and then using the blackboard to explain basic concepts and reactions. The pre-service teachers listened to the lesson, took notes and asked questions about the parts they did not understand. The instructor asked the pre-service teachers various questions about the topic and, after giving them sufficient time to work on the answers, either worked out the problem on the blackboard or asked one of the teacher candidates to do so. The control group worked on the content of the topic of alcohols in the same order as the experimental group and the instruction was completed in 4 weeks. In both the experimental and control groups, the content of the topic of alcohols was the same, and the same examples were given, the same questions asked. Content treatment, by weeks:

Week 1: General Properties of Alcohols, Classification of Alcohols

Week 2: Nomenclature of Alcohols, Alcohol Isomers

Week 3: Chemical Properties of Alcohols

Week 4: Synthesis of Alcohols

Data Analysis

In the analysis of the ACT, the total scores of the pre-service teachers on the pre-test and post-test were calculated by assigning 1 point to the Sound Understanding (SU) category, and 0 points to the Partial Understanding with Alternative Conceptions (PUAC) and Alternative Conceptions (AC) categories. The maximum score possible that the pre-service teachers could achieve is 16. The reason the PUAC category is given a score of 0 is because although the pre-service teachers have provided correct answers in this category, their explanations are scientifically incorrect, which makes their responses scientifically unacceptable (Cakmakci & Aydogdu, 2011). Similarly, the AC category is also assigned 0 points since the pre-service teacher here too has provided a scientifically unacceptable answer and explanation. The SPSS 15.0 program was used in the statistical analysis of the ACT data and the first step was to find out whether the data showed normal distribution. According to the Kolmogorov-Smirnov and Shapiro-Wilks test results, the data did not show normal distribution so the Mann Whitney U test was employed to compare the pre- and post-test scores of the experimental and control groups. The change in the pre-service teachers' responses to the ACT questions by category was evaluated in both the experimental and control groups and percentages were calculated (Table 5 and Table 6). Lastly, in order to clearly set forth the conceptual change displayed by both groups, the percentages of alternative conceptions found in the pre- and post-tests were determined and the differences between these were defined as the percentage of conceptual change (Table 7).

The percentage of conceptual change was classified by effectiveness. A percentage of conceptual change greater than 15% was labeled as "major", while a percentage of conceptual change between 15% and 10% was labeled as "limited"; a percentage of conceptual change smaller than 10% was labeled "minor". If conceptual change

was not determined as relating to the alternative conception, it was labeled "no". Similar classification was used by Sendur and Toprak (2013); Yakmacı-Guzel, (2013). In addition, if the percentage of alternative conceptions on the post-test was greater than on the pre-test, this was defined as a negative change.

Results

The results of the Mann-Whitney-U in Table 3 show that there was no significant difference between the pre-test scores of the experimental and control groups (U=775.500; p>.05). This indicates that the mean ranks of the experimental and control groups prior to the instruction were close to each other. In other words, the prior knowledge of the experimental and control groups was similar.

Table 3. Mann Whitney U Results of Pre-test

Group	N	Mean Rank	Sum of Ranks	Mann Whitney U	Z	Sig.
Experimental	38	39.91	1516.50	775.500	-.220	.826
Control	42	41.04	1723.50			

As can be understood from the results in Table 4, there is a significant difference between the post-test scores of the pre-service teachers in the experimental and control groups (U=193.500; p<.05). The results of the analysis indicate that when the mean ranks of the experimental and control groups after the instruction are compared, there is a difference in favor of the experimental group. This means that in the two groups that had no difference between them on the pre-tests, the pre-service teachers in the experimental group displayed significantly better acquisition of scientific concepts after the experimental instruction, compared to the pre-service teachers in the control group. These findings are consistent with respect to the studies indicating the effect of concept cartons in students' understanding of chemistry concepts (Say & Özmen, 2018; Karakırık & Kabapınar, 2019).

Table 4. Mann Whitney U Results of Post-test

Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z	Sig.
Experimental	38	56.30	2139.50	193.500	-5.840	.000
Control	42	26.20	1100.50			

In order to find out how the responses of the experimental and control group pre-service teachers on the ACT were distributed by categories, the percentages of all the questions on the pre- and post-test were calculated for the SU, PUAC, AC and NR categories. Table 5 displays the percentages of responses given by the experimental group on the pre- and post-tests according to category. A look into Table 5 shows that the experimental group achieved an increase in their sound understanding percentage on all the questions in the post-test and, except for questions 11 and 13, the percentage for sound understanding on all the questions was over 50%. When the

questions were examined in terms of their content, it was found that question 11 was associated with alcohol reactions with Lucas reagent and question 13 with the subject of alcohol synthesis from alkyl halides. This finding indicates that concept cartoon-based teaching contributed to the pre-service teachers' improved sound understanding of the topic of alcohols but that all of the content did not achieve the same level of improvement.

It can be seen from Table 5 that the change in the AC category of the experimental group's pre- and post-tests pointed to a lower percentage in all the questions on the post-test for this category compared to the pre-test. Also, some of the questions on the post-test yielded a considerably low AC percentage (2.6%) while some questions (Q. 7, 10, 11 and 13) displayed a rate of over 20%. When these questions (Q. 7, 10, 11 and 13) were evaluated in terms of content, it was seen that alcohol reactions with sodium and Lucas reagent derived from alcohol synthesis from carboxylic acids and alkyl halides. This outcome shows that the concept cartoon-based teaching was effective is achieving conceptual change but that it was not easy for all of the alternative conceptions to be replaced by scientific ones.

Table 5. Percentage of Responses of Pre-service Teachers in the Experimental Group

	Experimental Group							
	Pre-test				Post-test			
Question	SU(%)	PUAC(%)	AC(%)	NR(%)	SU(%)	PUAC(%)	AC(%)	NR(%)
1	50.0	2.6	42.1	5.3	78.9	2.6	7.9	10.5
2	52.6	18.4	21.1	7.9	68.4	15.8	5.3	10.5
3	31.6	7.9	44.7	15.8	86.8	5.3	7.9	0
4	18.4	5.3	52.6	23.7	55.3	10.5	18.4	15.8
5	36.9	5.3	31.6	26.3	65.8	5.3	10.5	18.4
6	10.5	28.9	34.2	26.3	71.1	10.5	13.2	5.3
7	13.2	7.9	52.6	26.3	57.9	5.3	31.6	5.3
8	13.2	2.6	60.5	23.7	68.4	10.5	15.8	5.3
9	28.9	13.2	31.6	26.3	89.5	2.6	7.9	0
10	10.5	7.9	44.7	36.9	68.4	5.3	23.7	2.6
11	13.2	2.6	55.3	28.9	44.7	13.2	26.3	15.8
12	23.7	21.1	31.6	23.7	84,2	10.5	2.6	2.6
13	7.9	13.2	52.6	26.3	47.4	7.9	31.6	13.2
14	7.9	31.6	34.2	26.3	65.8	10.5	13.2	10.5
15	18.4	23.7	15.8	42.1	73.7	18.4	7.9	0
16	13.2	5.3	36.9	44.7	73.7	5.3	18.4	2.6

As in the experimental group, the percentage of the responses of the pre-service teachers in the control group to the questions on the pre- and post-tests in the categories was calculated; this is shown in Table 6. Table 6 shows that the percentages in the SU category on the post-test of the control group were higher compared to the pre-

test. This indicates that the pre-service teachers in the control group achieved an increase in their conceptual understanding of alcohols. When the responses of the control group are analyzed on the basis of the questions on the post-test, it can be seen that in Q's 4, 7, 8, 9, 10, 11, 13 and 16, the percentage in the SU category was below 50%. When this is compared with the post-test results of the experimental group, a different result can be seen–the percentage in 6 questions (Q's 4, 7, 8, 9, 10 and 16) in the SU category is below 50%. When these questions are examined on the basis of content, it is seen that the subject matter is the solubility of alcohols, alcohol reactions (oxidation, dehydration, and reactions with sodium) and synthesis of alcohol (reduction of ketones and carboxylic acids). This indicates that the traditional method of teaching offered to the control group was not as effective in developing the pre-service teachers' conceptual understanding as the concept cartoon-based teaching offered to the experimental group, especially in the context of alcohol reactions and synthesis of alcohol.

Table 6. Percentage of Responses of Pre-service Teachers in the Control Group

	Control Group							
	Pre-Test				Post-Test			
Question	SU(%)	PUAC(%)	AC(%)	NR(%)	SU(%)	PUAC(%)	AC(%)	NR(%)
1	28,6	4.8	64.3	2.4	78.6	7.1	14.3	0
2	50.0	23.8	23.8	2.4	52.4	26.2	21.4	0
3	4.8	16.7	69.1	9.5	52.4	16.7	23.8	7.1
4	38.1	7.1	42.9	11.9	47.6	11.9	35.7	4.8
5	28.6	2.4	61.9	7.1	50.0	2.4	35.7	11.9
6	19.1	26.2	33.3	21.4	59.5	11.9	23.8	4.8
7	9.5	4.8	61.9	23.8	40.5	9.5	47.6	2.4
8	23.8	2.4	71.4	2.4	42.9	7.1	50.0	0
9	28.6	9.5	23.8	38.1	47.6	7.1	42.9	2.4
10	11.9	4.8	45.2	38.1	45.2	11.9	42.9	0
11	4.8	9.5	66.7	19.1	33.3	16.7	42.9	7.1
12	26.2	9.5	38.1	26.2	66.7	14.3	16.7	2.4
13	4.8	23.8	40.5	30.9	11.9	14.3	69.1	4.8
14	23.8	28.6	30.9	16.7	50.0	9.5	30.9	9.5
15	33.3	9.5	23.8	33.3	50.0	16.7	23.8	9.5
16	14.3	7.1	35.7	42.9	40.5	23.8	28.6	7.1

An examination of the percentages in the AC category in Table 6 shows that the percentages corresponding to Q's 9 and 13 on the post-test were higher than on the pre-test. In other words, in the control group, there were rises in the number of alternative conceptions in the control group about alcohol oxidation (Q.9) and synthesis of alcohol from alkyl halides (Q.13) after the traditional teaching. At the same time, there were no changes in the control group in the percentages in the AC category on the pre-test and post-test in the two questions (Q's 14, 15) on the classification of alcohols and alcohols' physical property of boiling point. All of this indicates

that the traditional teaching in the control group was not as effective as the concept cartoon-based teaching applied to the experimental group, and in fact that there was a rise in alternative conceptions after the instruction. To more clearly compare the level of understanding of the experimental and control groups on the pre- and post-tests, the percentages in the SU and AC categories have been displayed in Figures 2 and 3.

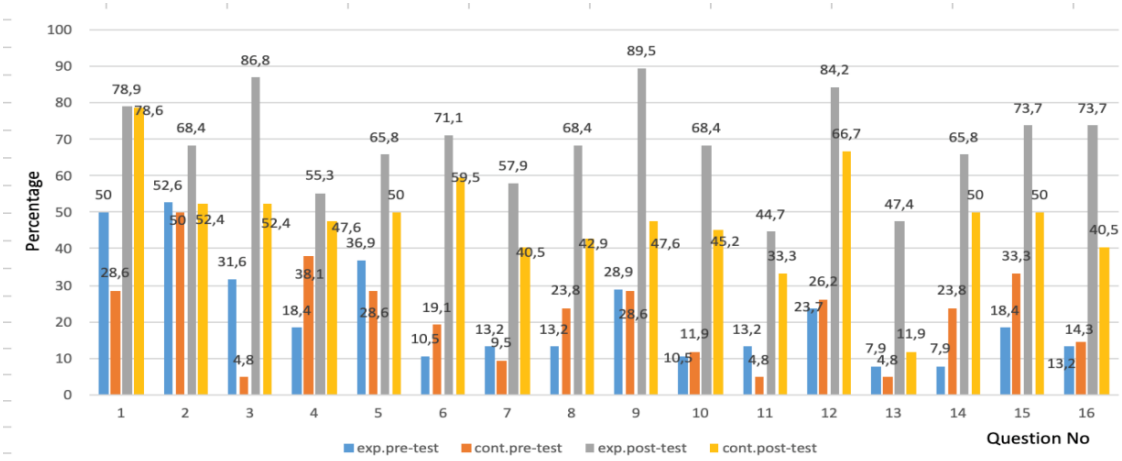

Figure 2. Percentages of the SU Categories of the Experimental and Control Groups

When Figure 2 is examined, it can be seen that on the pre-test, the experimental group was at a higher level in 8 questions (1, 2, 3, 5, 7, 9, 11 and 13) than the control group in the SU category but on the post-test, the situation turned in favor of the experimental group in all questions. In other words, in the experimental group, where concept cartoons were used in the instruction, it can be said that the participants were more successful in achieving the desired level of understanding of the basic concepts, reactions and synthesis in the subject of alcohols. It can be seen in Figure 3, which shows the percentages in the AC categories on the pre- and post-tests of both the experimental and control groups, that on the pre-test, the percentages in this category in six questions (4, 6, 9, 13, 14 and 16) were higher in the experimental group' compared to the control. In the post-test, it was found that the percentages in the AC category in all the questions were higher in the control group compared to the experimental group. This shows that the concept cartoon-based instruction applied to the experimental group was more successful in eliminating the alternative conceptions of the pre-service science teachers when compared to the results of traditional teaching.

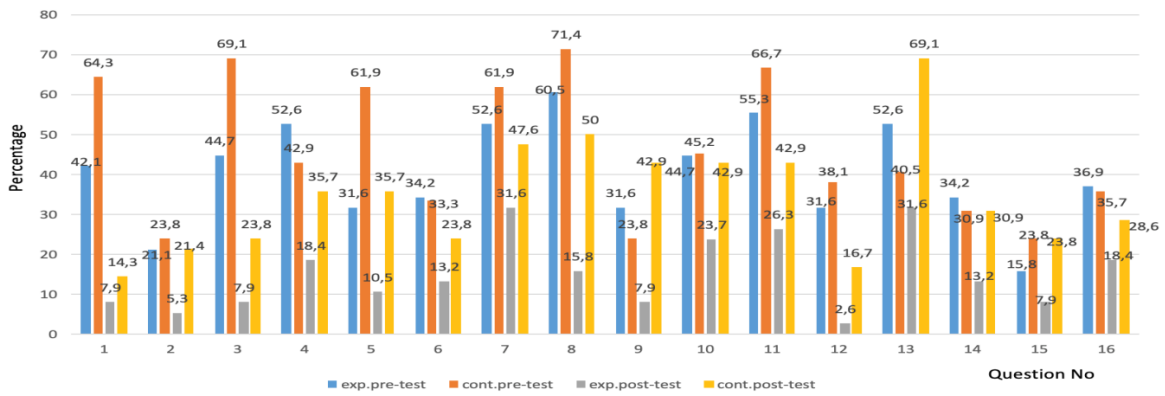

Figure 3. Percentages in the AC Categories of the Experimental and Control Groups

In the light of the third sub-problem, in order to set forth the conceptual change in the experimental and control groups, the pre-service teachers' alternative conceptions on the pre- and post-test have been displayed in Table 7. Table 7 at the same time offers a conceptual change (CC) percentage for each alternative conception determined. In the study, it was determined that pre-service teachers had several alternative conceptions related to alcohol. Here, we present 30 of these alternative conceptions as examples. The percentages were above 7% (above 3 in terms of frequency) on the experimental or control groups' pre-test.

Table 7. Percentages of Pre-service Teachers' Alternative Conceptions(AC) in Pre-test and Post- test

Que.	Alternative Conceptions	Experimental Group				Control Group			
		Pre-test	Post-test	CC	Effect.	Pre-test	Post-test	CC	Effect.
Q-1	All mono alcohols are represented with the molecular formula $C_nH_{2n+2}O$.	21.1	2.6	+18.5	Maj.	33.3	7.1	+26.2	Maj.
Q-1	Only ethers can be represented with the molecular formula $C_nH_{2n+2}O$.	15.8	2.6	+13.2	Lim.	23.8	4.8	+19.0	Maj.
Q-2	If C=C in the carbon chain, priority is not in the -OH group but in the C=C bond and the nomenclature is done according to the alkene.	13.2	2.6	+10.6	Lim.	14.3	9.5	+4.8	Min.
Q-3	To call a molecule as alcohol, this molecule should not include π bond	18.4	5.3	+13.1	Lim.	35.7	14.3	+21.4	Maj.
Q-3	The cyclic molecules are not characteristic of alcohol	13.2	0.0	+13.2	Lim.	23.8	4.8	+19.0	Maj.
Q-3	To call a molecule as alcohol, it is enough that hydroxyl group (-OH) is attached to a carbon atom in the molecule.	13.2	2.6	+10.6	Lim.	9.5	4.8	+4.7	Min.
Que.	Alternative Conceptions	Experimental Group				Control Group			

		Pre-test	Post-test	CC	Effect.	Pre-test	Post-test	CC	Effect.
Q-4	An increase in the number of C increases alcohol's solubility in water.	42.1	13.2	+28.9	Maj.	38.1	30.9	+7.2	Min.
Q-5	All alcohols are structural isomers with ethers.	21.1	5.3	+15.8	Maj.	35.7	23.8	+11.9	Lim.
Q-5	Only trialcohols are structural isomers with ethers.	7.9	5.3	+2.6	Min.	9.5	4.8	+4.7	Min.
Q-5	Only dialcohos are structural isomers with ethers.	2.6	0.0	+2.6	Min.	16.7	7.1	+9.6	Min.
Q-6	Branched-chain and straight-chain alcohols which they have the same number of carbon atoms has the same solubility in water.	26.3	7.9	+18.4	Maj.	28.6	21.4	+7.2	Min.
Q-7	Only primary alcohols react with metallic sodium	28.9	15.8	+13.1	Lim.	33.3	28.6	+4.7	Min.
Q-7	Only secondary alcohols react with metallic sodium	13.2	10.5	+2.7	Min.	19.0	9.5	+9.5	Min.
Q-7	Only tertiary alcohols react with metallic sodium	10.5	5.3	+5.2	Min.	9.5	9.5	0.0	No
Q-8	Reduction of ketones results in formation of primary alcohols	23.7	5.3	+18.4	Maj.	28.6	19.0	+9.6	Min.
Q-8	Reduction of ketones results in formation of tertiary alcohols.	21.1	5.3	+15.8	Maj.	16.7	9.5	+7.2	Min.
Q-8	Ketones cannot be reduced.	15.8	5.3	+10.5	Lim.	26.2	21.4	+4.8	Min.
Que.	Alternative Conceptions	Experimental Group				Control Group			

		Pre-test	Post-test	CC	Effect.	Pre-test	Post-test	CC	Effect.
Q-9	Cyclohexanol molecules cannot be oxidized because they are cyclic molecules.	26.3	2.6	+23.7	Maj.	21.4	33.3	-11.9	Neg.
Q-10	Secondary alcohols form with a two-step reduction of carboxylic acids.	15.8	5.3	+10.5	Lim.	19.0	19.0	0.0	No
Q-10	Tertiary alcohols form with a two-step reduction of carboxylic acids.	15.8	7.9	+ 7.9	min.	11.9	11.9	0.0	No
Q-10	Ethers form with a two-step reduction of carboxylic acids.	13.2	10.5	+2.7	min.	14.3	11.9	+2.4	Min.
Q-11	Primary alcohols react the fastest with Lucas reagent	36.8	15.8	+21.0	Maj.	35.7	23.8	+11.9	Lim.
Q-11	Secondary alcohols react the fastest with Lucas reagent	15.8	10.5	+5,3	Min.	28.6	19.0	+9.6	Min.
Q-12	Secondary alcohols do not oxidize.	23.7	2.6	+21.1	Maj.	23.8	9.5	+14.3	Lim.
Q-12	Tertiary alcohol oxidation results in ketones.	7.9	-	+7.9	Min.	11.9	7.1	+4.8	Min.
Q-13	In the reaction of 1-bromopropane with diluted strong bases, the major product is propene, which is an alkene.	26.3	13.2	+13.1	Lim.	26.2	35.7	-9.5	Neg.
Q-13	In the reaction of 1-bromopropane with diluted strong bases, the major product is propyne, which is an alkyne.	23.7	13.2	+10.5	Lim.	14.3	26.2	-11.9	Neg.
Que.	Alternative Conceptions	Experimental Group				Control Group			

		Pre-test	Post-test	CC	Effect.	Pre-test	Post-test	CC	Effect.
Q-14	For an alcohol to have the properties of primary alcohol, a hydrogen atom must be attached to the C atom of the hydroxyl group to which it belongs.	28.9	10.5	+18.4	Maj.	28.6	26.2	+2.4	Min.
Q-15	A monoalcohol, dialcohol and the boiling point of ether are equal to one another because they have the same number of carbons.	10.5	2.6	+7.9	Min.	14.3	11.9	+2.4	Min.
Q-16	When dehydration occurs in 2 moles of ethyl alcohol in the presence H_2SO_4 at 140 °C, ethene molecules are generated as the major product.	28.9	13.2	+15.7	Maj.	30.9	19.0	+11.9	Lim.

*Effect. = Effectiveness

It can be seen from an examination of the alternative conceptions in Table 7 that there were major conceptual changes in 11 alternative conceptions in the experimental group; there were 10 limited changes and 9 minor changes. On the other hand, the control group displayed major and limited conceptual changes in 4 alternative conceptions; the change was minor in 16 alternative conceptions. One striking point to note in the conceptual change in the control group was that the change was negative. In other words, in the control group, an increase was seen on the post-test in 3 alternative conceptions compared to the pre-test and this was a negative change. Also in the control group, no conceptual change was seen in 3 alternative conceptions. All of these findings show that the concept cartoon-based instruction applied to the experimental group was more successful than traditional teaching in terms of replacing the alternative conceptions of the pre-service science teachers with scientific conceptions about the topic of alcohols. Moreover, the fact that some of the alternative conceptions in the control group had not gone through conceptual change and that there was even an increase in these alternative conceptions clearly shows that this method was not as effective in achieving conceptual change as concept cartoon-based instruction. Indeed, other studies in the literature also state that not only is the desired level of conceptual change not achieved after traditional teaching, but there is an increase in alternative

conceptions (Bodner, 1991; Westbrook & Marek, 1991; Hesse &Anderson, 1992; Kaya, 2007; Hsu, 2008).

When the alternative conceptions on the basis of the questions are examined in Table 7, it can be seen that in Q.1 about the molecular formula of alcohol, both the experimental group and the control group displayed a decrease in alternative conceptions compared to the pre-test. In fact, the experimental and control groups both achieved a major conceptual change in the alternative conception "*all mono alcohols are represented with the molecular formula* $C_nH_{2n+2}O$*"*. On the post-test, however, a look into the percentages for this alternative conception shows that the percentage in the experimental group (2.6%) was lower than in the control group (7.1%). The percentage for the alternative conception "*only ethers can be represented with the molecular formula* $C_nH_{2n+2}O$*"* for the same question exhibited a fall in the post-test in the experimental and control groups compared to the pre-test; the conceptual change was on a major level in the control group but on a minor level in the experimental group. When the percentages of these alternative conceptions on the post-test were examined, it was seen that the percentage (2.6%) in the experimental group was lower than in the control group. All of these findings lead to the conclusion that both traditional teaching and concept cartoon-based teaching are similarly productive in achieving conceptual change about the molecular formula of alcohols.

The alternative conception "*If C=C in the carbon chain, priority is not in the -OH group but in the C=C bond and the nomenclature is done according to the alkene*" exhibited percentages close to one another in the experimental and control groups on the pre-test but the experimental group's percentage fell to 2.6% on the post-test, showing a limited level of conceptual change. In the control group, the percentage of this alternative conception on the post-test was 9.5%, which represented a minimum level of conceptual change. The higher percentage of conceptual change in the experimental group compared to the control as well as the lower alternative conception percentage on the post-test indicates that the concept cartoons drawn on the subject of nomenclature of alcohols was more successful than traditional teaching.

In the third question of the concept on the conditions for being alcohol, three alternative conceptions appeared in the pre-test in both the experimental and control groups. The alternative conception "*to call a molecule as alcohol, this molecule should not include* π *bond*" displayed a rate of 5.3% on the post-test in the experimental group and of 14.3% in the control. The alternative conception "*to call a molecule as alcohol, it is enough that hydroxyl group (- OH) is attached to a carbon atom in the molecule"* meanwhile showed a percentage of 2.6% on the post-test in the experimental group and of 4.8% in the control group. The alternative conception "*the cyclic molecules are not characteristic of alcohol*" was not encountered on the post-test in the experimental group but appeared at a rate of 4.8% in the control group. However, much the conceptual change rate was higher in the control group for the two alternative conceptions, their percentage on the post-test was lower in the experimental group and in fact, no alternative conception was seen in the experimental group on the post-test. These findings show that traditional teaching and concept cartoon-based teaching have a similar effect on eliminating alternative conceptions regarding the conditions for being alcohol.

The second question on the solubility of alcohol in water on the concept test revealed two alternative conceptions in Q's

4 and 6. One of these was the alternative conception "*an increase in the number of C increases alcohol's solubility in wate*r" which revealed a higher percentage in the experimental group on the pre-test and the exactly opposite situation in the case of the post-test. At the same time, the conceptual change achieved in this alternative conception in the experimental group was major while the change remained at a minimum level in the control group. Another alternative conception related to this subject, "*branched-chain and straight-chain alcohols which they have the same number of carbon atoms has the same solubility in water*" displayed a post-test percentage in the experimental group that was lower than in the control group. The level of conceptual change achieved was major in the experimental group and minimum in the control group. These results indicate that in the topic of the solubility of alcohol in water, the concept cartoon-based instruction applied to the experimental group was much more successful than traditional teaching in eliminating alternative conceptions.

In the 5th question on structural isomers, three alternative conceptions were found in both the experimental and control groups. The alternative conception "*all alcohols are structural isomers with ethers.*" may have originated from the pre-service teachers' acceptance of all monoalcohols as structural isomers of ethers. This subject in particular is one of the lessons that is emphasized in secondary school chemistry courses. The generalization of this statement by the pre-service teachers may have caused them to disregard the example of methyl alcohol. This also indicates that it was not easy for the pre-service teachers to replace their alternative conceptions with scientific ones and traditional teaching made it even harder. Indeed, while this alternative conception had been adopted by the high percentage of 23.8% of the pre-service teachers in the control group on the post-test, this rate was 5.8% in the experimental group. The fact that the post-test percentage in the experimental group regarding the other two alternative conceptions about structural isomers was lower than in the control group supported this premise.

When the alternative conceptions in Table 7 are examined, it can be seen that the most prominent differences between the experimental and control groups were in Q's 7, 8, 9, 10…. about alcohol reactions and synthesis of alcohols. For example, the reactions of alcohols to metallic sodium (Q.7) was a topic that revealed alternative conceptions in the experimental and control groups and both the level of conceptual change and the percentage on the post-test displayed a result that favored the experimental group. Among these, particularly the percentage for the alternative conception "*only tertiary alcohols react with metallic sodium*" showed no change in the pre- and post-tests of the control group, meaning there was no conceptual change. This indicates first that it was not easy for the pre-service teachers to make a change in their prior knowledge and secondly, that traditional teaching was not very effective in replacing alternative conceptions with scientific knowledge.

In connection with the reduction reaction, which is an alcohol reaction, it was observed that the alternative conception "*cyclohexanol molecules cannot be oxidized because they are cyclic molecules.*" (Q.9) exhibited percentages close to each other in both the experimental and control groups. The reason the pre-service teachers harbored this alternative conception was because they remembered from secondary school that examples of alcohol reactions were usually straight chains and so they generalized this knowledge. In the post-tests however, while a pronounced fall was seen in the percentage of this alternative conception in the experimental group, the

opposite was true in the control group and an increased percentage was seen. Thus, negative change was observed in the control group. In Q.12 of the concept test about alcohol oxidation, the alternative conceptions of "*secondary alcohols do not oxidize"* and "*tertiary alcohol oxidation results in ketones"* were noted. A comparison of the percentage of these alternative conceptions on the post-tests with the rate of conceptual change revealed that there was a more positive change in the experimental group.

Another alcohol reaction, the reaction with Lucas reagent, was referred to in a large percentage in both the experimental and control groups on the pre-test as the "*primary alcohols react the fastest with Lucas reagent*" alternative conception. That the pre-service teachers had this alternative conception showed that they did not know enough about reaction mechanisms and types of reactions. Also, the second meaning of "primary" in Turkish, "first," may have caused the pre-service teachers to believe that primary alcohol was the type of alcohol that showed the fastest reaction. Indeed, Wellington and Osborne (2001) found that confusion in language was an obstacle to students' conceptual change. It can be seen from Table 7 when the percentage of this alternative conception on the post-test is examined that this rate was 2.6% in the experimental group and 9.5% in the control group. At the same time, the percentages of the alternative conception *"secondary alcohols react the fastest with Lucas reagent*" was 13.2% in the experimental group and 21.4% in the control group.

The question on alcohol reaction acid catalyzed dehydration and the product of ether (Q.16) elicited the alternative conception "*when dehydration occurs in 2 moles of ethyl alcohol in the presence H_2SO_4 at 140ºC, ethene molecules are generated as the major product"* in both the experimental and control groups on the pre-test, it was found. This finding shows that the pre-service teachers confused synthesis of ether and alkene. At the same time, this alternative conception is important in that it shows that the pre-service teachers did not pay attention to the conditions for a reaction. In the post-tests, both groups had a lesser number of alternative conceptions but the conceptual change in the experimental group was on a major level while the control group only showed a limited level of conceptual change. Furthermore, the percentage of this alternative conception in the experimental group was lower than in the control group. This outcome indicates that in the context of this reaction, as in other reactions of alcohols, the concept cartoon-based instruction was more effective in achieving a replacement of alternative conceptions with scientific knowledge. In connection with the synthesis of alcohols, a look into the alternative conceptions that appeared in Q.8 of the concept test, shows that there was a more positive change in the experimental group. Indeed, in all of the alternative conceptions, namely, *"reduction of ketones results in formation of primary alcohols*," "*reduction of ketones results in formation of tertiary alcohols*," and "*ketones cannot be reduced*," the percentage of conceptual change was higher in the experimental group and also lower in the post-test compared to the control group.

In Q.10 on the synthesis of alcohols, there were striking differences between the experimental and control groups. In this question, the alternative conceptions "*secondary alcohols form with a two-step reduction of carboxylic acids"* and "*tertiary alcohols form with a two-step reduction of carboxylic acids"* showed a decrease on the post-test in the experimental group while in the control group, no change was seen and no conceptual change took place. In connection with another type of alcohol synthesis treated in Q.13, alcohol synthesis from

alkyl halides, it was observed that the pre-service teachers in both the experimental and control groups displayed high percentages (26.2% and 26.3%) of the alternative conception of "*in the reaction of 1-bromopropane with diluted strong bases, the major product is propene, which is an alkene.*" This showed that the pre-service teachers mixed up two reactions that were in competition with each other–elimination and substitution. They were unable to completely differentiate when an alkene and when an alcohol product would appear in these two different reaction mechanisms.

It can be seen in Table 7 that the post-test findings showed pronounced differences between the experimental and control groups. In the experimental group, the percentage of this alternative conception had fallen to 13.2%, while in the control group there had been an increase, reaching 35.7%. A similar situation could be seen in the alternative conception "*in the reaction of 1-bromopropane with diluted strong bases, the major product is propyne, which is an alkyne*." While on the pre-test, the experimental group had a higher percentage of this alternative conception, the post-test shown that this percentage had decreased in the experimental group but had shown a tendency to rise in the control group. In short, the control group displayed a negative change in two alternative conceptions following the instruction. All of these findings indicate that the instruction applied to the experimental and control groups produce different effects in achieving conceptual change in the subject of alcohol synthesis among the pre-service teachers and that in comparison to traditional teaching, concept cartoon-based teaching was more effective in this context.

The question that revealed a pronounced effect on conceptual change of the type of instruction applied to the experimental and control groups was Q.14 on the concept test. It was seen that this question regarding the classification of alcohols displayed percentages close to those found for the alternative conception "*for an alcohol to have the properties of primary alcohol, a hydrogen atom must be attached to the C atom of the hydroxyl group to which it belongs"* (28.9% and 28.6%). In the post-tests, it was seen that this percentage in the experimental group fell sharply, and conceptual change was at a major level. In the control group, the percentage of alternative conceptions on the post-test was lower than on the pre-test but this was not a striking fall; conceptual change remained limited at a minor level.

Q.15 on the concept test having to do with the alcohol property of boiling point showed a percentage for the alternative conception "*a monoalcohol, dialcohol and the boiling point of ether are equal to one another because they have the same number of carbons.*" that was less on the post-test compared to the pre-test in both the experimental and control groups and each group experienced conceptual change at a minor level. When the post-test percentages for this alternative conception were compared in both the experimental and control groups, it was seen that the experimental group displayed a lower percentage.

Discussion and Conclusion

This study aimed at exploring the effect of concept cartoon-based teaching on the conceptual understanding of pre-service science teachers regarding the subject of alcohols. It was found that concept cartoon-based teaching was much more effective than traditional teaching in ensuring the learning of scientific concept and eliminating alternative

conceptions. Indeed, while there was no significant difference between the experimental and control groups according to their pre-test scores, the significant difference appearing on the post-test in favor of the experimental group supports our conclusion. Moreover, when the level of understanding of the pre-service teachers in the experimental and control groups on the pre- and post-test was examined, it was observed that percentage of sound understanding(SU) of the experimental group on all of the questions in the post-test was higher than in the control group, and that the percentage of alternative conceptions was also low, which indicated that concept cartoon-based teaching was more effective in helping pre-service teachers reach the desired level of conceptual understanding. These results are consistent with the findings of other studies in the literature (Stephenson & Warwick, 2002; Kabapınar, 2005)

One of the important findings in the study was that concept cartoon-based teaching was more effective than traditional teaching in achieving conceptual change. On the other hand, concept cartoon-based teaching did not have the same effect on eliminating all the alternative conceptions the pre-service teachers had regarding the topic of alcohols. For example, the question on the molecular formula, a part of the topic of the general property of alcohols (Q.1), and the conditions for being alcohol (Q.3) displayed conceptual changes in the experimental and control groups that were close to each other but in the topics in particular of alcohol reactions and products (Q.9, 10, 13), it was seen that the experimental group showed a much more pronounced conceptual change. These results show that concept cartoon-based instruction is more successful in teaching pre-service teachers the more specific reactions in organic chemistry, therefore having more of an effect on conceptual change compared to traditional teaching methods. This draws us to the conclusion that, as some researchers have reported, conceptual change may differ according to content (Tao and Gunstone, 1999; Havu-Nuutinen, 2005; Jonassen *et al.*, 2005; Pımthong *et al.*, 2012). Another important result of our study was that although alternative conceptions showed a decline in the experimental group on the post-test, there was no change in some aspects in the control group (Q.s 7 and 10) and even showed an increase in others (Q.s 9 and 13). This clearly indicates that traditional teaching is insufficient is eliminating alternative conceptions to the point desired. Similar findings have been reported in other studies as well (Bodner, 1991; Westbrook & Marek, 1991; Hesse &Anderson, 1992; Kaya, 2007; Hsu, 2008).

Recommendations

All of the results of the study pointed to the effectiveness of concept cartoon-based instruction in developing conceptual understanding about the topic of alcohols and eliminating alternative conceptions as compared to traditional teaching methods. The concept cartoons that were drawn up however did not all produce the same effect. For example, in Q.11 on the post-test, the sound understanding percentage was lower than in the other questions. The higher percentage of alternative conceptions in this question showed that the concept cartoon drawn for Lucas reagent was not as effective as the other concept cartoons.

At the same time, since a retention test was not implemented to determine whether or not the alternative conceptions were permanent, remarks about the permanence of alternative conceptions, especially in the experimental group of pre-service teachers, cannot be made. From this perspective, we believe that it will be useful for future studies to focus on a retention test and reexamine this particular aspect. Also, although an environment of discussion was set up in the

classroom and in the experiment group during the concept carton-based instruction whereby the students could exchange views, we think that if this process could be handled in a period of argumentation supported by data, evidence and warrant, this would have a positive effect on conceptual change.

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