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Effects of 3D Applications in Organic Chemistry Lessons on Preservice Teachers' Spatial Ability

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Abstract

Chemistry lessons, especially organic chemistry lessons, require basic skills to imagine and mentally rotate 3D and 2D objects. These skills are related to spatial ability. For meaningful learning, students should have enough spatial ability and teachers should consider to develop students' spatial ability. Spatial ability could be developed permanently by activities and training. 3D printers and 3D pens could be effectively used to design and apply such activities. This research is conducted to analyze the effect of 3D applications on Elementary Science Education students' spatial ability in Organic Chemistry lessons. Organic molecule models were designed and printed in 3D printers. The molecules were used in Organic Chemistry lessons to show coordination of atoms. Also the students draw 3D molecule structures by using a 3D pen. The Purdue Visualization of Rotation Test was administered as pretest and posttest to analyze spatial ability level of the students. The result of the study shows that; traditional Organic Chemistry lessons have no significant effect on spatial ability development; however, 3D applications have significant effect on spatial ability development.

INTRODUCTION

Organic chemistry could be identified as the chemistry of carbon compounds and carbon is an essential element for all living organisms on earth (Solomons, 1990). Stereochemistry is a key element to comprehend organic compounds (Kurbanoğlu & Taşkesengil, 2002). Difficulties in learning stereochemistry could become an obstacle in organic chemistry education (Barta & Stille, 1994) and teachers should be aware of these difficulties and should look for methods to overcome the difficulties.

Drawing molecule structures became very easy by the help of software such as ACD / Chem Sketch (Akpolat & Kartal, 2009). Besides, virtual reality and online communication facilitate people to create and share three dimensional (3D) objects (Hai, 2010). Technological developments provide unlimited opportunities by distance education, simulations and visualization of scientific phenomena. International educational institutions and educators consider the potential of 3D virtual environments that support a place to work in a group regardless of the location (Dalgarno & Lee, 2010). 3D simulations have positive effects; however, it does not give tangible products. 3D printers close this gap. 3D printers convert virtual objects to real objects. Actually 3D printers not only print but also ‘make’ objects. Products of 3D printers are just limited to imagination. All chemical molecules could be constructed by 3D printers.

Chemistry deals with atoms, molecules and their orientation in space. For this reason, it is inevitable to consider spatial ability for chemistry education. Spatial ability has an effect on students’ organic chemistry achievement. Students, who have high spatial ability scores, are more successful on complex multiple-step problems that require problem solving skills and mental manipulation of objects, however, spatial ability has no significant effect on solving some organic chemistry problems, which could be solved by a simple algorithm (Pribyl & Bodner, 1987). Organic chemistry courses include spatial visualization processes, and students, who have low spatial ability, may not able to perform such processes (Supasorns, Suits, Jones & Vibuljan; 2008).

Spatial ability is a cognitive measure and could be examined by tests. Spatial ability tests measure participant’s performance on the rotation of 2D objects and 3D objects in space. These tests are mainly three types regarding test administration time. Power test measures ability in enough time to complete, and speed test measures ability in a limited time. Third type is speeded test is a kind of combination of power test and speed test and it is administered in a limited time (Lu & Sireci, 2007).

Activities and training could help to improve spatial ability, and medium term applications make this improvement permanent (Terlecki, Newcombe & Little, 2008). Technological developments facilitate the use of beneficial activities. 3D printers and 3D pens are technological tools to diversify learning environments. Teachers could utilize 3D printers and 3D pens for developing activities and students could make training by 3D objects to develop spatial ability.

The main research question of this research is; “What is the effect of 3D applications on students’ spatial ability?”. Beside that, another research question is posed as “Is there any effect of organic chemistry lessons on students’ spatial ability?”.
The results of the study may highlight the importance of 3D applications and reveal the effect of 3D applications on spatial ability development.

Methodology of Research

Quasi-experimental research with nonequivalent groups design was conducted to examine the effect of 3D applications on students’ spatial ability. For this purpose, students designed organic molecules, such as nitrobenzene, acetylsalicylic acid etc., and they draw by using a 3D pen in one semester. Also fundamental organic molecule structures were constructed by 3D printer and these molecules were used in Organic Chemistry lesson spring semester in the 2016-2017 academic year.

Sample of Research

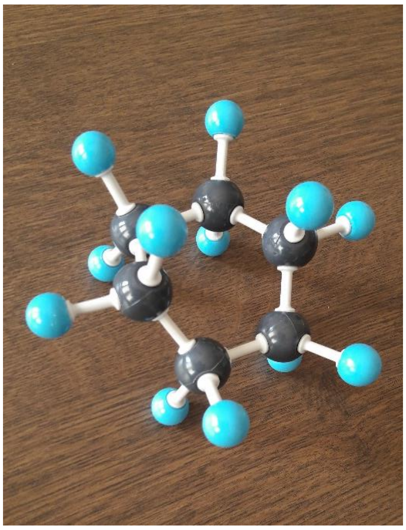
Sample of research is 80 2nd grade level Elementary Science Education students in Ereğli Faculty of Education, at Zonguldak Bülent Ecevit University. Only accessible and available students participated in this study, so convenient sampling is used in the sampling procedure. Data were collected in the 2015-2016 academic year and 2016-2017 academic year. 40 2nd grade level Elementary Science Education students in the 2015-2016 academic year were assigned as control group and 40 2nd grade level Elementary Science Education students in the 2016-2017 academic year were assigned as experimental group. All students in this study were assigned to Organic Chemistry lessons. The Purdue Visualization of Rotation Test was administered to students at the beginning of the study. Spatial ability levels of the experimental and control groups are not significantly different (Table 1.)

The experimental group and the control group did not practice in the same semester. Both the control group and the experimental group members studied the same curriculum in a smiliar context, so extraneous variables, such as context, effect of lecturer, effect of course loading, were assumed identical.

Instrument and Procedures

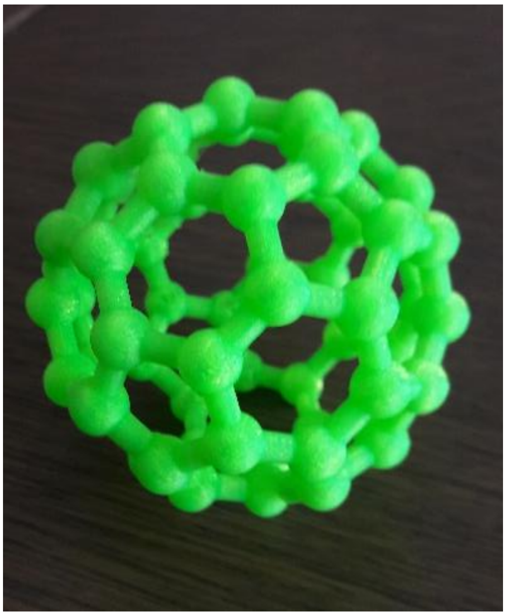
Data collection instrument of the research is The Purdue Visualization of Rotation Test. The test was developed by Guay (1976) and it was revised by Yoon (2011). Test has 30 items and it is aimed to measure spatial ability in 3D mental rotation in a limited time. Time limit was 20 minutes for both pre-test and post-test application. In order to check internal consistency, Kuder-Richardson reliability coefficient was calculated and found as 0,73.

The Purdue Visualization of Rotation Test was administered to both the control group and the experimental group as pretest at the beginning of semester and posttest at the end of the semester.

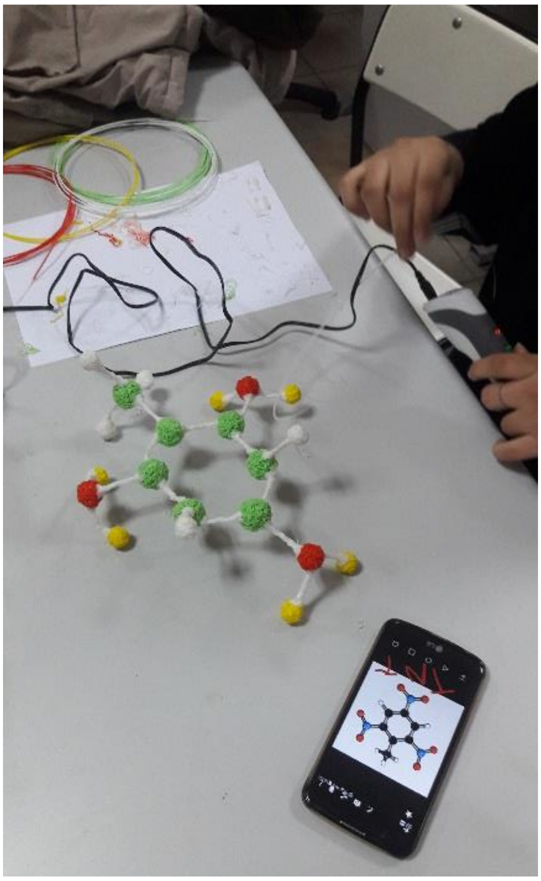


Picture 1. Balls and sticks model

Any special teaching method was not applied in the control group. The students in the control group just used molecular model kits involving balls and sticks. The molecular model kit, which consists of balls and sticks, is easy to operate and students do not need to spend a long time constructing a molecule (Picture 1.). Besides this, the kit is limited to construct only simple molecules.

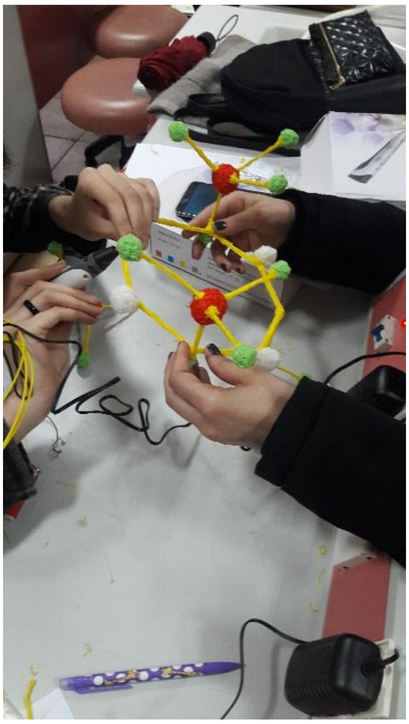


Picture 2. Molecule model constructed with 3D printer



Picture 3. Molecule model constructed with 3D pen

The control group lessons were supported by 3D printed organic molecules (Picture2.). They designed and built organic molecules by using 3D pens (Picture3. and Picture 4.). They were not familiar with 3D pens but it is easy to operate. The students were aware that unlimited molecules could be constructed.



Picture 4. Students are constructing molecule model with 3D pen

Data Analysis

Normality assumption of all pretest scores of control and experimental group were analyzed with Kolmogorov-Smirnov test (p>0,05). Kolmogorov-Smirnov test checks scores whether distribution of scores deviate from normal distribution (Field, 2013). According to results, parametric statistics methods were conducted. Data were analyzed in SPSS package program by independent t-test and paired t-test in 95% confidence interval.

RESULTS

An independent samples t-test was conducted to compare scores of the control group and the experimental group. There is no significant difference in The Purdue Visualization of Rotation scores of the experimental group (M=11,88, SD=4.58) and the control group (M=12,38, SD=3,99), t(78)=0,52, p=0,60 (Table 1.).

Table 1. Independent t test scores of The Purdue Visualization of Rotation Test

	N	M	S.D.	df	t	p
Experimental Group	40	11,88	4.58	78	0,52	0,60
Control Group		12,38	3.99			

Table 2. Paired t test scores of control group

	N	M	S.D.	df	t	p
Pre-test	40	12.38	3.99	39	0,94	0,35
Post-test		13.00	4.96			

A paired-sample t-test was conducted to compare the control group's pretest scores and posttest scores. There is no significant difference between pre-test scores (M=12,38, SD=3,99) and posttest (M=13,00, SD=4,96) scores; t(39)=0,94, p= 0,35 .

Table 3. Paired t test scores of experimental group

	N	M	S.D.	df	t	p
Pre-test	40	11.88	4.58	39	2.92	0,01
Post-test		13.30	5.40			

A paired-sample t-test was conducted to compare the experimental group's pretest scores and posttest scores. There is significant difference between pretest scores (M=11,88, SD=4,58) and posttest (M=13,30, SD=5,40) scores; t(39)=2,92, p= 0,01 .

DISCUSSION AND CONCLUSION

The experimental group and the control group were assumed as identical because they were studying at the same department and same grade level. Also spatial ability levels of the experimental group and the control group were not significantly different (Table 1.). There were two expected variables which affect spatial ability; Organic Chemistry lessons and 3D applications. Analysis of the control group's pretest and posttest scores (Table 2.) revealed the effect of Organic Chemistry lessons on spatial ability. The control group's spatial ability scores had increased but there was no significant difference. So we argue that traditional Organic Chemistry lessons performed by lecturing have no significant effect on spatial ability development. Similarly, Salkind (1976) stated the deficiency of traditional teaching to develop spatial ability. Organic chemistry course involves mental manipulation of 3D objects, but this course is not enough to develop spatial ability without appropriate activities. 3D diagrams are a part of Organic Chemistry lessons but as Huang & Lin (2017) stated; just figuring 3D images in students' minds has only a limited impact on spatial visualization. Omar & Mozol (2020) have reported the positive effect of 3D applications in Chemistry classes on spatial ability. They conducted an experimental study to test effectiveness of technological aids and 3D materials. The results revealed the 3D materials' superiority over technological aids. We can conclude that 3D materials, rather than 3D images, could help to improve spatial ability.

The main research question was tested by analyzing pretest scores and posttest scores of the experimental group (Table 3.). This result reveals the positive effect of 3D applications on students' spatial ability. The control group had also used molecular models, but they did not use their creativity and they did not spend a long time. Because molecular model sets are limited to construct basic molecules and it is too easy. The Students, who are using 3D pens, are not limited by tools. On the contrary, dealing with a 3D pen and spending time by creating molecules motivates them. Molecular model sets are intended to create molecules without error and it prevents the development of students' spatial ability. On the other hand, students creating molecules by 3D pen have the possibility to make errors. They could notice the error and learn the cause of error.

Students should have accurate and realistic imagery to have a robust idea about visualization (Olkun & Uçar, 2007). Molecular model sets provide accurate and realistic imagery, but it is not sufficient to develop spatial ability. Activities based on spatial training help to develop spatial ability (Owens & Clements, 1998), but appropriate materials should be used in such activities (Olkun & Altun, 2003). Molecular model sets are not enough to develop spatial skill, because these sets are designed to create just molecules. Students do not have to manipulate figures. On the other hand, 3D pens are not designed to draw just specific objects. Students have to design molecules mentally and give decisions about processes. So students engage more mentally active when building molecules with 3D pens, compared to building molecules with molecular model sets.

Chemistry courses, especially organic chemistry, deal with atoms, molecules and their orientation in space. Students should be able to imagine molecules orientation and also rotations in space. Besides, chemistry includes concrete and abstract phenomena. Abstract phenomena could be transformed into concrete phenomena by visualization. These facts highlight the importance of spatial ability, so students' spatial ability should be improved. 3D applications have a positive effect on spatial ability development. 3D applications could be integrated into the curriculum not only in Organic Chemistry but also other courses involving models and figures. In order to improve spatial ability, activities with 3D materials are superior over just dealing with images. Similarly, creating 3D objects is superior over performing activities with pre-built 3D materials.

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REFERENCES

Akpolat, O. & Kartal, F. (2009). Kimyacılar için bilişim teknolojileri, *Akademik Bilişim'09 - XI. Akademik Bilişim Konferansı Bildirileri,* 11-13 Şubat 2009 Harran Üniversitesi, Şanlıurfa.

Barta N.S. & Stille, J.R. (1994). Grasping the concepts of stereochemistry. *Journal of Chemical Education, 71(1)*, 20-23.

Dalgarno, B. & Lee, M. J. W. (2010). What are the learning affordances of 3d virtual environments?, *British Journal of Educational Technology,* 41*(1),* 10-32.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage.

Guay, R. B. (1976). *Purdue spatial visualization test*. West Lafayette, IN: Purdue Research Foundation.

Hai-Jew, S. (2010). *Virtual Immersive and 3d Learning Spaces: emerging technologies and Trends.* USA: Igi Publishing.

Huang, T. C., & Lin, C. Y. (2017). From 3d modeling to 3d printing: development of a differentiated spatial ability teaching model. *Telematics and Informatics, 34*(2), 604-613.

Kurbanoğlu, N & Taşkesenligil, Y. (2002). *Organik kimyada stereokimya konusunun programlı öğretimi*, V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, 16-18 Eylül 2002, ODTÜ.

Lu, Y., & Sireci, S. G. (2007). Validity issues in test speededness. *Educational Measurement: Issues and Practice, 25(4),* 29-37.

Olkun, S., & Altun, A. (2003). İlköğretim öğrencilerinin bilgisayar deneyimleri ile uzamsal düşünme ve geometri başarıları arasındaki ilişki. *The Turkish Online Journal of Educational Technology*, 2(4), 86-91.

Olkun, S.& Uçar, Z. T. (2007*). İlköğretimde etkinlik temelli matematik öğretimi*. Ankara: Maya Akademi.

Omar, K., & Mozol, V. (2020). Exploring the role of viewing technologies in the chemistry classroom. *Papers on Postsecondary Learning and Teaching, 4,* 68-75.

Owens, K. D., & Clements, M. K. (1998). Representations in spatial problem solving in the classroom. *The Journal of Mathematical Behavior*, *17*(2), 197-218.

Pribyl, J. R., & Bodner, G. M. (1987). Spatial ability and its role in organic chemistry: a study of four organic courses. *Journal of research in science teaching*, *24*(3), 229-240.

Salkind, N. J. (1976). A cross-dimensional study of spatial visualization in young children. *The Journal of genetic psychology*, *129*(2), 339-340.

Solomons,T.W.G. (1990). *Organic chemistry*. New York: Wiley.

Supasorn, S., Suits, J. P., Jones, L. L., & Vibuljan, S. (2008). Impact of a pre-laboratory organic-extraction simulation on comprehension and attitudes of undergraduate chemistry students. *Chemistry Education Research and Practice*, *9*(2), 169-181.

Yoon, S. Y. (2011). *Psychometric properties of the revised purdue spatial visualization tests: visualization of rotations (The Revised PSVT: R)*. Purdue University.

Terlecki, M. S., Newcombe, N. S., & Little, M. (2008). Durable and generalized effects of spatial experience on mental rotation: Gender differences in growth patterns. *Applied Cognitive Psychology*, *22*(7), 996-1013.

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Lisansüstü Öğrencilerin Argümantasyon Temelli Öğretim Yaklaşımına Yönelik Görüşleri

Graduate Students' Opinions on Argumentation Base Approach

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Abstract

In this study, it was aimed to determine the views of graduate students towards the argumentation-based teaching approach. The study group of the research consists of 15 graduate students in different branches. As a result of the research, it was determined that the knowledge of the participants about the argumentation-based teaching approach was not sufficient, while science and computer teachers were more knowledgeable. In the study, participants agree that the argumentation-based teaching approach has a positive effect on the learning process, conceptual understanding and the nature of science. Participants report that the argumentation-based teaching approach develops critical thinking, communication, scientific thinking and permanent learning skills, while poor class readiness, student readiness and time can negatively affect the learning process.

Anahtar Kelimeler

Argümantasyon
Bilimde argümantasyon
Yüksek lisans öğrencileri

Özet

Bu araştırmada yüksek lisans öğrencilerinin argümantasyon temelli öğretim yaklaşımına yönelik görüşlerinin belirlenmesi amaçlanmıştır. Araştırmanın çalışma grubu, farklı branşlarda 15 yüksek lisans öğrencisinden oluşmaktadır. Araştırma nitel bir araştırmadır. Araştırmada elde edilen verilerin analizinde içerik analizi yöntemi kullanılmıştır. Araştırmanın sonucunda, genelde katılımcıların argümantasyon temelli öğretim yaklaşımı hakkındaki bilgilerinin yeterli olmadığı tespit edilirken fen bilgisi ve bilgisayar öğretmenlerinin daha bilgili oldukları belirlenmiştir. Araştırmada katılımcılar argümantasyon temelli öğretim yaklaşımının öğrenme sürecine, kavramsal anlamaya ve bilimin doğasına ilişkin olumlu etki ettiğini bildirmektedirler. Katılımcılar, argümantasyon temelli öğretim yaklaşımının eleştirel düşünme, iletişim, bilimsel düşünme ve kalıcı öğrenme becerilerini geliştirirken, sınıf mevcudu, öğrenci hazırbulunuşluğunun yetersiz olmasının ve zamanın öğrenme sürecini olumsuz etkileyebileceğini bildirmektedirler.

GİRİŞ

Fen bilimleri eğitimi hızla değişen teknoloji ve bilime eşlik etmeye çalışmaktadır. Bu değişimlerden biride öğrencilerin yaparak yaşayarak öğrendiği, öğrenciyi merkeze alan eski bilgilerle yeni bilgileri yapılandıran yaklaşım olan yapılandırmacı yaklaşımdır (Günel, Kıngır ve Geban, 2012). Yapılandırmacı yaklaşımı içine alan uygulama alanlarından biride argümantasyon temelli öğretim yaklaşımıdır. Öğrenme ortamlarında, öğrenci yaşadığı olayları açıklamalı, argüman oluşturmalı, öğretmen ise öğrencinin kendini rahatça ifade edebileceği ortamları hazırlamalıdır. Öğretim sürecinde öğrenci fikirler oluşturmalı, araştırmalar yapıp farklı fikirleri veriler ve gerekçelerini açıklayarak çürütmeli öğretmen oluşan tartışma sürecini yönlendirmeli ve bir rehber rolü üstlenmelidir (MEB, 2013). MEB (2018) programında argüman; iddia, çürütme, karşıt argüman oluşturma, bilimsel olguların yarar ve zararlarını tartışan ortamların oluşturulmasına vurgu yapılmıştır (MEB, 2018). Fen bilimleri dersinde önem kazanan argümantasyon ilk olarak Toulmin (1958) ele almış ve iddiaları verilere dayandırarak uygun gerekçelere ilişkilendirme süreci olarak tanımlamıştır. Bilim insanlarının kullandığı altı öğeye argüman ismini vermiştir. Bu öğeler: iddia, veriler, gerekçeler, destekler, çürütme, niteleyiciler, karşıt görüşlerdir (Erduran, Simon ve Osborne, 2004). İddia, gözlemler sonucunda ya da bir konu, olay sonrası oluşan görüşler, hipotezler; veriler iddiayı destekleyen bilimsel kanıt ya da gerekçelerdir. Gerekçeler ise iddia ve veriler sonucunda oluşan bilimsel bulgulardır. Destekleyiciler daha önceden ispatlanmış, herkes tarafından kabul görmüş iddiaların doğruluğunu kuvvetlendiren kanıtlardır. Çürütme farklı iddiaları geçersizliğini; niteleyiciler her zaman, genellikle, nadiren gibi sınırlıkları belirleyen ifadelerdir (Apaydın, Peker ve Taş, 2012; Çepni, 2016; Toulmin, 2003; Tümay ve Köseoğlu, 2011).

Argümantasyon, dersi verimli hale getirirken öğrencilerdeki biliş ve üst bilişi harekete geçirmekte, bilimsel akıl yürütme ile kalıcı izli öğrenmelere neden olmakta, öğrencilerin derse katılmasıyla beraber iletişim becerileri ve eleştirel düşünme becerilerini geliştirmekte, bilimsel okuryazarlığı sağlamakta ve bilimsel akıl yürütmeyi artırmaktadır (Jiménez-Aleixandre ve Erduran, 2007). Argümantasyona dayalı eğitimin sınırlılıklarından bazılarının ise öğrenciler arasındaki düzey farkı, konuya uyarlanabilmesi, zaman, konunun merkezinden uzaklaşma ve kalabalık gruplar olarak düşünülmektedir. Argümantasyonun birçok uygulama alanı vardır. Kavram karikatürleri, tahmin gözlem açıklama tekniği, sınıf içi söylem, akıl yürütme tekniği bunlara örnek verilebilir. Argümantasyon temelli öğretim yaklaşımı matematikte kesinliği sağlamak ve doğruluğu ispatlamak amacıyla kullanılır (Bülbül ve Urhan, 2016). Fen bilimlerinde ise iddialar, kanıtlar, argümanı yapılandırma ve farklı iddiaları açıklamak için kullanılır (Hiğde ve Aktamış, 2017). Kuhn (1991) problem çözümü için argüman oluşturulması ve değerlendirilmesi gerektiğinden bahsetmiştir. Bilimsel akıl yürütme ve argümantasyon delillere dayanarak ortaya koyduğu düşünceler için gerekçeler sunması bilimi diğer disiplinlerden ayırmıştır (Siegel, 1989).

Çeşitli araştırmacılar tarafından öğretmen adaylarının argümantasyon temelli öğrenme yaklaşımına yönelik görüşleri (Aktamış ve Atmaca, 2016; Aydemir, Karakaya Cirit, Kaya ve Azger, 2018); bilimsel süreç becerilerine ve derse yönelik tutumuna etkisi (Aslan, 2016); fen öğretimi özyeterlik inancına etkisi (Eymur ve Çetin, 2017); başarılarına ve laboratuvara yönelik tutumlarına etkisi (Erkol, Kışoğlu ve Gül, 2017); argümantasyon düzeyleri (Özcan, Aktamış ve Hiğde, 2018) araştırılmıştır. Apaydın ve Kandemir (2018) Toulmin argümantasyon yönteminin sadece fen bilimlerinde değil, diğer alanlarda da kullanılabileceği düşüncesini belirtmektedir. Aydın ve Kaptan (2014) argümantasyon tabanlı eğitimi yalnızca fen bilimlerinde değil bütün derslerde (sınıf, matematik, sosyal bilgiler gibi) kullanılabilen bir bakış açısı olarak tanımlamışlardır. Aktamış ve Atmaca (2016), ilköğretimden başlayarak derslerde argümantasyonun kullanılmasının argümantasyona dair olumsuz görüşleri azaltacağı bildirmektedir.

Araştırmanın Amacı

Bu araştırmada, yüksek lisans öğrencilerinin argümantasyon temelli öğretim yaklaşımına ilişkin görüşlerinin belirlenmesi amaçlanmıştır. Ayrıca yüksek lisans öğrencilerinin argümantasyon temelli öğretim yaklaşımının öğretim süreçlerinde uygulamaya geçirilmesi hakkındaki görüşleri değerlendirilerek argümantasyon temelli öğretim yaklaşımının avantaj ve dezavantajları belirlenmeye çalışılmıştır.

YÖNTEM

Araştırma Deseni

Araştırma da yüksek lisans öğrencilerinin argümantasyon temelli öğretim yaklaşımına yönelik görüşlerini belirlemek amacıyla nitel araştırma yöntemi kullanılmıştır. Nitel araştırma araştırmacıların araştırılacak konuları doğal ortamında, insanların bakış açısından olguyu anlamlandırma çabası içinde oldukları bir araştırma yöntemidir (Denzin ve Lincoln, 1998) Nitel araştırma yöntemi "gözlem, görüşme ve doküman analizi gibi nitel veri toplama yöntemlerinin kullanıldığı, algıların ve olayların doğal ortamda gerçekçi ve bütüncül bir biçimde ortaya konmasına yönelik nitel bir sürecin izlendiği araştırmadır" (Yıldırım ve Şimşek 1999). Nitel araştırma metodlar ortamı etkilemeden sosyal olguların açıklanmasına çalışan çeşitli araştırma basamaklarını içerir (Merriam, 1998).

Çalışma Grubu

Bu çalışma, Devlet Üniversitelerinin Eğitim Bilimleri Enstitüsünde öğrenim gören farklı branşlardaki yüksek lisans öğrencileri ile gerçekleştirilmiştir. Araştırmanın katılımcı grubu 15 kişiden oluşmaktadır. Katılımcı grupta yer alan 15 öğrencinin 12'i kadın (%75), 3'ü erkek (%25) öğrencilerden oluşmaktadır. Çalışma grubunun %6.66'sını müzik, %20'sini matematik, %13.33'ünü bilgisayar, %13.33'ünü fizik, %6.66'sını sınıf ve %40'ını da fen bilgisi öğretmenleri oluşturmaktadır. Araştırmaya katılan katılımcılar K1'den K15'e kadar sıralanmıştır.

Veri Toplama Araçları

Araştırmada Tümay (2008) tarafından geliştirilen "Bilimde ve Bilim Eğitiminde Argümantasyon Hakkında Açık Uçlu Soru Formu" kullanılmıştır. Açık uçlu soru formu geçerliliği üç fen eğitimcisi tarafından kontrol edilerek, gerekli düzenlemelerden sonra kullanılmıştır (Tümay, 2008). Araştırmada kullanılan soru formu ile katılımcıların bilimde argümantasyonun rolü hakkındaki görüşlerini belirlemek amacıyla veri- delil arasındaki farklar; öğrenme yaklaşımı olarak argümantasyonun öğrencilerin öğrenmesini nasıl etkilediği ve katılımcıların argümantasyon temelli öğretim yaklaşımı uygulamaları hakkındaki görüşleri sorgulanmaktadır (Tümay, 2008). Araştırmanın geçerlik ve güvenilirliğini artırmak için tüm önlemler alınmıştır (Tümay, 2008).

Verilerin Analizi

Çalışma da yüksek lisans öğrencilerinin "Bilimde ve Bilim Eğitiminde Argümantasyon" görüşme anketin sorularına verdikleri cevapların analizinde içerik analizi yöntemi kullanılmıştır. Genel olarak toplanan verilerin ayrıntılı raportaştırılması nitel araştırmada geçerliliğin önemli ölçütleri olarak kabul edilmekte ve araştırma sonuçlarının doğruluğunu konu edinmektedir (Yıldırım ve Şimşek, 1999). Araştırma sonuçlarının güvenilirliği ise başka araştırmacıların benzer ortamlarda aynı verileri kullanarak aynı sonuçlara ulaşabilmesi durumuyla ilişkilidir (Yıldırım ve Şimşek, 1999). Nitel bir araştırmada güvenilirliği sağlamanın bir yolu veri toplama ve veri analizinin birden fazla arştırmacı tarafından gerçekleştirilmesidir. Araştırmada kullanılan ölçme aracına verilen cevaplar iki araştırmacı tarafından değerlendirilmiştir.

BULGULAR

Araştırmanın bu bölümünde farklı branşlarda yüksek lisans öğrencilerinin argümantasyon temelli öğretim yaklaşımına ilişkin nitel verileri analiz edilip veriler tablolar ve temalar halinde sunulmuştur. Çalışma kapsamında elde edilen bulgular araştırma soruları doğrultusunda verilmiştir.

1. Katılımcıların Bilimde Argümantasyon Temeli Öğretim Yaklaşım Hakkındaki Anlayışları

Bu araştırmada, katılımcılara yönlendirilen sorular ile katılımcıların bilim ve argümantasyon hakkındaki anlayışları belirlenmeye çalışılmıştır. Araştırmada, araştırmacılar tarafından katılımcıların argümantasyon, bilimsel bilgi, bilimsel bilgi oluşturma süreci, bilimde argümantasyonun önemi, bilim adamları arasında anlaşmazlıklar ve çözüm yolları gibi sorulara verdikleri cevaplar bulunmaya çalışılmştır.

- ✓ Katılımcılar, araştırmada elde edilen verilere göre bilimsel bilgiyi, deney ve gözlemlerle ispatlatlanan, doğruluğunun kanıtlanan, tekrarlanabilen ve herkesin kabul ettiği bilgi olarak belirtmişlerdir. Bütün branşlar fikrinin belirtmiş olup branşlar arasında fark gözlenmemiştir. Katılımcıların bu konuda verdiği cevaplardan bazıları şunlardır:
  K5; "Bilimsel bilgi doğruluğu kanıtlanmış birçok araştırma sonucu elde edilen bilgidir."
  K12; "Bilimsel temellere dayandırılmış kanıtlanabilir bilgidir. Doğruluğu kanıtlanabilir, herkesçe kabul görmüştür"
  K13; "Kanıt ve argümantasyona dayanan bilgidir. Tekrarlanabilir kanıtlanabilir olması gerekir."
- ✓ Araştırmada katılımcılar, bilimsel bilginin oluşturma sürecini deneme yanılma, kaynak araştırma, verilerin analizi, gözlem ve hipotez olarak belirtilmiştir. Katılımcıların bazılarına ait bu konudaki görüşler aşağıda verilmiştir.
  K11; "*Problemin tanınması, veri toplanması, hipotez oluşturulması, verilerin analizi, uygulama, değerlendirme sonucu oluşan bilgidir"*
  K12; "Deneme-yanılma, testler, hipotez"
- ✓ Katılımcıların bilimde argümantasyon temelli öğretim yaklaşımının rolü hakkındaki fikirleri incelendiğinde ise fizik, bilgisayar, fen bilgisi öğretmenleri bilim öğrenmede argümantasyonun rolü olduğunu belirtirken, müzik ve sınıf öğretmenleri fikrini belirtmemişlerdir. Katılımcılar tarafından bilimde farklı düşüncelerin değerlendirilmesi ile doğru sonuç elde edilebileceği, yeni fikirlerle ortaya çıkabilecek yeni durumlardan, beyin fırtınası ile konunun değişik açılardan ele alınmasının öneminden bahsedilmiştir. Katılımcılar:
  K3; "Bilimde argümantasyonun rolü vardır. Farklı düşünceler göz önünde bulundurularak daha doğru sonuç elde edilebilir."
  K9; "Tartışmaların sonucunda varılan bilgi deneysel olarak test ediliyorsa tabi ki rolü çok büyüktür."
  K12; "Argümantasyon konuyu bakış açısını genişleyip beyin firtınası sağlayarak değişik açıdan ele almayı sağlar." biçiminde cevap vermişlerdir.
- ✓ Araştırmada elde edilen verilere göre, araştırmalarla ilgili olarak katılımcıların %73.33'ü bilim adamları arasında anlaşmazlıkların olabileceğini belirtirken, %26.67'sini fikirlerini belirtmemişlerdir. Katılımcılar, soyut kavramlarda anlaşmazlıklar olabileceğini farklı bakış açılarıyla bakarak problemlerin çözülebileceğinden bahsetmişlerdir. Katılımcılardan bazıları:

K9; "Bilimin gelişmesi bilim adamlarının anlaşmazlık sayesinde olmuştur. Bilim adamları fikrini beğenmeyip konu üzerinde düşünüp farklı deneyler yaparak yeni bilgiye ulaşılabilir."
K12; "Bilimadamları arasında anlaşmazlıklar olabilir. Fikirler dinlenerek gerekli araştırmalar yapılarak ulaşılabilecek en doğru bilgiye ulaşılmalıdır."
K15; "Aynı konuyu farklı bakış açıları ile bakarken anlaşmazlıklar olabilir. Empati ve benzer koşulların sağlanması ile çözülebilir." şeklinde fikir belirtmektedirler.

- ✓ Araştırmada yer alan katılımcılar, argümantasyonun bilimsel tartışma, tartışma, dayanaklandırma, ispat, kanıt olarak tanımlamışlardır. Katılımcılardan müzik ve sınıf öğretmenliği braşındakilerin fikir belirtmemiş oldukları belirlenmiştir. Katılımcıların verdiği cevaplar:
  K1; "Argümantasyon bilimsel tartışmadır"
  K11; "Argümantasyon kanıtlara dayanacak şekilde araştırma yapma bilgileri toplama"
  K12; "Argümantasyon bilimsel tartışmalar ile ortaya konulan ispatlamalar, kanıtlar" şeklindedir.

2. Argümantasyon Temelli Öğretim Yaklaşımının Uygulanması Hakkındaki Görüşler

Bu kategoride katılımcılara argümantasyon temelli öğretim yaklaşımının uygulanmasında hangi derslerin uygun olduğu, derslerinde argümantasyonu kullanıp kullanmadıkları, uygulamalarda dikkat ettikleri hususlar, öğrenim hayatlarında argümantasyon temelli öğretim yaklaşımına yönelik dersler işlendiyse bunların hangi dersler olduklarına dair sorular yöneltilmiştir.

- ✓ Argümantasyon bilgisayar branşındaki bir katılımcı temelli öğretim yaklaşımının bütün derslerde uygulanabileceğini, müzik branşındaki bir katılımcı ise uygulamanın daha çok sözel dersler için uygun olduğunu belirtmiştir. Katılımcılara tarafından verilen bazı ifadelere aşağıda yer verilmiştir.:
- ✓ *K9; "Argümantasyon temelli öğretim yaklaşımı sözel derslerde kullanılabilir"*
  K11; "Aslında tüm derslerde uygulanabilir. Bilimsel dersler için daha uygundur."
  K15; "Argümantasyon temelli öğretim yaklaşımı fen bilimleri, matematik derslerinde uygulanabilir"
- ✓ Araştırmada, derslerinde argümantasyon temelli öğretim yaklaşımını uygulayacağını söyleyen katılımcılar fen bilimleri, bilgisayar ve matematik branşları; problem çözme, farklı bakış açısı kazandırma, sorgulama ve öğrencileri araştırmaya yönlendirdiğinden söz etmişlerdir. Araştırmada argümantasyon temelli öğretim yaklaşımını uygulamayı düşünmediğini belirten katılımcıların fizik, müzik ve sınıf branşlarından olduğu belirlenmiştir. Katılımcılar argümantasyon temelli öğretim yaklaşım uygulamaları hakkında tam bilgiye sahip olmadıklarını, sınıf hâkimiyetinde zorlanılacak bir uygulama olduğunu ve zamanının kısıtlılığı sebebiyle gerçekleştiremeyeceklerini belitmişlerdir. Katılımcılar:
- ✓ *K15; "Argümantasyon iyi bir yöntem olmasına rağmen sınıf hâkimiyetine ve öğrencilerin hazır bulunuş düzeyleri göz önünde bulundurarak sınıfa uygulanması ve hâkimiyet kurulması zor olur."*
  K13; "Argümantasyonu uygulamayı düşünüyorum. Çünkü problem çözme, farklı bakış açısıyla bakma, doğru bilgiye doğru kaynaktan uluşabilmesi için…"
  K9; "Zamanın kısıtlı olması ve pek bir bilgimin olmaması sebebiyle Uygulamayı düşünmüyorum." şeklinde fikir belirtmektedirler

- ✓ Araştırmada, sınıflarında argümantasyon temelli öğretim yaklaşımını kendilerinin uygulama şekilleri konusunda, katılımcılardan fen bilgisi ve bilgisayar branşlarından olan katılımcılar bilimsel konuların tartışılması üzerinde durmuşlardır.
  K12; "Bilimsel bir konu üzerinde tartışmalarla kanıtları dayandırarak hipotez kurdururdum."
  K13; "Deneylerle tartışmalar sonucunda bilgiye ulaştırırım."
- ✓ Katılımcıların %66,67'si öğrenim hayatlarında argümantasyon temelli öğretim yaklaşımı konusunda ders almadıklarını belirtmişlerdir. Katılımcı grubun %33,33'ünü oluşturan fen bilimleri, bilgisayar öğretmenleri bütün derslerinde argümantasyon temelli öğretim yaklaşımının yer aldığından bahsetmişlerdir.
  K12; "Yaklaşık olarak tüm derslerimizde kullandık. Alanım doğrudan kanıtlanabilir bilgi üzerine kurulu olduğu için genel olarak argümantasyon temelli öçğretim yaklaşımı ile işliyoruz."
  K13; "Fen bilimlerinin araştırma sorgulama yaklaşımını temel alır argümantasyonda bütün içerisindedir bütün derslerimizde kullanıyoruz."

3. Argümantasyon Temelli öğretim Yaklaşımının Öğrenciye Katkıları Hakkındaki Görüşler

Araştırmada, yüksek lisansta öğrenim gören katılımcıların argümantasyon temelli öğretim yaklaşımının öğrenme süreci içeresinde öğrenciye katkıları hakkındaki görüşleri Tablo 1'de sunulmuştur.

Bu çalışma ile araştırmaya katılan katılımcılar argümantasyon temelli öğretim yaklaşımının öğrenciye katkılarının olduğunu belirtmişlerdir. Katılımcılar argümantasyon temelli öğretim yaklaşımının öğrenme sürecinin kişileri araştırmaya yönlendirdiğinden, farklı düşünceleri açığa çıkararak bu düşüncelerin paylaşılmasının sorgulayarak öğrenmeye katkı sağladığını belirtmişlerdir. Araştırmada yer alan katılımcılar argümantaston temelli öğretim yaklaşımının kavramsal anlamaya etkileri olduğunu, anlamsal öğrenme, doğru bilgiye ulaşma ve yanlış kavramları giderilmesinde olumlu etkisi olabileceğini bildirmektedirler. Bazı katılımcılar, argümantasyon temelli öğretim yaklaşımının öğrencilerinin bilimin doğası ile ilgili anlayışlarını olumlu etkilediğinden bahsederken, katılımcılardan biri ise bu öğretim yaklaşımının bilimin doğasını anlaşılır hale getireceğinden bilime farklı bakış açıları oluşturabileceğini belirtmektedir. Araştırmada katılımcılar genel olarak argümantasyon temelli öğretim yaklaşımının duyuşsal kazanımlar boyutunda derse karşı tutumları etkilediğini ve derse ilgiyi artıracağını bildirmektedirler.

Tablo 1. Argümantasyon temelli öğretim yaklaşımın öğrenim sürecinde öğrenciye katkıları

Kategori	Alt kategori	Kod	F	Betimsel cümle
Öğrenciye Katkıları	Öğrenme sürecine etkileri	Araştırmaya yönlendirme	1	K12; "…fikirler öğrenciyi araştırmaya yönlendirir.
		Farklı düşüncelerin açığa çıkması	10	K8; "Konuya farklı düşünce ve görüşlerden bakmış olunur." K15; "Farklı görüşler duymak…"
		Düşüncelerin paylaşılması	3	K13; "…farklı düşünceleri öğrenmek düşünceleri paylaşmak"
		Sorgulayarak öğrenme	1	K10; "Karşılaşılan her bilginin doğru olmadığını sorgulanmasına fayda sağlar."
	Kavramsal	Anlayarak	2	K7; "Argümantasyon sayesinde kavramları

	anlamaya	öğrenme		yaparak yaşayarak öğrenerek anlamlı öğrenmeler gerçekleşir.”
		Doğru bilgiye ulaşma	1	K12; “Kavramların anlamları argümantasyon ile doğru kullanımını sağlanır.”
		Yanlış kavramları giderme	3	K8; “…kavram yanılgısının gidermede etkilidir.” K5; “…deneyler ile eski bilgiler değişebilir.”
	Bilimin doğası	Bilimin doğasını anlarlar	2	K12; “bilimin doğasının argümantasyon ile daha iyi anlaşılabilir ve kavramalarını sağlarlar.”
		Bilime farklı bakış açıları	1	K7; “Farklı fikirlerin tartışılması bilimin temelini oluşturur.”
	Duyuşsal kazanımlar	Derse ilgi	5	K8; “…aktif katılım sağlandığı için ders ilgi çekici hale gelebilir.” K7; “… argümantasyon ile öğrencinin derse olan ilgisi, isteğinde artış olur.”

4. Argümantasyon Temelli Öğretim Yaklaşımının Avantaj ve Dezavantajları

Araştırmada katılımcılara ait argümantasyon temelli öğretim yaklaşımının avantajları, dezavantajları hakkındaki görüşlerinin frekans değerleri Tablo 2 ve Tablo 3’de sunulmuştur.

Tablo 2. Argümantasyon temelli öğretim yaklaşımının avantajları

Kategori	Kod	Frekans (f)
Argümantasyon temelli öğretim yaklaşım avantajları	Eleştirel düşünme becerisi	5
	İletişim becerisi	5
	Bilimsel düşünme becerisi	1
	Kalıcı öğrenme	2

Araştırmada katılımcılar, argümantasyon temelli öğretim yaklaşımının öğrencilere eleştirel düşünme, iletişim becerileri kazandırma, bilimsel düşünme becerisi ve kalıcı öğrenme kazandırmak gibi avantajlar sağlayabileceğini belirtmişlerdir (Tablo 2).

Bu araştırmada katılımcılar, argümantasyon temelli öğretim yaklaşımının uygulanması sırasında sınıf mevcudu, kalabalık sınıflar, öğrenci hazırbulunuşluğunun düşük olması ve zaman sıkıntısının dezavantaj oluşturabileceğini belirtmişlerdir (Tablo3).

Tablo 3. Argümantasyon temelli öğretim yaklaşımının dezavantajları

Kategori	Kod	Frekans (f)
Argümantasyon temelli öğretim yaklaşımı dezavantajları	Sınıf mevcudu	3
	Öğrenci hazırbulunuşluğu	1
	Zaman	7

SONUÇ, TARTIŞMA VE ÖNERİLER

Bu çalışma eğitim bilimleri enstitüsünde öğrenim gören farklı branşlarda yüksek lisans öğrencilerinin argümantasyon temelli öğretim yaklaşımına dair bilgilerini belirlemek amacıyla gerçekleştirilmiştir. Bu çalışmada elde edilen bulgulardan yola çıkarak, araştırmada yer alan bütün branşlardaki katılımcıların bilimsel bilgi ve oluşturma süreci hakkında bilgi düzeylerinin orta seviyede olduğu belirlenmiştir. Araştırmada elde edilen verilere göre, argümantasyon ve bilimde argümantasyon temelli öğretim yaklaşımının rolü hakkında, müzik ve sınıf öğretmenlerinin diğer branşlara göre daha az bilgiye sahip oldukları, bilgisayar ve fen bilimleri braşındaki öğretmenlerinin ise daha fazla bilgiye sahibi oldukları belirlenmiştir. Çalışmanın bulguları Apaydın ve Kandemir (2018) tarafından yapılan sınıf öğretmenlerinin argümantasyon hakkındaki görüşleri çalışmasıyla benzerlik gözlenmiştir.

Yapılan araştırmada bilgisayar branşında bir katılımcı argümantasyon temelli öğretim yaklaşımının derslerde uygulanması konusunda, bu yaklaşımın bütün derslerde; müzik branşından bir katılımcı bu yaklaşımın sözel derslerde uygulanabileceğini belirtmiştir. Diğer branşlardaki katılımcılar ise argümantasyon temelli öğretim yaklaşımının fen bilimleri ve matematik derslerinde uygulanabileceğini belirtmişlerdir. Aydın ve Kaptan (2014) tarafından argümantasyon tabanlı eğitimin yalnızca fen bilimlerinde değil bütün derslerde de kullanılabilen bir bakış açısı olduğuna değinilmiştir. Elde edilen bulgulara göre, fen bilimleri, bilgisayar ve matematik branşlarındaki katılımcılar derslerinde argümantasyon temelli öğretim yaklaşımının uygulanması aşamasında, bu yaklaşımın öğrencileri problem çözme, farklı bakış açısı kazandırma, sorgulama ve araştırmaya yönlendirdiğinden bahsetmişlerdir. Araştırmada elde edilen verilere göre özellikle sınıf, fizik ve müzik bransından katılımcılar uygulamanın sınırlılıkları olduğunu; bilgi eksikliği, zaman kısıtlılığı ve sınıf hakimiyeti konusunda sıkıntılar yaşanabileceğini bildirmektedirler. Katılımcılar, argümantasyon temelli öğretim yaklaşımının bilimin doğası üzerine, öğrenme sürecine, kavramaya ve duyuşsal kazanımlara katkı sağladığını belirtilmektedir. Araştırmanın bulguları ele alındığında sözkonu yaklaşımın öğrenim sürecine etkileri hakkında bütün branşların aynı fikirlere sahip olduğu ve argümantasyonun öğrencilerin öğrenmelerinde farklı düşünceleri açığa çıkardığı, araştırmaya yönlendirdiği ve sorgulayarak öğrenmeye katkı sağladığı ortaya çıkmıştır. Çalışmada yer alan fen bilimleri, matematik ve bilgisayar branşlarında yer alan katılımcılar, argümantasyon temelli öğretim yaklaşımının kavramsal anlamayla ilgili olarak anlamsal öğrenme, doğru bilgiye ulaşma ve yanlış kavramları giderilmesi gibi katkıları olduğunu belirtmektedirler. Argümantasyonun bilimin doğasına etkisi hakkında fen bilimleri ve fizik branşlarından katılımcılar cevap vermiş olup diğer branşlardan katılımcılar yeterli bilgilerinin olmadığını bildirmektedirler. Namdar ve Salih (2017) yaptıkları araştırmada argümantasyon öğrenme sürecine katkıları ile bilimin doğası öneminden bahsetmişlerdir. Katılımcılar argümantasyon temelli öğretim yaklaşımının öğrencilere eleştirel düşünme, iletişim, bilimsel düşünme ve kalıcı öğrenme becerileri kazandırma gibi avantajları olduğunu; sınıf mevcutlarının kalabalık olması, öğrenci hazırbulunuşluğunun yeterli olmaması ve zaman kısıtlmasının ise dezavantaj olarak ortaya çıkabileceğini belirtmişlerdir. Belirlenen bu bulgular, Aktamış ve Atmaca (2016); Aydın ve Kaptan (2014); Hiğde ve Aktamış (2017) tarafından yapılan çalışmalar ile benzerlik göstermektedir. Fen bilgisi öğretmen adayları argümantasyonun çok zaman alması, uygulanmasının zor olması, kolay kargaşa oluşması gibi dezavantajları olabileceği konusunda fikir bildirmektedirler (Aydemir, Karakaya Cırıt, Kaya ve Azger, 2018).

Eleştirel düşünmek, işe yarar ve doğru çözümler bulmaya çalışmak, uygun bilgileri bir araya getirip bilgileri yorumlarken hem sağlam deliller aramayı hemde soyut fikirleri etkin bir şekilde kullanmayı gerekli kılmaktadır (Paul ve Elder, 2008). Eleştirel düşünmeyi başarmak için alternatif fikirleri belirleme, fikirlerin dayanaklarını, sonuçlarını belirlemek gerekmektedir (Facione 1998; Cevizci, 2012). Eleştirel düşünmenin bu kriterler bakımından incelenmesi durumunda argümantasyonla bağlantılı olabileceği belirtilmektedir (Braund, Scholtz, Sadeck ve Koopman, 2013). Argümantastona dayalı uygulamalarda hem sorgulama hemde araştırma süreçleri aktif olarak kulanılmaktadır (Hohenshell, 2004). Öğrenciler argümantasyon temeli öğretim ortalamalarında eleştirel, problem çözme, yaratıcı düşünme becerilerini kazanmaktadırlar (Erduran, Arday ve Güzel 2006; Demir ve İşleyen, 2015).

Argümantasyon temelli öğretim yaklaşımının pek çok araştırma sonuçlarına göre kavramsal anlamayı artırdığı (Tümay, 2008; Okumuş ve Ünal 2012; Yalçın Çelik ve Kılıç, 2014), öğrencide merak uyandırdığı, bilimsel akıl yürütmeyi sağladığı (Tümay, 2008), bilimsel süreç becerilerini geliştirdiği (Çınar, 2013; Gültepe, 2011), akademik başarıları artırdığı (Okumuş ve Ünal, 2012; Öğreten ve Uluçınar Sağır, 2014), fen başarılarını artırdığı (Hasançebi, 2014; Yeşildağ, Günel ve Yılmaz, 2010) bildirilmektedir. Argümantasyon temelli öğretim yaklaşımının tüm öğrencilerin aktif katılımının sağlandığı bir öğrenme ortamı oluşturulması sebebiyle öğrenciler arasında sosyal etkileşimin arttığı ve fikirlerini rahatça ifade etme durumundan dolayı derse aktif katılım sağlayıp öğrenmeyi anlamlı ve kalıcı hale getirdiği (Öğreten ve Uluçınar Sağır, 2014; Yalçın Çelik ve Kılıç, 2014; Hakyolu, 2010) bilinmektedir. Argümantasyon temelli öğrenme yaklaşımının kullanılması öğrencilerin derse olan tutumlarını olumlu yönde geliştirmek, birbirini anlayan bireyler yetiştirmek için önem arzetmektedir (Aktamış ve Atmaca, 2016).

Bu çalışma sonucunda elde edilen bulguların incelenmesi ile genel olarak branşlardaki katılımcıların, argümantasyon hakkındaki bilgilerinin yeterli olmadığı tespit edilirken fen bilimleri ve bilgisayar öğretmenlerinin ortaya seviyede bilgileri olduğu gözlenmiştir. Fizik ve matematik öğretmenlerinin argümantasyon temelli öğretim yaklaşımı hakkında bilgileri olmasına ragmen, yaklaşımın uygulanması hakkında yeterli bilgiye sahip olmadıkları belirlenmiştir. Argümantasyon temelli öğretim yaklaşımın bütün branş bazlarında hizmet öncesi ve hizmet içi eğitimlerle tanıtılması gerekmektedir.

KAYNAKLAR

Aktamış & Atmaca (2016). Fen Bilgisi Öğretmen Adaylarının Argümantasyon Tabanlı Öğrenme Yaklaşımına Yönelik Görüşleri. *Elektronik Sosyal Bilimler Dergisi*, 15(58).

Apaydın, Z. & Kandemir, Y.L.M.A. (2018). İlkokulda Sınıf Öğretmenlerinin Fen Bilimleri Dersinde Argümantasyon Yöntemi Kullanımına İlişkin Görüşleri. *Journal of Computer and Education Research*, 6(11), 106-122.

Apaydın, Z. Peker, E. & Taş, E. (2012). Isı yalıtımını argümantasyonla anlama: İlköğretim 6. sınıf öğrencileri ile durum çalışması. *Dicle Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *4* (8), 79-100.

Aslan, S. (2016). Argümantasyona dayalı laboratuar uygulamaları: Bilimsel süreç becerilerine ve laboratuar dersine yönelik tutuma etkisi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*. 31(4): 762-777.

Aydemir, S., Cırıt, D. K., Kaya, S., & Azger, C. (2018). Fen Bilgisi Öğretmen Adaylarının Argümantasyona İlişkin Görüşleri ve Argüman Kurma Becerilerinin Araştırılması. *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi*, 6(STEMES'18), 131-138.

Aydın, Ö. & Kaptan, F. (2014). Fen-teknoloji öğretmen adaylarının eğitiminde argümantasyonun biliş üstü ve mantıksal düşünme becerilerine etkisi ve argümantasyona ilişkin görüşler. *Eğitim Bilimleri Araştırmaları Dergisi*, 4(2), 163-188.

Braund, M., Scholtz, Z., Sadeck, M., & Koopman, R. (2013). First steps in teaching argumentation: A South African study. *International Journal of Educational Development*, 33, 175-184.

Bülbül A. & Urhan S. (2016). Argümantasyon ve Matematiksel Kanıt Süreçleri Arasındaki İlişkiler. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi*, 10 (1), 0-0. DOI: 10.17522/nefefmed.00387

Cevizci, A. (2012). *Bilgi Felsefesi*, İstanbul: Say Yayınları.

Çepni, S. (2016). *Fen ve teknoloji öğretimi*. Ankara: Pegem Akademi.

Çınar, D. (2013). *Argümantasyon Temelli Fen Öğretiminin 5. Sınıf Öğrencilerinin Öğrenme Ürünlerine Etkisi*. Necmettin Erbakan Üniversitesi Eğitim Bilimleri Enstitüsü, Doktora Tezi (Basılmamış), Konya

Demir, B. K., & Isleyen, T. (2015). The effects of argumentation based science learning approach on creative thinking skills of students. *Educational Research Quarterly*, 39(1), 49.

Denzin, N. K., & Lincoln, Y. S. (1998). *Entering the field of qualitative research*. In N. K. Denzin & Y. S. Lincoln (Eds.). Collecting and interpreting qualitative materials (pp.1 - 34). Thousand Oaks, CA: Sage.

Erduran, E. Simon, S. & Osborne, J. (2004). Tapping into argumentation: developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education, 88* (6), 915-933.

Erduran, S., Arday, D., & Guzel, B.Y. (2006). Learning to teach argumentation: Case studies of pre-service secondary science teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, 2(2), 1-13.

Erkol, M., Kışoğlu, M., & Gül, Ş. (2017). Argümantasyon tabanlı bilim öğrenme yaklaşımı rapor formatının öğretmen adaylarının başarılarına ve fen bilgisi laboratuvarına yönelik tutumlarına etkisi. *Elementary Education Online*, 2017; 16(2): 614-627.

Eymur, G., & Çetin, P. S. (2017). Argümantasyon tabanlı sorgulayıcı araştırma yönteminin öğretmen adaylarının fen öğretimi öz yeterlik inancına etkisi. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 19(3), 36-50.

Facione, P. A. (1998). *Critical thinking: What it is and why it counts.* Millbrae, CA: California Academic Press. Retrieved January 25, 2005, from http:// www.insightassessment.com/pdf~files/ what&why98.pdf

Gültepe, N. (2011). *Bilimsel tartışma odaklı öğretimin lise öğrencilerinin bilimsel süreç ve eleştirel düşünme becerilerinin geliştirilmesine etkisi*. Yayımlanmamış Doktora Tezi. Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.

Günel, M. Kıngır, S. & Geban. O. (2012). Argumantasyon Tabanlı Bilim Öğrenme (ATBO)Yaklaşımının kullanıldığı sınıflarda Argumantasyon ve soru yapılarının incelenmesi. *Eğitim ve Bilim*, 37(174), 316-330.

Hakyolu, H. (2010). *Farklı öğrenme seviyelerindeki öğrencilerin fen derslerinde oluşturulan argüman ortamlarındaki performansları*. Unpublished master thesis, Marmara University, İstanbul.

Hasançebi, F. (2014). *Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımının (ATBÖ) Öğrencilerin Fen Başarıları, Argüman Oluşturma Becerileri ve Bireysel Gelişimleri Üzerine Etkisi*. Atatürk Üniversitesi Eğitim Bilimleri Enstitüsü, Doktora Tezi, Erzurum.

Hiğde, E., & Aktamış, H. (2017). Fen bilgisi öğretmen adaylarının argümantasyon temelli fen derslerinin incelenmesi: Eylem araştırması. *İlköğretim Online*, 16(1).

Hohenshell, L. (2004). *Enhancing science literacy though ımplementation of writing- to – learn strategies: Exploratory studies in high school biology*. Doctoral Dissertation. Iowa State University, USA.

Jimenez-Aleixandre, M. P. & Erduran, S. (2007). Argumentation in science education: an overview. S. Erduran & M.P. Jimenez-Aleixandre (Eds.), *Argumentation in Science Education: Perspectives from Classroom-Based Research(ss.3-28)* İçinde, Netherland: Springer.

Kuhn, D. (1991). *The Skills of Argument*. Cambridge: Cambridge University Press

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Milli Eğitim Bakanlığı. MEB (2013). *İlköğretim Kurumları (İlkokullar ve Ortaokullar) Fen Bilimleri Dersi (3, 4,5, 6, 7 ve 8. Sınıflar) Öğretim Programı*. Talim ve Terbiye Kurulu Başkanlığı, Ankara.

Milli Eğitim Bakanlığı. MEB (2018). *Fen Bilimleri Dersi (3, 4, 5, 6, 7 ve 8. Sınıflar) Öğretim Programı.* Temel Eğitim Genel Müdürlüğü, Ankara.

Namdar, B. & Salih, E. (2017). Fen Bilgisi Öğretmen Adaylarının Teknoloji Destekli Argümantasyona Yönelik Görüşleri. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 17 (3), 1384-1410.

Okumusa, S., & Unalb, S. (2012). The effects of argumentation skills in science. *Procedia-Social and Behavioral Sciences*, 46, 457-461.

Öğreten, B., & Uluçınar Sağır, Ş. (2014). Argümantasyona dayalı fen öğretiminin etkililiğinin incelenmesi. *Türk Fen Eğitimi Dergisi,* 1, 75-100.

Özcan, R., Aktamış, H. & Hiğde, E. (2018). Fen bilimleri derslerinde kullanılan argümantasyon düzeyinin belirlenmesi, *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, 43, 93-106.

Paul, R. & Elder, L. (2008). *The miniature guide to critical thinking concepts and tools*. Dillon Beach, CA: Foundation for Critical Thinking Press.

Siegel, H. (1989). The rationality of science, critical thinking and science education. *Synthese*, 80(1), 9–42.

Toulmin, S. E. (1958). *The Uses of Argument.* Cambridge: Cambridge University Press.

Toulmin, S. E. (2003). *The uses of argument*. Cambridge: Cambridge University Press

Tümay, H. (2008). Argümantasyon Odaklı Kimya Eğitimi. *Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Doktora Tezi, Ankara*.

Tümay, H. & Köseoğlu, F. (2011). Kimya öğretmen adaylarının argümantasyon odaklı öğretim konusunda anlayışlarının geliştirilmesi. *Türk Fen Eğitimi Dergisi, 8* (3), 105-120.

Yalcin Celik, A., & Kilic, Z. (2014). The impact of argumentation on high school chemistry students' conceptual understanding, attitude towards chemistry and argumentativeness. *Eurasian Journal of Physics and Chemistry Education, 6*(1), 58-75.

Yeşildağ, F., Günel, M. & Yılmaz, A. (2010). *İlköğretim 8. sınıf seviyesinde maddenin yapısı ve özellikleri ünitesini öğrenmede argümantasyon tabanlı bilim öğrenme (ATBÖ) yaklaşımının akademik başarıya etkisi*. 9. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi. 23-25 Eylül 2010. İzmir.

Yıldırım, A. & Şimşek, H. (1999). *Nitel Araştırma Yöntemleri*. Ankara: Seçkin Yayınevi.

EXTENDED ABSTRACT

Purpose and Significance

Science education is trying to accompany rapidly changing technology and science. One of these changes is the constructivist approach, which is the approach that the students learn by living and construct the new information with the old information centering the student. One of the application areas which includes constructivist approach is argumentation-based learning approach.

It will help to eliminate the disadvantages of the argumentation-based teaching approach by evaluating the opinions of the graduate students about the implementation of the argumentation-based learning approach in the teaching processes. It will reveal the awareness that it can be used in different areas.

Methodology

In this research, case study was used in qualitative research methods in order to determine the opinions of graduate students towards argumentation-based education and to reveal the differences between branches. This study was conducted with graduate students at different educational institutions at a public university. The participants of the study consisted of 15 people.

"Argumentation in Science and Science Education" semi-structured interview questionnaire developed by Tümay (2008) was used in this study.

Results

In this part of the research, the qualitative data were analyzed and presented in tables and themes. The findings obtained within the scope of the study were given in line with the research questions.

In this research, the questions directed to the participants were tried to determine their understanding of science and argumentation. Argumentation, scientific knowledge, scientific knowledge creation process, the importance of argumentation in science, disagreements among scientists and solutions to the questions such as the answers of the participants were given.

Graduate students stated that argumentation contributed to the student with this study. As they are directed to research the effects of learning process, they have revealed that they contribute to learning by revealing different thoughts and sharing and questioning these thoughts. It was mentioned that argumentation had a positive effect on students' conceptual understanding and some participants did not express their opinions about their effects.

Discussion and Conclusion

As a result of this study, it was found out that the knowledge of the branches about argumentation was not sufficient, and it was observed that science and computer teachers had an advanced level of knowledge. Although physics and mathematics teachers have ideas about argumentation, they do not have enough information about their applications and music and classroom teachers do not have any knowledge about argumentation-based education.

Argumentation-based training should be introduced through pre-service and in-service trainings on all branch bases. The study can be applied to all branches. In this study, there are not enough people to make generalizations to the branches and the number of people can be increased. The fact that the questions used in the study consisted of open-ended and multiple questions led the participants to refuse to do so, and some questions were not answered. The number of questions should be reduced and corrected.

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The Effect of Student-Content Interaction on Students' Academic Achievement and Attitude towards Science[1]

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Abstract

The aim of the study was to compare the effects of teaching on academic achievement and science attitudes of students with interactive PowerPoint presentations and non-interactive PowerPoint presentations in terms of teaching the "Electricity Transmission" Unit of the 6th grade Science course. The research was designed as a semi-structured experimental design and consisted of 65 students from the 6th grade of a public secondary school. The participants were separated into two groups as control and the experiment groups. The transmission of electricity unit 20-question academic achievement test and 22-item science attitude scale were used for data collection. Achievement test and attitude scale were applied to the groups as pretest and posttest. In light of the data obtained in the study, it was concluded that the use of interactive PowerPoint presentations in teaching electricity transmission unit to secondary school 6th-grade students increased academic success but did not have the same effect on their attitudes towards science. Students can work on each grade level with interactive PowerPoint presentations according to their own level.

INTRODUCTION

The rapid advancements of teaching technologies have caused a change in the social structure and it has become inevitable for individuals to follow and adapt themselves to the technological inventions. The increase in the volume of the knowledge and the population of learners has raised various problems. Classes have become crowded and inadequate hardware. In addition, the number of teachers is insufficient and classes cannot use the advantages of developing technologies. It has become imperative to use the technology, especially the instructional technologies in order to solve such problems in teaching environments. The technology has been evolved as of 1926 when the idea of a machine was found to test the learning level of students. Pressey's teaching machines were developed later by Skinner and they have become an inseparable part of the classes with the effect of different learning theories (Burton, Moore, & Magliaro, 2003).

Although the use of technology has been increasing in educational environments, it is clear that individuals who have the required level of knowledge by the age cannot be raised without technology today. How these technologies could be used pedagogically in teaching environments has always been the subject of discussion. Thus, there has always been the need for developing new methods and new educational software. The enrichment of teaching environments is enabled by such initiatives. The enrichment of educational environments also resulted in the formation of efficient educational environments. Technological developments in teaching environments established the need for the preparation of new programs and new educational materials. The computer technologies used in the classrooms have facilitated the preparation of enriched educational environments. Teaching materials are used to support multiple environments. Therefore, students can access different teaching contents, and uninterrupted learning has been realized because these contents attract the attention of more than one sense of the learners at a time. However, the physical availability of the technology in classrooms cannot be the solution for effective, efficient and engaging learning.

One of the technologies found in most of the learning environments is digital boards called either interactive boards or smart boards. Interactive boards were first designed and manufactured in the 1990s. It has been used in classroom environments since the 1990s. While it is a technology enabling the content of the computer to be projected on a flat surface with the projection and using the content interactively, it has replaced the chalkboards in class environments with its compact computer system design. These smartboards have an operating system including hardware such as processor and memory with a touch screen. The smartboard industry reached a market of $1 billion in 2008 in the world (interactive board, 2000). It is observed that many countries have invested significantly on interactive boards (Ekici & Yılmaz, 2013). The UK comes first among these countries. It has been noted that all primary schools have interactive boards. It has also been stated that not only primary education but almost most of secondary education uses interactive boards. The UK is not the only country investing in interactive boards. Two other important countries investing in interactive board applications are the US and Australia (Zengin, Kırılmazkaya, & Keçeci, 2012).

Turkey has applied some projects to use developing technologies effectively in classrooms. Initially, the project called "The Movement to Increase Opportunities to Improve Technology" in education, known as FATİH, has been carried out. The project was announced to the public in November 2010, and the Ministry of National Education explained its purposes as a transition from computers to the availability of computers in every classroom. Thus, students would reach the information in a shorter time and much more easily. The interactive board is similar to the classical board physically. However, what makes it different compared to the classical board is that it provides interaction via its touch screen. Moreover, it has various advantages such as being able to update its content easily and quickly. This was expected to lead to a result of interactive boards replacing the regular normal textbooks. Some other properties of interactive boards are as follows: making presentations, giving academic lectures including advanced content interaction and increased audience engagement, sharing and storing of presentation file, and interaction with network computers and peripherals.

It could be noted that the interactive board is more advantageous compared to the computers in classrooms. The advantages of the interactive board over the computers are as follows: it can attract more attention, the teacher can record what he/she notes on the board and view them later, the teacher can share them with students. The disabled students can participate in the activities as seated and different learning activities can be performed. The aim of interactive whiteboards in classrooms is make learning effective, efficient, and engaging. It is clear that teachers can use the content on these interactive boards compatible with their curriculum and the content.

The Ministry of National Education has focused on e-content development for its investments. Education Information Network (EBA), which is an online platform for the e-content developed by the Ministry of National Education, has been offered to the service of teachers and students. It constitutes one of the important pillars of the FATİH project, the major education technology investment of the EBA Students have the opportunity to perform continuous learning with different activities through EBA. All these developments have once again revealed the importance of technology in the field of education. Due to the rapid increase of information and the population of learners, it is necessary to use technology and digital learning materials to teach more to a higher number of participants. It is believed that technology should be used efficiently to achieve effective learning in crowded classrooms. However, many technological learning tools cannot be used effectively because they do not allow teachers to organize and change the content according to their classroom settings. The major advantage of this study is that it allows the content to be prepared quickly by the researcher. In addition, the ability to make changes in the content can be shown as another advantage of the study. It is seen that the educational software which is a one-to-one educational software is difficult to apply in learning environments (classes of 30 people). It is believed that the problem can be solved by allowing teachers to organize the content according to their learning environment. Furthermore, thanks to the content making the student interact, the learners interact with the content to show that effective learning can be achieved. When the disadvantages of instructional software are examined, one of the major drawbacks is seen as the license fee. Mouse Mischief used completely free of charge by Microsoft Windows was used in the study. PowerPoint presentations are undoubtedly one of the most used technological programs in education. However, it is noteworthy that teachers do not pay attention to the techniques of preparing them and could not leave the traditional method where the teacher is at the center. The aim of the study was to present the importance of content preparation for teachers according to their class level free of charge, to use technology effectively, and to be at the center of learning together with the students actively participating. For the 6th grade students, the aim was to address the science lesson including abstract concepts and experiences and to increase the attitudes towards the lesson with the increase of academic success. The students were enabled to adapt the lesson by understanding the relationship between the subjects and the concepts of daily life. Another significance of the present study is to make the course more enjoyable by using interactive presentations for students having difficulty in learning the subjects of the science lesson. It is important for students to enjoy the course in terms of their academic success and attitudes. In this study, it is thought that students' use of technology more actively in the lesson will contribute to them in terms of being science literate. When the literature review was conducted, no study was found investigating the effect of 6th-grade students ‘interactive PowerPoint presentation on learners' academic achievement and attitudes towards science lessons. For this reason, this research is expected to guide future studies on students' academic achievement and attitudes towards the lesson.

METHOD

Research method, data collection tools, application process are presented in this section.

Research Method

The study used semi-experimental research design. Semi-experimental design, one of the quantitative research methods, is a commonly used research method, especially in studies on education, when there is no random selection and it is possible to control all the variables (Cohen, Manion & Marrison, 2000). In semi-experimental designs with unsynchronized control groups, the method of selecting the control group is conducted by neutral assignment. Moreover, the fact that the groups are similar as much as possible is considered. There is no special attention given for the selection of the groups (Karasar, 2003). The experimental model of the research is given in Table 1.

Table 1. Pretest – posttest quasi-experimental method with control group model design

Groups	Pretest	Application	Posttest
Student interactive PowerPoint presentation	Achievement test Attitude towards science lesson scale	Four weeks x four hour	Achievement test Attitude towards science lesson scale
PowerPoint presentation	Achievement test Attitude towards science lesson scale	Four weeks x four hour	Achievement test Attitude towards science lesson scale

The study group consisted of a total of 65 students studying in the 6th grade in a secondary school in Seydiler district of Kastamonu province in the 2015-2016 academic year. Two groups were identified in order to make the two groups similar as much as possible. One of these classes (6-B) was selected as the experimental group (N = 34), and the other (6-A) was identified as the control group (N = 31) to receive the lesson according to the 2005 Science Program with the Student Interactive PowerPoint presentation. The number of students in each class is given in Table 2.

Table 2. Experiment and control groups information

Groups	Class	Female	Male	n
Experiment	6-B	17	17	34
Control	6-A	16	15	31
Total		33	32	65

Data Collection Tools

A 20-items academic achievement test, and the 22-items Science Attitude Scale were used for data collection.

Achievement test

The achievement test (Annex-1) developed by Gürbüz (2012) was used as test questions. In the first stage, the academic achievement test consisting of 30 items has been reorganized as 27 questions by correcting three items required to be fixed in line with the expert opinions and three questions stated to be inappropriate. Before conducting the reliability studies of the test, forms for expert opinion were created according to the relevant student acquisition, and scientific process skills of each question, and a pilot application was carried out. A classification table was prepared according to the scientific process dimension and knowledge accumulation of each item and answer in the test. Experts checked the validity of the developed test, and the reliability of the test was found to be $\alpha = 0.79$.

Attitude towards science lesson scale

As another tool of data collection, the attitude scale developed by Şaşmaz Ören and Tezcan (2009) was used to measure students’ attitudes towards science lessons. The reliability coefficient of this scale, measuring the attitude towards science lessons was Alpha = 0.93. For the scale validity consisting of 22 items, the opinions of five experts were received. One of the experts was specialized in science education, one in evaluation and assessment, two in language education, and the other in educational sciences. The scale is a five-point Likert-type scale. Some of the items in the scale are positive (13 items), and some are negative (9 items). For each item, answers can reflect the students' opinions as "I totally agree", "I agree", "I am indecisive", "I disagree", and "I totally disagree". The scale was applied to all of the students in both groups as pretest and posttest.

Application process and lesson processing

In the control group and experimental group, lessons were taught using PowerPoint presentations. The PowerPoint presentation about "Electricity Transmission" unit was displayed on the smartboard and explained following the curricula. The implementation period for both groups was planned as 20 lessons and four weeks. In the control group, the lessons were taught through non-interactive PowerPoint presentations whereas the lessons are taught by making the student interact in the experimental group. The student interactive PowerPoint presentation prepared by Mouse Mischief after taking an expert opinion was developed and implemented as follows:

The Mouse Mischief program and the Unifying program were installed on interactive boards used in the classes within the scope of the FATİH project. Thanks to the Unifying program, it was possible to connect up to 10 wireless microphones to a wireless mouse receiver. Thus, it became a mouse for each group to interact with the board. Students interacted with the presentation using the mouse.

Each group interacted with the presentation on the smartboard and carried out activities using their mouse. Some examples of student interactive presentations were given below. They carried out activities such as drawing, marking items, and answering the questions with the mouse cursor. A timer was placed, and the activities of each group can be followed. Some examples of student interactive PowerPoint presentations and classroom application were presented in Figure 1.

Figure 1. Lesson teaching in the experimental group

RESULTS

The academic achievement and attitude scale were tested at .05 significance level using independent sample t-test analysis using the SPSS 20 program. It was decided to use the independent sample t-test after investigating that the data showed normal distribution. One of the indicators showing the data is normally distributed is skewness and kurtosis (kurtosis). When these values are between -1.5 and +1.5, it could be noted that our data show a normal distribution (Tabachnick & Fidell, 2013). In Table 3, the results of the analysis where the data are normally distributed are given in Table 3.

Table 3. Normal distribution of the data

Scales	**Pretest**		**Posttest**	
	Skewness	**Kurtosis**	**Skewness**	**Kurtosis**
Attitude Scale	-0,737	-0,227	-0.825	0,640
Achievement Test	-0,394	-0,474	-0,422	-0,889

The results of the attitude scale and academic achievement scale applied to the control and experimental groups before and after the application were analyzed with the 'independent groups t-test' analysis, and the results of the pretest, posttest mean scores, standard deviations (S.D.) and a p-value of both groups were given in Tables. In order to examine whether there is a statistically significant difference between two groups, level of significance alpha was set at the 0.05 level to achieve statistical significance for all analyses.

The comparison of the experimental group and the control group students' academic success was carried out before and after the application:

While examining the academic success of the groups before application, the results of the implementation of the same test as a pretest are given in Table 4. There was no difference between the pretest results of the groups. In this case, it can be said that the groups had similar characteristics.

Table 4. Comparison of the pretest of achievement test scores

Groups	N	$\bar{x}$	SD	t	p
Experiment	34	11,00	3,339	0,875	0,385
Control	31	10,29	3,185		

While examining the academic success of the groups after application, the results of the implementation of the same test as a pretest are given in Table 5.

Table 5. Comparison of the posttest of achievement test scores

Group	N	$\bar{x}$	SD	t	p
Experiment	34	16,35	2,922	4,885	0,000
Control	31	12,71	3,090		

The 34 participants in the experimental group (M = 16,35 SD = 2.92) compared to the 31 participants in the control group (M = 12,71, SD = 3,090) demonstrated significantly better posttest of achievement test scores, $t(63) = 4.88$, $p = .00$. It was found that there was a statistically significant difference between the achievement test scores of the two groups. Accordingly, it could be noted that the instruction with the student interactive PowerPoint presentations used in the experimental group increased the success compared to that of the student non-interactive PowerPoint presentations applied to the control group.

The comparison of the experimental group and the control group students' attitudes towards science was carried out before and after the application. The results of the application of the same test as a pretest are given in Table 6.

Table 6. Comparison of the pretest of attitude toward science course

Group	N	$\bar{x}$	SD	t	p
Experiment	34	38,88	16,272	0,074	0,941
Control	31	38,61	12,646		

When the data in Table 6 are examined, it is seen that there is no significant difference among the groups. This result shows that there is no significant difference in the attitudes of the experimental and control groups towards the pre-applied science lesson.

Table 7. Comparison of the posttest of attitude toward science course

Group	N	$\bar{x}$	SD	t	p
Experiment	34	38,88	11,092	-0,738	0,463
Control	31	40,03	17,143		

Experiment group (M = 38,88 SD = 11,092) compared to the control group (M = 40,03, SD = 17,143) demonstrated no significantly difference in the posttest of attitude toward science course scores, t(63) = -0,738 , p = ,463. Accordingly, it could be noted that the lessons supported by the student interactive PowerPoint presentation in the experimental group did not cause any change in the attitudes towards the science lesson according to the Science Education Program applied to the control group.

DISCUSSION AND CONCLUSION

The study was conducted to examine how students 'interactive PowerPoint presentations in the 6th-grade "Electricity Transmission" unit were affected by students' academic achievement and attitudes towards the lesson compared to student non-interactive PowerPoint presentations. The study was carried out in a public school in Kastamonu province where Class 6-B was selected as the experimental group and the lessons were taught with interactive PowerPoint presentations. Class 6-A was selected as the control group, and the lessons were taught with non-interactive PowerPoint presentations. The t-test was used to test the hypotheses of the research. When the posttest scores of the two groups did not differ significantly, no significant difference was found between students' attitudes towards science lessons. On the other hand, a significant difference was found in favor of the experimental group for their academic achievements. Lessons were conducted by the researcher in both groups. Prior to the study, the pre-test applied to assess the preliminary information of both groups was used as the posttest after the application was completed. At the end of the study, it was seen that both groups improved their performance throughout acquisition. However, the academic success of the experimental group was higher than that of the control group. These results have revealed that the use of interactive PowerPoint presentations contribute to learning in science classes. According to these results, it is seen that the use of student interactive PowerPoint presentations in science teaching positively affects students' academic success.

As a conclusion, it was observed that interactive PowerPoint presentations had no impact on students' attitudes, and learning took place in both groups. The academic achievement average of the experimental group was found to be higher than that of the control group. However, it was observed that there was no significant effect on their attitudes towards the lesson.

In a study carried out by Çepni, Ayvacı, and Bacanak (2004), it has been noted that computer technology can be used as a tool in order to facilitate students' learning as well as providing meaningful and permanent learning.

In a study conducted by Hallet and Faria (2006), the effects of multimedia and PowerPoint presentations on learning were investigated. Multimedia environments include sound, video, animation, graphics, and tests. The study has revealed that the information learned in multiple learning environments is easier to remember than traditional lessons with PowerPoint slides (Hallett & Faria, 2006).

When we examine various studies on PowerPoint presentations, it can be seen that the studies have presented that these presentations are predominant with positive results. However, some studies have shown that PowerPoint presentations also have some negative aspects (Apperson, Laws, and Scepansky, 2006). As a result of all these studies, it has been revealed that computers have become a part of education. In some studies, it has been stated that it should be seen as an aid for computer-based education systems (Geban, & Demircioğlu, 2003; Seferoğlu, 1996).

In some studies, students' attitudes towards lecture presentations were investigated, and positive results were obtained regarding the effectiveness of PowerPoint presentations. In a study, comparing the effect of teaching via PowerPoint presentation in higher education, it has been stated that PowerPoint presentations cannot replace the blackboards, and they will be auxiliary tools improving learning. Moreover, it has been highlighted that the use of PowerPoint does not result in very high academic success of students. it is more useful in teaching specific subjects, rather than using it throughout the entire lesson. Furthermore, it facilitates to remember what is learnt through animated models, animations, and key concepts (Szabo & Hastings, 2000).

In another study conducted on PowerPoint presentations, it was observed that the PowerPoint presentations provided a significant increase in students' level of knowledge (Baştürk, 2008). In a study on teaching English courses in Higher Education Program, the effect of teaching with traditional teaching methods and computer-aided PowerPoint presentation on students' access was investigated. In the research, using pretest and posttest, experiment and control groups were compared. According to this research, a significant difference was found in favor of the experimental group, where PowerPoint-supported teaching was conducted (Akdağ, 2008). Accordingly, it could be noted that the computer-aided teaching method positively affects students' academic success (Güven & Sülün, 2012).

In some other studies, it has been revealed that the presentations made by students improve their teaching and organizational skills (Susskind, 2005). In a study on the use of computers explaining the subject of photosynthesis in the field of biology, it was found that Computer Assisted Instruction (CAI) materials were effective for the understanding and application levels of students' learning. It was seen that CAI materials were effective in terms of increasing students 'achievements. However, the same effect could not be seen in terms of improving students' attitudes. This has been related to the difficult development of attitudes in a short time (Çepni, Taş, & Köse, 2006). The effect of overhead slides on learning with PowerPoint has been investigated in certain learning areas (nursing education, educational sciences, social psychology, commerce) with specific course hours and term studies. In these studies, different results were obtained regarding the students' performances. In the presentations made as PowerPoint, it was stated that there was an increase in students 'self-confidence and positive attitudes, and the increase in students' success was based on the support given to them by means of other methods and techniques (Savoy, Proctor & Salvendy, 2009).

Kaya and Aydın (2011) stated that the students understood the lesson better, they did not get bored in the lesson and their interest in the lesson increased with the use of smart boards in the social studies lesson.

Emre, Kaya, Özdemir, and Kaya, (2011) have not found a significant difference in favor of smartboard for academic success in their studies where they investigated the effects of the use of Smart Board on the success of science and technology teacher candidates studying on the structure of the cell membrane and their attitudes towards information technologies. As a result of a computer-aided study on the granular structure unit of the class it was observed that there was a significant difference between the posttest scores of the experimental group using the computer-assisted teaching method and the posttest scores of the control group using the traditional teaching methods. This differentiation was in favor of the experimental group. Another study showed that there was a negative correlation between students' use of PowerPoint presentations and their exam scores (Sugahara & Boland, 2006). This was not in consistency with the results of the present study. The reason could be the difference in the effectiveness of the PowerPoint presentations used in the classroom.

Similar results were obtained in terms of academic success compared to the above studies. However, different results were found in students' attitudes towards the course. It can be stated that the application in the experimental group was limited to four weeks, and this period was insufficient for students to develop an attitude towards the lesson. Further studies can be conducted on the long-term.

It should be taken into consideration that the ability of researchers to conduct such studies to use the properties of interactive boards is important for the results of the research. The implementation period of the research covers four hours of lectures per week for four weeks. Research can be done with the study carried out in a longer interval. This research, which is applied in the 6th grades of secondary school, can also be applied to other classes.

REFERENCES

Akdağ, M. (2008). Geleneksel Öğretim ile PowerPoint Sunum Destekli Öğretimin Öğrenci Erişisine Etkisi The Effects of Traditional Instruction and PowerPoint Presentation – Supported Instruction on Student ' s Achievement. *Eğitim ve Bilim - Education and Science, 33,* 26–34.

Apperson, J. M., Laws, E. L., & Scepansky, J. A. (2006). The Impact of Presentation Graphics On Students' Experience In The Classroom. Computers & Education, 47, 116–126. https://doi.org/10.1016/j.compedu.2004.09.003

Baştürk, R. (2008). Assessment & Evaluation İn Higher Education Applying The Many I Facet Rasch Model To Evaluate PowerPoint Presentation Performance İn Higher Education. *Assessment & Evaluation in Higher Education*, *33(4)*(January), 431–444. https://doi.org/10.1080/02602930701562775 Erişim Tarihi: 30.05.2016

Burton, J. K., Moore, David, M., & Magliaro, S. G. (20). Behaviorism and Instructional Technology. In David H. Jonassen (Eds). Handbook of Research on Educational Communications and Technology (Second Edition). London: Lawrence Erlbaum Associates

Cohen, L., Manion, L. and Morrison, K. (2000) Research Methods in Education. 5th Edition, London: Routledge.

Çepni, S., Ayvacı, H. S. & Bacanak, A. (2004). Fen Eğitimine Yeni Bir Bakış, Fen Teknoloji-Toplum. Trabzon:Top-Kar Matbaacılık.

Çepni, S., Taş, E., & Köse, S. (2006). The Effects of Computer-Assisted Material On Students' Cognitive Levels , Misconceptions And Attitudes Towards Science. *Computers & Education 46*, 192–205. https://doi.org/10.1016/j.compedu.2004.07.008

Demircioğlu, H. & Geban, Ö. (1996). Fen Bilgisi Öğretiminde Bilgisayar Destekli Öğretim ve Geleneksel Problem Çzöme Etkinliklerinin Ders Başarısı Bakımından Karşılaştırılması, Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 12, 183-185.

Ekici, S., & Yılmaz, B. (2013). FATIH Projesi üzerine bir değerlendirme. *Türk Kütüphaneciliği*, 27(2), 317-339.

Emre, İ., Kaya, Z., Özdemir, T. Y., & Kaya, O. N. (2011, May). Akıllı tahta kullanımının fen ve teknoloji öğretmen adaylarının hücre zarının yapısı konusundaki başarılarına ve bilgi teknolojilerine karşı tutumlarına karşı etkileri. In 6th International Advanced Technologies Symposium (IATS'11) (pp. 16-18).

Gürbüz, F. (2012). 7E Öğrenme Modelinin 6. Sınıf Fen ve Teknoloji Dersi "Yaşamımızdaki Elektrik" Ünitesinde Öğrencilerin Akademik Başarılarına ve Kalıcılığa Etkisi. (Yayınlanmamış Doktora Tezi). Atatürk Üniversitesi, Eğitim Bilimleri Enstitüsü, Erzurum.

Güven, G., & Sülün, Y. (2012). Bilgisayar Destekli Öğretimin 8. Sınıf Fen ve Teknoloji Dersindeki Akademik Başarıya ve Öğrencilerin Derse Karşı Tutumlarına Etkisi. *Türk Fen Eğitimi Dergisi,* 9(1), 69-76

Hallett, T. L., & Faria, G. (2006). Teaching With Multimedia : Do Bells And Whistles Help Students Learn ? *Journal of Technology in Human Services*, 24(2-3), 167–179. https://doi.org/10.1300/J017v24n02.

Interactive Boards (2020). In Wikipedia. Retrieved Apple 17, 2020, from https://tr.wikipedia.org/wiki/Etkile%C5%9Fimli_tahta. Erişim Tarihi: 07.05.2020

Karasar, N. (2003). Bilimsel Araştırma Yöntemi. (12. Baskı). Ankara: Nobel Yayıncılık.

Kaya, H. ve Aydın, F. (2011). "Sosyal Bilgiler Dersindeki Coğrafya Konularının Öğretiminde Akıllı Tahta Uygulamalarına İlişkin Öğrenci Görüşleri". *Zeitschriftfür die Welt der Türken*, 3, 179-189.

Savoy, A., Proctor, R. W., & Salvendy, G. (2009). Information retention from PowerPoint and traditional lectures. *Computers & Education*, 52(4), 858–867. https://doi.org/10.1016/j.compedu.2008.12.005

Sugahara, S., & Boland, G. (2006). The effectiveness of PowerPoint presentations in the accounting classroom. *Accounting Education*, 15(4), 391-403.

Susskind, J. E. (2005). PowerPoint's power in the classroom: enhancing students' self-efficacy and attitudes. *Computers & Education*, 45, 203–215. https://doi.org/10.1016/j.compedu.2004.07.005

Szabo, A., & Hastings, N. (2000). Using IT İn The Undergraduate Classroom : Should We Replace The Blackboard With PowerPoint? *Computers & Education*, 35, 175–187. https://doi.org/10.1016/S0360-1315(00)00030-0

Seferoğlu, S. S. (2006). Öğretim Teknolojileri ve Materyal Geliştirme (3. Baskı).Ankara: Pegem.

Şaşmaz Ören, F., & Tezcan, R. (2009). The Efectiveness of Learning Cycle Approach on Learners' Attitude towards Scirncr i Seventh Grade Science Classesof Elemantary School. *Elementary Education Online,* 8(1), 103-118.

Tabachnick, B. G., & Fidell, L.S. (2013). Using Multivariate Statistics (sixth ed). Boston: Perason Publishing.

Zengin, F., Kırılmazkaya, G., & Keçeci, G. (2012). Akıllı Tahta Kullanımının Fen Bilimleri Dersindeki Başarı ve Tutuma Etkisi. NWSA-Education Sciences, 7, 526–537.

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How Does Argumentation-based Instruction Affect Pre-service Science Teachers' Conceptual Understanding of Organic Chemistry? The Case of Aromatic Compounds[1]

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Abstract

Aromatic compounds are one of the fundamental topics in Organic Chemistry. For this reason, creating learning environments that will contribute to pre-service teachers' meaningful understanding of aromatic compounds is of importance. The purpose of this study was to explore whether argumentation-based instruction has an effect on the conceptual understanding of pre-service science teachers in the topic of aromatic compounds. In pursuit of this aim, the study was conducted in quasi-experimental, pre-test/post-test and control group design during the 2016-2017 academic year at the Science Education Division of a state university in Turkey. Two classes were randomly selected as an experimental group (N=30) and a control group (N=35). The data collection instruments used in the study were pre- and post-tests, consisting of 10 open-ended questions. Following the application of the pre-test, the topic of aromatic compounds was taught in the control group in the line of the current teaching programwhile the experimental group was taught using the argumentation-based instruction. The instruction in the experimental group was carried out with 6 argumentation activities under the headings of "conditions of aromaticity," "properties of aromatic hydrocarbons," and "naming aromatic compounds." The independent samples t-test showed that the pre-test scores of the experimental and control groups had no significant difference between them, but that the experimental group presented a difference as opposed to the other group in the post-test. These findings showed that the pre-service science teachers receiving argumentation-based instruction were more successful in their conceptual understanding of the topic of aromatic compounds than the control group.

INTRODUCTION

The content of organic chemistry covers many interconnected concepts, molecules and reactions. This nature of organic chemistry makes it necessary for learners to not only understand and interpret the concepts, molecules and reactions, but also to question the changes in molecules and explore what these changes lead to (Graulich, 2015). In particular, students taking General Chemistry course, which has more of a concentration of quantitative aspects to it, may have difficulty in adapting to lessons in Organic Chemistry, which is based on the relationship between structure and reactivity. Indeed, it was reported in a study conducted by Anderson and Bodner (2008) that many students who were successful in their general chemistry course had trouble achieving the same success when they transitioned into their organic chemistry classes. Additionally, the results of many studies indicate that there is a high percentage of failure in organic chemistry classes, evidencing that this course is difficult for students (Ratcliffe, 2002; Johnstone, 2006; Grove, Hershberger & Bretz, 2008; Eastwood, 2013; Flynn, 2015; O'Dwyer & Childs, 2017). Ellis (1994) has pointed out that the reason why organic chemistry classes are considered difficult by students is that the course requires three-dimensional thinking, using a new language that is specific to the subject matter, with no problem-solving algorithm available to guide the student. Because of the requirements of organic chemistry, students tend to memorize instead of learn concepts and as a result, they find themselves struggling with unrelated clusters of knowledge that make up the content of organic chemistry (Anderson & Bodner, 2008; Anzovino & Bretz, 2015; Galloway, Stoyanovich & Flynn, 2017; Caspari, Weinrich, Sevian, & Graulich, 2018). Consequently, it is important, to create learning environments that can contribute to students' meaningful learning instead of having them memorize their organic chemistry lessons.

When we look into the content of organic chemistry, we see that the topic of aromatic compounds takes up a good portion of the subject. Basically, the topic of aromatic compounds includes aromatic substitution reactions that are unique to this class of molecules, and multi-step synthetic reactions that make it possible to form more comprehensive relationships between different molecular classes. All of these factors that have made this topic a central element in organic chemistry (Balaban, Oniciu & Katritzky. 2004; Krygowski & Cyranski 2001). Because of this, when students can first identify aromatic compounds correctly, this will help them to distinguish between and name other organic molecules, aiding them also to accurately make associations between other topics in organic chemistry. If this cannot be achieved, not only will the desired level of learning that is targeted with respect to aromatic compounds not be accomplished, but it will be more difficult to prevent the adoption of alternative conceptions. For example, a student who interprets the aromatic compound benzene to be an alkene because of its C=C bond may think that benzene will have a tendency to show an addition reaction like other alkenes. A student who misinterprets this may find it difficult to form a relationship between the electrophilic aromatic substitution reaction unique to aromatic compounds and the synthesis of different organic molecules. Lying at the foundation of such incorrect interpretations is the inability of students to differentiate between aromatic compounds and alkenes and their failure to completely understand the conditions of aromaticity. Indeed, in some studies that have been conducted, it has been concluded that students can interpret reactions incorrectly as a result of their incorrect classification of organic molecules (Sendur & Toprak, 2013; Ealy, 2018).

In studies related to aromatic compounds, it has been shown that students have conceptual difficulties in this topic, leading them to adopt alternative conceptions. One of these studies is the study by Ealy and Hermanson (2006) that was conducted with science undergraduate students. The researchers reported that the students had trouble identifying aromatic molecules and that the main reason for this was that they focused on the Octet Rule and certain atoms, ignoring electron delocalization. Omwirhiren and Ubanwa (2016) established in their study with high school students that students had particular difficulty with identifying aromatic compounds according to their structural formulas. In a study by Topal, Oral and Özden (2007), the researchers examined the levels of success high school students and chemistry undergraduates (1st and 3rd grades) had with the concept of aromatics as well as their alternative conceptions. The study indicated that 3rd year undergraduate students had the highest success in the topics of aromatic compound reactions, Huckel's Rule, conjugation, planarity and the properties of cyclic in aromatic compounds; high school students, however, were the least successful in these topics. Another striking finding in the study was that both high school and undergraduate students commonly resorted to the alternative conceptions of "all molecules with rings are aromatic." Another important finding of the study was that in a question where Huckel's Rule was to be applied to identify the aromatic ion, only a very few of both 3^{rd} year and 1st year undergraduate students were able to respond correctly. These results indicate that the concept of aromatics is still not adequately understood even at the undergraduate level.

Another study on aromatics is by Rushton, Hardy, Gwaltney and Lewis (2008), who conducted their research with 4^{th} year chemistry undergraduates. The researchers reported that students associated the property of being aromatic with molecules that had hexagonal bond-line formulas, which is actually in reality just the opposite. For example, while some of the students identified molecules such as cyclohexane, cyclohexene and cyclohexadiene as aromatic, another group of students wrongly identified a six-carbon arene as cyclohexane or an alkene. Similar findings have been reported in various other studies (Domin, al-Masum & Mensah, 2008; Sendur, 2020). Duffy (2006) conducted a study with undergraduates and found that in identifying aromatic compounds, students usually focused on Huckel's Rule, cyclic structures and conjugated systems and did not adequately consider sp^2 hybridization or the stability of p orbitals.

It can be understood from all of these studies that the concept of having an aromatic property gives students from high school to the university level conceptual difficulties and is a topic for which alternative conceptions have been adopted. When the basic rules involved in the concept of aromaticity are considered, it can be seen that it is very difficult to handle the topic with experimental activities. From this perspective, it has been suggested that students instead can interact with their classmates and have evidence-based discussions, supported by a teaching program that introduces argumentation in a collaborative learning setting to promote agreement and learning.

Argumentation can be described as a form of study in which students use reasoning based on evidence, justification and warrants (Erduran, 2019). This nature of argumentation occupies a place in the methods by which students carry out scientific reasoning and develop conceptual understanding. It can be said in other words that argumentation is at the center of science instruction and learning (Msimanga & Mudadigwa, 2019). Indeed, studies have indicated that argumentation-based instruction on the secondary school and university level has a positive effect on conceptual understanding among chemistry students (Aydeniz & Doğan, 2016; Şekerci & Canpolat, 2014; Kaya, 2013). On the other hand, studies in this context in the field of organic chemistry have remained too limited. In some studies, argumentation is presented not as a teaching strategy but as a tool with which strategies for students' reasoning can be determined. As an example, de Arellano and Towns (2014) examined students' responses to questions on alkyl halide reactions according to the Argumentation model. Similarly, Hand and Choi (2010) looked at students' written arguments after completing a series of activities in the organic chemistry laboratory on the basis of how they used multi-model representations. A teaching activity for argumentation used in organic chemistry was created by Pabuçcu and Erduran (2017). In this study with pre-service science teachers, the researchers tried to determine the degree of conceptual understanding the pre-service teachers had gained from their arguments regarding the conformational analysis of butane.

As can be seen from these studies, there is a need for further in-depth research into the effect argumentation-based instruction in organic chemistry has on students' conceptual understanding. At the same time, in view of the importance of the topic of aromatic compounds in organic chemistry and the existence of alternative conceptions in this area, it is believed that this study on the effect on students' conceptual understanding and conceptual change of argumentation-based instruction in the topic of aromatic compounds will fill an important gap in the literature.

The Purpose of Study

The aim of this study was to analyze the effect of argumentation-based instruction on elimination of the alternative conceptions pre-service teachers have about aromatic compounds and whether or not this instruction is effective in terms of developing conceptual understanding.

For this purpose, answers were sought to the following sub-problems in this study:

1) Is there a significant difference between the mean scores of the experimental and control groups of pre-service teachers on the pre-test?
2) Is there a significant difference between the mean scores of the experimental and control groups of pre-service teachers on the post-test?
3) How effective is argumentation-based instruction compared to current program based-teaching in achieving conceptual change?

METHOD

Study Design

The study was conducted using a pre-test-post-test, control group, quasi-experimental design. This type of design is appropriate for situations where the participants cannot be randomly assigned to experimental and control groups but in which the experiment can be randomly assigned to groups (Hinkle, Wiersma, & Jurs, 1998; Gravetter & Wallnau, 2002). Accordingly, one of the classes in this study was randomly chosen as the experimental group (n=30), another as a control group (n=35). Lessons in the experimental group were taught with argumentation-based instruction; the control group was taught according to the current program.

Participants

The participants in the study consisted of 65 pre-service teachers enrolled in the second-year class of the Science Education Department of a state university in Turkey's Aegean region during the spring term of the 2016-2017 academic year. All of the pre-service teachers had voluntarily consented to participate. The pre-service teachers in the study had received similar scores on the university entrance examination, been accepted at the university and took the same courses leading up to their second year. From this perspective, it can be said that the randomly selected experimental and control groups of pre-service teachers had similar backgrounds.

Data Collection Tools

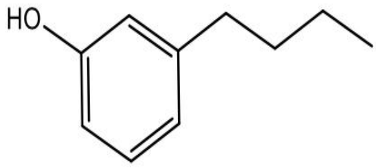
Ten open-ended questions related to aromatic compounds were used in the study as data collection tools. Five of the questions were related to the conditions of aromaticity. The students were given 1,3-Cyclopentadiene, furan, 1,3,5-Cycloheptatriene molecules and 1,3,5-Cycloheptatrienyl cations and 1,3,5-Cycloheptatrienyl anions and asked whether or not these were aromatic and for an explanation as to why they are or are not. In the other five questions, the structural formulas of aromatic compounds were given (4-Chloroaniline, 2-Bromo-5-chlorotoluene; 2-Bromobenzoic acid, 4-Bromobenzyl alcohol and 3-Butylphenol) and the students were asked to name these according to IUPAC. Two members of the chemistry education departments were consulted as these open-ended questions were prepared and in addition, a pilot study was conducted with another group of pre-service teachers who had studied the topic of aromatic compounds. The final form of the questions was applied to the experimental and control groups as a pre-test 2 weeks before the actual instruction, and then a post-test was simultaneously administered a week following the instruction. Two open-ended questions were presented in Figure 1.

1) Please state **whether the compounds below are aromatic and explain why they are or are not.**

a)  .... Please explain, with reasons

....

2) Please name the compounds according to **IUPAC. Please explain why you identified it in this way.**

a) 

....Because...

....

Figure 1. Sample open-ended questions

The Instruction Process

The argumentation-based instruction on the subject of aromatic compounds was completed in the experimental group in 3 weeks. Training was provided to the pre-service science teachers in the experimental group one week before the instruction. The elements of argumentation according to Toulmin's argumentation model were explained in this training and the students were encouraged to practice writing out arguments. In the next week, 7 groups of 4-5 individuals were created from among the pre-service teachers, after which the argumentation-based activities were launched. In total, 6 activities were organized, two to be carried out each week in 2 class hours, for a duration of 3 weeks. The group activities were executed with the techniques of "pairs to fours technique" and "envoys' arrangement" and the groups first discussed their own claims, evidence, and warrants, then wrote up their arguments. The group spokespeople presented these written arguments to the class for classroom discussion. Table 1 shows the activities carried out in the experimental group as well as the group techniques and argumentation strategies these activities were based on.

Table 1. Activities carried out in the experimental group

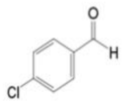
Activity No.	Name of Activity	Strategy	Group Technique
Activity 1.	Properties of aromatic hydrocarbons	Constructing an argument	Pairs to fours technique
Activity 2.	Is cyclobutadiene aromatic?	Competing Theories with Concept Cartoons	Envoys' arrangement
Activity 3.	I Can Identify Aromatic Compounds	Clue Cards	Envoys' arrangement
Activity 4.	My Concept Map of Aromatic Compounds	Constructing a concept map	Pairs to fours technique
Activity 5.	Let's Name Aromatic Compounds	Table of Statements + clue cards	Envoys' arrangement
Activity 6.	Let's find the mistakes we made in naming the Aromatic Compounds	Scenario-based task	Pairs to fours technique

The two faculty members in the organic chemistry department were consulted in setting up the 6 activities in the experimental group and the worksheets were applied as a pilot study to another group of pre-service teachers who had learned the topic. Examples of the worksheets used in the study can be seen in Figure 2 and Figure 3.

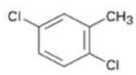
The same subjects were covered in the control group in the same period of 3 weeks but the instruction consisted of the teaching by lecturing and using the question-and-answer technique. The same instructor conducted the lessons in both the experimental and control groups.

Where Did Inci Make A Mistake?

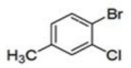
Inci chose the topic of aromatic compounds for her project assignment in organic chemistry. She was very careful in naming the aromatic compounds and researching their areas of utilization. After she handed in her assignment however, her teacher told her that she had made a mistake and gave her the paper back so she could correct the error. Inci was sorry she had made a mistake and immediately started to look for where she had gone wrong. Looking over the assignment, Inci thought she may have made a mistake in the 4 examples she gave in the naming section but realized that she was unable to find the mistake by herself. That is why she is asking you to help her. Where do you think Inci made the mistake?



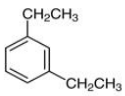
m-Chlorobenzaldehyde



1,3-dichloro-2-methylbenzene



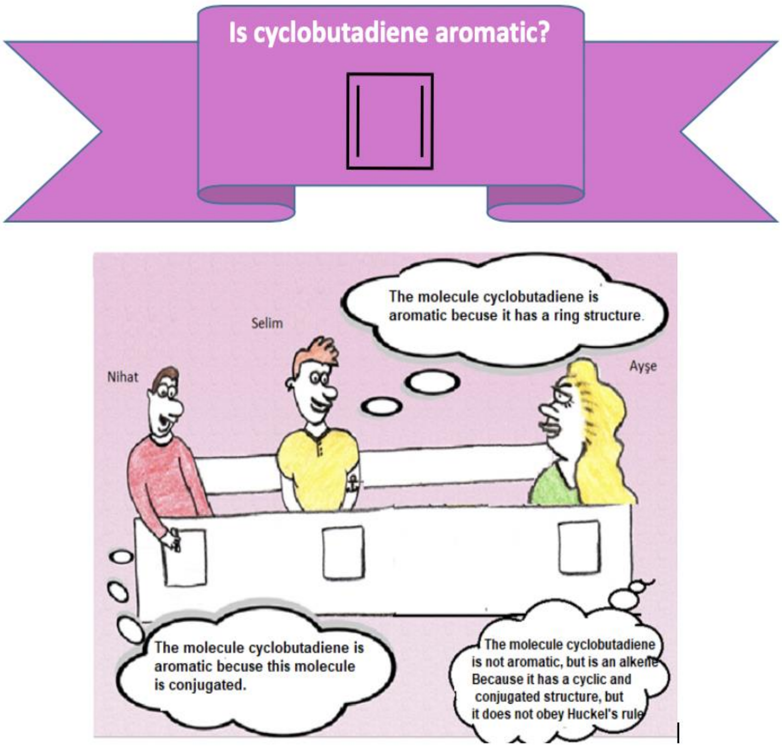
4-Bromo-3-chlorotoluene



1,3-Diethylbenzene

I think that:
This evidence supports my idea because:
Arguments against my idea:
How can you convince someone who doesn't believe you?

Figure 2. Worksheets used in activity 6



The concept cartoon above discusses whether cyclobutadiene is aromatic or not. Accordingly, Whose thought do you think right? Mark the box you think is right with √

Nihat : ☐ Selim : ☐ Ayşe: ☐

I think that:
This evidence supports my idea because:
Arguments against my idea:
How can you convince someone who doesn't believe you?

Figure 3. Worksheets used in activity 2

Data Analysis

The open-ended questions in the study were analyzed under the categories of "sound understanding," "partial understanding," "partial understanding with alternative conception," "alternative conception," and "no understanding" 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 (PU): This involves some responses and explanations that are scientifically accepted as true.
- Partial Understanding with Alternative Conception (PUAC): This refers to responses accepted as scientifically true, but which are false.
- Alternative Conception (AC): This refers to responses and explanations that are not completely accepted as scientifically true.
- No Understanding (NU): this category involves irrelevant answers. Also, pre-service science teachers could leave the question empty.

The total scores of the pre-service teachers based on their responses to the open-ended questions were calculated in the analysis in terms of a score of 4 for the category of Sound Understanding (SU), 3 for Partial Understanding (PU), 2 for Partial Understanding with alternative conceptions(PUAC), 1 for Alternative Conception (AC), and 0 for No understanding (NU) on both the pre- and post-tests. The maximum possible score that the pre-service teachers could achieve in their responses to the open-ended questions was 16. The SPSS 15.0 program was used in the statistical analysis of the data and the first step was to find out whether the data showed normal distribution. After the results of the Kolmogorov-Smirnov and Shapiro-Wilks tests indicated normal distribution, the pre- and post-test scores of the experimental and control groups were then compared with the independent samples t-test. The pre-service teachers' responses to the questions by category was evaluated in both the experimental and control groups and percentages were calculated (Table 4 and Table 5). 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 6).

FINDINGS

In line with sub-problems 1 and 2, the independent samples t-test was used to compare the pre- and post-test scores of the experimental and control groups. Table 2 displays the results of the analysis for the pre-test, Table 3 the results of the analysis for the post-test.

Table 2. Results of the independent samples t-test for pre-test scores

	Group	n	$\bar{X}$	s	t	df	p
Pre-test	Experimental	30	13.5667	5.84680	.329	63	.743
	Control	35	13.1429	4.53835			

The results of the independent samples t-test in Table 2 show that there was no significant difference between the pre-test scores of the experimental and control groups ($p>.05$). This indicates that the mean scores of the experimental and control groups were very close to each other before the instruction. In other words, the experimental and control groups were similar to each other in terms of their prior knowledge.

Table 3. Results of the independent samples t-test for the post-test scores

	Group	n	$\bar{X}$	s	t	df	p
Post-test	Experimental	30	33.5000	2.56972	9.204	45.078	.000
	Control	35	22.2000	6.71171			

Table 3 shows that there was a statistically significant difference between the post-test scores of the pre-service teachers in both the experimental and control groups (t=9.204; p<.05). The results of the analysis indicate that when the mean scores of the experimental and control groups after the instruction are compared, there is a difference in favor of the experimental group. This reveals that in these two groups that did not have significant differences between them on the pre-test, the pre-service teachers in the experimental group exhibited a higher level of conceptual improvement in understanding after the instruction compared to the control group.

In order to examine in more depth how the conceptual understanding levels of the experimental and control groups in the study changed from their understanding level after the instruction, the distribution of the responses of the pre-service teachers on the pre- and post-tests were calculated by categories and are shown in Tables 4 and 5.

Table 4. Percentages of responses of the experimental group on the pre- and post-tests, by category

Question	Experimental Group									
	Pre-test					Post-test				
	SU(%)	PU(%)	PUAC(%)	AC(%)	NU(%)	SU(%)	PU(%)	PUAC(%)	AC(%)	NU(%)
1	0.0	13.3	33.3	43.3	10.0	63.3	3.3	33.3	0.0	0.0
2	0.0	36.7	10.0	26.7	26.7	83.3	0.0	16.7	0.0	0.0
3	0.0	16.7	6.7	46.7	30.0	86.7	0.0	10.0	0.0	3.3
4	0.0	16.7	13.3	40.0	30.0	33.3	3.3	56.7	6.7	0.0
5	0.0	46.7	13.3	10.0	30.0	90.0	10.0	0.0	0.0	0.0
6	23.3	0.0	46.7	20.0	10.0	100.0	0.0	0.0	0.0	0.0
7	0.0	0.0	73.3	20.0	6.7	90.0	0.0	10.0	0.0	0.0
8	3.3	0.0	43.3	16.7	36.7	46.7	16.7	23.3	6.7	6.7
9	10.0	0.0	30.0	0.0	60.0	90.0	6.7	0.0	0.0	3.3
10	0.0	0.0	16.7	23.3	60.0	33.3	3.3	13.3	13.3	36.7

It can be seen in the distribution of the experimental group's responses on the pre- and post-test in Table 4 that in particular, no response was given to the question on the properties of being aromatic (Q1, 2, 3, 4, 5) that fell in the category of SU. In the post-test however, there was a noticeably increase in the responses falling into the SU category, and in fact, outside of Q4, the percentage indicated for the rest of the questions was over 50%. In Q4 on the molecule furan, 33.3% of the preservice teachers were able to explain all of the conditions of aromaticity. It was found that in the case of the heterocyclic aromatic molecule foran, the preservice teachers could not explain this molecule's aromaticity because they did not consider that one of the lone pairs of electrons on the oxygen atom is delocalized into the ring. When compared with the alternative conception percentages on the pre- and post-test in these questions, it was observed that the percentage on the post-test was slower than on the pre-test and in fact, outside of Q4, the other four responses did not reveal any alternative conceptions in the post-test.

The questions related to the naming of aromatic compounds (Q6, 7, 8, 9 and 10), the examination of the understanding level percentages showed that sound understanding was very low on the pre-test and in fact, there were no responses to Qs 7 and 10 that fell into the sound understanding category. In the post-test, it was seen that the responses in this category had noticeably increased and in fact, Q6 received a 100% response from the pre-service teachers in the experimental group while this rate in Qs 7 and 9 was 90%. The lowest sound understanding percentage of the pre-service teachers was Q10, which was on 4-bromobenzyl alcohol. It was seen here in particular that the pre-service teachers had trouble with naming the benzyl structure. In the examination of the percentages of alternative conceptions related to naming compounds in the experimental group, it was seen that there were no alternative conceptions for Q9 on the pre- or post-test, but the percentages on the post-test were lower than on the pre-test for the other questions. In fact, Qs 6 and 7 exhibited no alternative conceptions at pos-test.

A review of Table 5, which shows the response percentages on the pre- and post-test of the pre-service teachers in the control group, indicates that, as in the experimental group, none of the responses to the questions on aromaticity fell into the SU category. An examination of the sound understanding percentages for the same questions on the post-test shows that although there are responses that fall into this category, the percentage of this is negligible. For example, only one pre-service teacher was able to fully explain that the molecule 1,3,5-cycloheptatriene was not aromatic (Q1). Similarly, only 8.6% of the pre-service teachers were able to fully explain that the molecule 1,3-cyclopentadiene was not aromatic (Q5). In the control group, it was found that the sound understanding percentage in these questions remained lower when compared with the experimental group.

Table 5. Percentages of responses of the control group on the pre- and post-tests, by category

	Control Group									
	Pre-test					Post-test				
Question	SU(%)	PU(%)	PUAC(%)	AC(%)	NU(%)	SU(%)	PU(%)	PUAC(%)	AC(%)	NU(%)
1	0.0	14.3	42.9	37.1	5.7	2.9	8.6	28.6	60.0	0.0
2	0.0	14.3	25.7	22.9	37.1	17.1	25.7	20.0	34.3	2.9
3	0.0	14.3	2.9	48.6	34.3	14.3	28.6	17.1	40.0	0.0
4	0.0	14.3	2.9	62.9	20.0	17.1	11.4	11.4	60.0	0.0
5	0.0	34.3	37.1	8.6	20.0	8.6	54.3	28.6	8.6	0.0
6	28.6	2.9	34.3	28.6	5.7	54.3	2.9	14.3	14.3	14.3
7	8.6	0.0	60.0	25.7	5.7	60.0	0.0	11.4	20.0	8.6
8	0.0	0.0	37.1	22,9	40.0	14.3	11.4	28.6	22.9	22.9
9	0.0	0.0	34.3	11.4	54.3	62.9	2.9	8.6	17.1	8.6
10	0.0	0.0	28.6	11.4	60.0	22.9	2.9	5.7	28.6	40.0

In the review of the alternative conception percentages of the pre-service teachers in the control group for the same questions, various striking points were seen. While the alternative conception percentages of the pre-service teachers did not change for Q5, the percentages in Qs 3 and 4 declined somewhat. On the other hand, in Qs 1 and 2, the percentages of alternative conceptions increased in the post-test. This shows that the system of instruction in the control group was not as effective in eliminating alternative conceptions when identifying aromatic compounds as the argumentation-based instruction applied to the experimental group.

As shown in Table 5, it can be seen from a review of the levels of understanding of the pre-service teachers in the control group regarding naming of aromatic compounds, that no response falling into the sound understanding category was given to Qs 8, 9 and 10 on the pre-test and that in Qs 6 and 7, there only a few responses that fell into this category. In the post-test, it was observed that the responses to all 5 questions displayed an increase in the SU category as compared to the pre-test. On the other hand, when these SU categories were examined, it was understood that the percentages were not as high as in the experimental group. In the review of the percentages in the alternative conception categories, it was seen that the percentages on the pre- and post-tests for Q8 did not change, but that in Qs 9 and 10, there was an increase on the post-test. These results make it evident that the instruction carried out in the control group was not effective in eliminating alternative conceptions with regard to naming of aromatic compounds.

In the context of the third sub-problem of the study, a comparison was made of the conceptual changes occurring in the experimental and control groups. The pre-service teachers' percentages of alternative conceptions on the pre- and post-tests were calculated and are displayed in Table 6. Table 6 also shows the percentage of conceptual change occurring for each alternative conception.

Table 6. Percentages of pre-service science teachers' alternative conceptions

Q.	Alternative Conceptions		Experimental Group			Control Group		
			Pre-test	Post-test	CC	Pre-test	Post-test	CC
Q-1	1	The 1,3,5-cycloheptatriene molecule is aromatic because it has a ring structure.	23.3	-	+23.3	17.1	22.9	-5,8
Q-1	2	The 1,3,5-cycloheptatriene molecule is aromatic because it contains 3 double bonds.	10.0	-	+10.0	11.4	14.3	-2.9
Q-1	3	The 1,3,5-cycloheptatriene molecule is aromatic because it only contains carbon and hydrogen atoms.	10.0	-	+10.0	2.9	5,7	-2,8
Q-1	4	The 1,3,5-cycloheptatriene molecule is aromatic because it contains unsaturated carbon atoms.	-	-	-	2.9	11.4	-8,5
Q-1	5	The 1,3,5-cycloheptatriene molecule is aromatic because all of the carbon atoms form four bonds.	-	-	-	2.9	5.7	-2,8
Q-2	6	The 1,3,5-cycloheptatrienyl anion is aromatic because it has a ring structure.	13.3	-	+13.3	17.1	11.4	+5.7
Q-2	7	The 1,3,5-cycloheptatrienyl anion is aromatic because it only contains carbon and hydrogen atoms.	13.3	-	+13.3	5,7	14.3	-8.6
Q-2	8	The 1,3,5-cycloheptatrienyl anion is aromatic because it contains 3 double bonds.	-	-	-	-	8.6	-8.6
Q-3	9	The 1,3,5-cycloheptatrienyl cation is not aromatic because it lacks a hydrogen atom bonded to a carbon atom.	13.3	-	+13.3	11.4	-	+11.4
Q-3	10	The 1,3,5-cycloheptatrienyl cation is not aromatic because the carbon atom has not completed its number of bonds and has formed 3 bonds.	10.0	-	+10.0	11.4	-	+11.4
Q-3	11	The 1,3,5-cycloheptatrienyl cation is not aromatic because it is not hexagonal.	10.0	-	+10.0	8.6	2.9	+5.7
Q-3	12	The 1,3,5-cycloheptatrienyl cation is not aromatic because it is charged (+).	3,3	-	+3,3	8.6	2.9	+5.7
Q-3	13	The 1,3,5-cycloheptatrienyl cation is not aromatic because it has 7 carbons.	10.0	-	+10.0	8.6	2.9	+5.7
Q-3	14	The 1,3,5-cycloheptatrienyl cation is not aromatic because it does not comply with Huckel's rule.	-	-	-	-	17.1	-17.1
Q-3	15	The 1,3,5-cycloheptatrienyl cation is not aromatic because it does not contain a p orbital.	-	-	-	-	8.6	-8.6
Q-3	16	The 1,3,5-cycloheptatrienyl cation is not	-	-	-	-	5.7	-5,7

Q.		Alternative Conceptions	Experimental Group			Control Group		
			Pre-test	Post-test	CC	Pre-test	Post-test	CC
		aromatic because it does not contain a conjugated system.						
Q-4	17	The furan molecule is not aromatic because it does not have the C_6H_6 molecular formula.	10.0	-	+10.0	11.4	17.1	-5,7
Q-4	18	The furan molecule is not aromatic because the structure of furan contains the oxygen atom.	10.0	-	+10.0	11.4	11.4	-
Q-4	19	The furan molecule is not aromatic because does not contain 6 carbon atoms.	10.0	-	+10.0	17.1	11.4	+5.7
Q-4	20	The furan molecule is not aromatic because it has lone-pair electrons	6.7	3.3	+3.4	8.6	11.4	-2.8
Q-4	21	The furan molecule is not aromatic because it does not contain 3 π bonds.	3.3	3.3	-	8.6	2.9	+5.7
Q-4	22	The furan molecule is not aromatic because not all the atoms in the rink contain a π bond.	-	-	-	5.7	5.7	-
Q-5	23	The 1,3-cyclopentadiene molecule is aromatic because it contains carbon and hydrogen atoms.	6.7	-	+6.7	5.7	5.7	-
Q-5	24	The 1,3-cyclopentadiene molecule is aromatic because it has a ring structure.	3.3	-	+3.3	2.9	2.9	-
Q-6 Q-7	25	When naming aromatic compounds, molecules are classified as alkenes according to the double bond in the ring and in alphabetical order.	30.0	-	+30.0	42.9	8.6	+14.3
Q-6 Q-7 Q-8 Q-9 Q10	26	Aromatic compounds are named alphabetically and the prefix “cyclo” is used when a molecule has rings.	50.0	20.0	+30.0	57.1	74.3	-17.2

Table 6 reflects a review of alternative conceptions by question, showing that there were prominent differences in conceptual change between the experimental and control groups. In the experimental group, only one alternative conception (21st) percentage was the same on both the pre- and post-test, while the percentage of alternative conceptions diminished in the post-test. We can say therefore that a positive conceptual change was seen. On the other hand, the same thing cannot be said of the control group. In the control group, only 9 alternative conceptions (6, 9, 10, 11, 12, 13, 19, 21 and 25) showed positive conceptual change; 4 (alternative conceptions 18, 22, 23 and 24) displayed no change, and 13 (alternative conceptions 1, 2, 3, 4, 5, 7, 8, 14, 15, 16, 17, 20 and 26) displayed a negative conceptual change. These findings indicate that argumentation-based instruction in the topic of aromatic compounds was much more effective in achieving conceptual change compared to current program based-teaching and that it was not feasible to expect an elimination of alternative conceptions using the current program based-teaching. It was seen in fact, that this teaching was responsible for creating an increase of alternative conceptions. Indeed, it has been reported in various research articles that it is difficult to achieve the desired level of conceptual change using traditional teaching methods (Bodner, 1991; Westbrook & Marek, 1991; Hesse & Anderson, 1992; Treagust & Duit, 2008).

In a review of the alternative conceptions presented in Table 6, it can be seen that in Q1, the alternative conception, “*The 1,3,5-cycloheptatriene molecule is aromatic because it has a ring* *structure"* was expressed in both the experimental and control groups on the pre-test. The underlying thought in this alternative conception may be that the pre-service teachers believed that the condition of having a ring structure was sufficient for aromaticity. In the post-test, it was seen that in the experimental group, this alternative conception was not expressed; it was just the opposite in the control group however; in this group, the percentage of alternative conceptions increased among the pre-service teachers. Regarding the alternative conceptions related to this question, namely *"The 1,3,5-cycloheptatriene molecule is aromatic because it contains 3 double bonds"* and "*The 1,3,5-cycloheptatriene molecule is aromatic because it only contains carbon and hydrogen atoms,*" these were not encountered in the experimental group on the post-test but were seen at a higher percentage in the control group following the instruction. The reason that these two alternative conceptions appeared could be because the pre-service teachers were more accustomed to encountering the example of benzene in the topic of aromatic compounds and therefore applied the number of double bonds in benzene and its atoms to the other molecules. In the control group, unlike the experimental group, there were 2 alternative conceptions on the pre-test. These alternative conceptions were, "*The 1,3,5-cycloheptatriene molecule is aromatic because it contains unsaturated carbon atoms"* and "*The 1,3,5-cycloheptatriene molecule is aromatic because all of the carbon atoms form four bonds,"* which displayed a higher percentage on the post-test as compared to the pre-test.

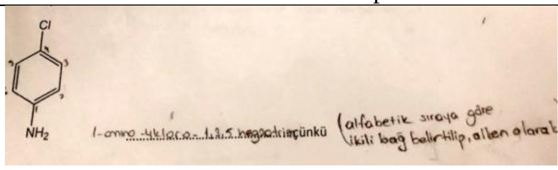
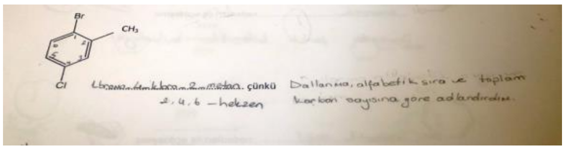
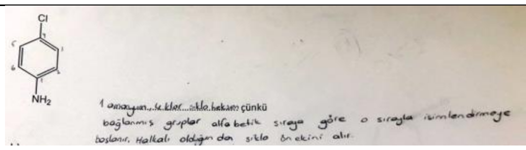
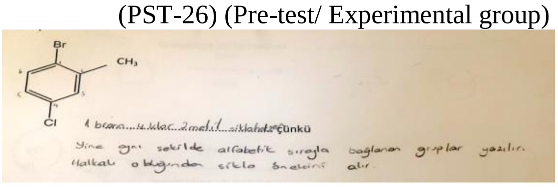
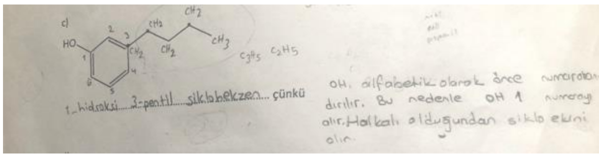
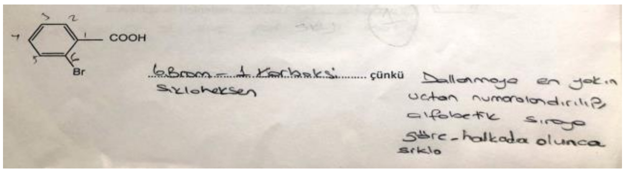
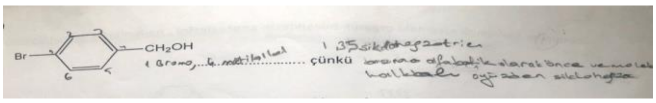
As in Q1, there were both experimental and control group pre-service teachers who displayed their belief in Q2 that a ringed structure was a sufficient condition for aromaticity on the pre-test. In the post-test, while the alternative conception "*The 1,3,5-cycloheptatrienyl anion is aromatic because it has a ring structure*" did not appear in the experimental group; this was seen at 11.4% in the control group. Another alternative conception, "*The 1,3,5-cycloheptatrienyl anion is aromatic because it only contains carbon and hydrogen atoms"* was not encountered in the experimental group on the post-test, but in the control group, no change of percentage was seen from the pre- to the post-test. Another alternative conception in Q2 (8th) did not appear in the experimental group on the pre- or post-test, but did appear in only the post-test in the control group, exhibiting a negative conceptual change. The fact that this alternative conception appeared on the post-test in the control group indicates that the pre-service teachers in the control group had not fully understood the conditions of aromaticity. It was seen that Q3 about the 1,3,5-cycloheptatrienyl cation had the most number of alternative conceptions in both the experimental and control groups. Eight alternative conceptions were found related to this question and 5 of these (9, 10, 11, 12 and 13) were seen on the pre-test in both groups while 3 alternative conceptions (14, 15, 16) were observed only in the control group on the post-test, and indicated a negative conceptual change. In the 9th and 10th alternative conceptions among these, it was observed that the pre-service teachers in the experimental and control groups interpreted aromaticity on the pre-test as related to the number of bonds formed by the carbon atom. In the post-test however, this alternative conception was not encountered in either the experiment or the control group, indicating a positive conceptual change. In the 11th and 13th alternative conceptions related to this question, it was seen that the pre-service teachers in both the experimental and the control group believed that the 1,3,5-cycloheptatrienyl cation could not be an aromatic compound because it had 7 carbons or because it was not hexagonal. This belief may possibly have been based on the fact that the pre-service teachers were accustomed to dealing mostly with the benzene molecule as an aromatic compound. The post-tests did not contain these alternative conceptions in the experimental group, while a few were noted in the control group. Similarly, in the 12th alternative conception, both the experimental and the control group indicated on the pre-test that the 1,3,5-cycloheptatrienyl cation could not be an aromatic compound since it was charged (+). The main reason the pre-service teachers had this alternative conception was possibly that they associated aromaticity with neutral molecules such as benzene. On the post-test however, this alternative conception appeared less in both groups, indicating a positive conceptual change. In Q3, differing from the experimental group, only the control group displayed three of the alternative conceptions appearing on the post-test. A review of these alternative conceptions shows that all of them are related to the conditions for aromaticity. In other words, the pre-service teachers in the control group showed a lack of understanding of the conditions of aromaticity, specifically those of "being in a conjugated system," "fitting Huckel's Rule," and "each atom in a ring containing a p orbital perpendicular to the plane of the ring."

Another question that yielded many alternative conceptions in both the experimental and control groups was Q4 on the aromaticity of the furan molecule. In this question, the alternative conceptions appearing on the pre-test were consistent with those that were seen in the first three questions. For example, in both the experimental and control groups, the alternative conception that "*The furan molecule is not aromatic because it does not have the* C_6H_6 *molecular formula*" showed that the pre-service teachers' knowledge of aromatic compounds was limited to what they knew about benzene. Similarly, the pre-service teachers' conception that "*The furan molecule is not aromatic because the structure of furan contains the oxygen atom."* may have stemmed from their not having previously encountered a heterocyclic aromatic compound. The other alternative conceptions, namely "*The furan molecule is not aromatic because does not contain 6 carbon atoms*" "*The furan molecule is not aromatic because it does not contain 3* π *bonds*" and *"The furan molecule is not aromatic because it has lone-pair electrons"* showed that the pre-service teachers thought about aromaticity on the basis of what they knew about benzene. In the post-tests, most of these alternative conceptions were lesser in the experimental group, indicating a positive conceptual change. In the control group however, some conceptions (19th and 20th) were less, the percentage of some did not change (18th alternative conception), while the percentage of some increased (17th and 20th alternative conceptions), indicating a negative conceptual change. Differing from the experimental group, the control group displayed no conceptual change from the pre- to the post-test in the alternative conception of *"The furan molecule is not aromatic because not all the atoms in the rink contain a* π *bond"*.

In the last question on aromaticity, Q5, it was seen that the pre-service teachers had fewer alternative conceptions compared to the other four questions. It can be understood from a look at these alternative conceptions that the pre-service teachers in the experimental and control groups, as in Q1, thought that the molecule 1,3-cyclopentadiene was an aromatic compound because it has a ring structure and it contains carbon and hydrogen atoms. In the post-tests, it was observed that these two alternative conceptions did not appear in the experimental group but their percentages in the control group were the same as in the pre-test.

In the questions on naming aromatic compounds, it was seen that there were mainly two alternative conceptions in both the experimental and control groups. The first of these was *"When naming aromatic compounds, molecules are classified as alkenes according to the double bond in the ring and in alphabetical order."* These alternative conceptions were found in both the experimental and control groups on the pre-test, in both Q6 and Q7. The pre-service teachers' naming an aromatic compound as they would an alkene shows that they are not able to differentiate aromatic compounds from alkenes. Another striking point in their responses was that they made their classification as they would a straight chain. In the post-tests, there were no alternative conceptions in the experimental group but in the control group, the percentage of 28.6% showed a slight decline but was still significant. The second alternative conception related to naming aromatic compound was “*Aromatic compounds are named alphabetically and the prefix ‘cyclo’ is used when a molecule has rings*” The percentage of this alternative conception declined in the experimental group on the post-test, but showed an increase in the control group. Table 7 displays examples of the responses of both experimental and control group pre-service teachers that can be categorized within the scope of these two alternative conceptions.

Table 7. Responses of the experimental and control group pre-service science teachers containing alternative conceptions

Alternative Conception	Question	Pre-service Science Teachers’ Response
When naming aromatic compounds, molecules are classified as alkenes according to the double bond in the ring and in alphabetical order.	Question 6	 (PST-12) (Pre-test/ Experimental group)
	Question 7	 (PST-6) (Pre-test/ Controlgroup)
Aromatic compounds are named alphabetically and the prefix “cyclo” is used when a molecule has rings.	Question 6	 (PST-26) (Pre-test/ Experimental group)
	Question 7	 (PST-9) (Pre-test/ Experimental group)
	Question 8	 (PST-11) (Post-test/ Control group)
	Question 9	 (PST-19) (Pre-test/ Control group)
	Question 10	 (PST- 32) (Post-test/ Control group)

DISCUSSION, CONCLUSION AND SUGGESTIONS

In this study, where the effect of argumentation-based instruction in the topic of aromatic compounds on the conceptual understanding and conceptual change of pre-service science teachers was compared with the effect of the current program based-teaching, the results of the independent samples t-test (Table 2 and Table 3) showed that argumentation-based instruction was much more effective in achieving conceptual understanding among the pre-service teachers. Similarly, it was found in the analysis of the responses of the pre-service teachers on the pre- and post-tests in terms of their level of understanding that in both groups, the percentage of sound understanding was very low in the pre-tests. In the post-tests, however, the sound understanding percentage in the experimental group was much higher than in the control group. Another important finding in the analysis was related to percentages of alternative conceptions. In the experimental group, it was seen that the percentage of alternative conceptions in all of the questions declined from the pre-test to the post-test and in fact, in some of the questions (Q1, 2, 3, 5, 6, 7 and 9), no response containing an alternative conception was seen in the post-test. The situation was different in the control group. The percentage of alternative conceptions in four questions in the control group declined from the pre-test to the post-test, but did not change in two questions, in fact showing an increase in four other questions (Table 6). These results indicate that argumentation-based instruction was more effective in improving the pre-service science teachers' level of understanding of the topic of aromatic compounds and was more useful in eliminating their alternative conceptions as compared to the current program based-teaching. Indeed, these results are consistent with those reported in the field literature (Aydeniz & Doğan, 2016; Şekerci & Canpolat, 2014; Kaya, 2013). Moreover, the way in which alternative conceptions showed an increase in some of the questions after the instruction in the control group was evidence that this teaching not only failed to achieve the desired level of understanding but also was not very effective in achieving conceptual change. Various study results support this finding (Wandersee et al. 1994; Özkan & Selçuk, 2012). The instruction given in the experimental and control groups was analyzed in terms of the percentage of conceptual change achieved for each alternative conception in order to be able to more clearly evidence the effect of the respective teaching methods on conceptual change. The analysis results shown in Table 6 indicate that a positive conceptual change was achieved in almost all of the alternative conceptions in the experimental group while in the control group, where the current program based-teaching was employed, negative changes were in the majority. This supports the conclusion that argumentation-supported instruction is much more effective in eliminating alternative conceptions as compared to current program based-teaching. The underlying factor playing a role in this is the fact that the pre-service teachers were able to discuss their claims, data, supporting arguments and reasoning in the instruction process, thus becoming aware of any alternative conceptions and being helped to dispel these (Cross, Taasoobshirazi, Hendricks & Hickey, 2008). Also, as Venville and Dawson (2010) have pointed out, the writing frames that are used in argumentation-based instruction supported and contributed to the decision-making and learning process.

Another important finding of the study was related to the alternative conceptions that were discovered. Most of the alternative conceptions that had to do with aromaticity showed that the pre-service teachers thought that aromatic compounds were all benzenes and treated the topic according to this premise. For example, the alternative conceptions "*The 1,3,5-cycloheptatriene molecule is aromatic because it contains 3 double bonds*," *"The 1,3,5-cycloheptatrienyl cation is not aromatic because it is not hexagonal,"* "*The furan molecule is not aromatic because it does not have the C_6H_6 molecular formula*," "*The furan molecule is* *not aromatic because the structure of furan contains the oxygen atom.,"* and "*The 1,3-cyclopentatiene molecule is aromatic because it contains carbon and hydrogen atoms"* show that the pre-service teachers accepted only benzene as an aromatic compound. The main reason for this could be that especially in secondary school chemistry lessons, benzene and its derivatives are usually provided as examples of aromatic compounds and it is not generally pointed out that a heterocyclic molecule or an ion can be classified as an aromatic compound. Another point that arose in the responses of the pre-service teachers was that they considered it sufficient for a compound to be aromatic if it had a ring structure. Domin, Al-Masum and Mensah (2008) explained this by stating that students perceived aromaticity as a structural concept rather than a functional one. Rushton et al. (2008) suggested in this context that students usually classify molecules with hexagonal bond-line formulas in the same molecular category. Researchers have emphasized that to avoid this, it would be necessary to review the various molecules with hexagonal bond-line formulas and clarify the differences between them. Still another important finding in the study regarding aromaticity was witnessed in the control group. It was seen that when the pre-service teachers were applying the properties of being aromatic to molecules or ions, instead of taking all of the rules into consideration, their interpretations were focused on only a few of these rules. One of these rules was Huckel's Rule. When the pre-service teachers in the control group were applying Huckel's Rule in particular after the instruction, they took into consideration only the π electrons in the ring, meaning that they did not take into account the electrons that did not participate in the bond but were a part of the π system in the ring. This may have been because the pre-service teachers could not fully identify the hybrid type of atoms in the ring. Indeed, Duffy (2006) reported that because students were wrong in identifying the hybrid types of atoms in aromatic compounds, they made a mistake in calculating the number of electrons according to Huckel's Rule and consequently could not identify the aromatic compounds correctly. This points to the importance of making sure that hybridization and types of hybrids are sufficiently learned before introducing the concept of aromaticity. It was observed from the alternative conceptions related to naming aromatic compounds that the pre-service teachers accepted aromatic compounds to be alkenes. This indicates that organic chemistry lessons need to emphasize the differences between aromatic compounds and alkenes.

The recommendation to be made in the light of all of the findings in the study is that researchers involved in education, especially in the field of organic chemistry, should conduct further studies argumentation-based instruction in different topics of organic chemistry in a continued effort to investigate the effect of this mode of teaching on learning outcomes. At the same time, although the present study was an attempt to explore the level of conceptual understanding and conceptual change among preservice science teachers using pre- and post-tests, a retention test was not employed and therefore the extent of retention gained by the application could not be determined. Because of this, it is also recommended that a retention test is explored in future studies.

REFERENCES

Abraham, M. R., Grzybowski, E. B., Renner, J. W. & Marek, E. A. (1992). Understandings and misunderstandings of eight grades of five chemistry concepts found in textbooks. *Journal of Research in Science Teaching, 2*9(2), 105–120.

Anderson, T. L. & Bodner, G. M. (2008). What can we do about Parker? A case study of a good student who didn't ''get'' organic chemistry. *Chemistry Education Research and Practice* 9(2), 93–101.

Anzovino, M. E. & Bretz, S. L. (2015). Organic chemistry students' ideas about nucleophiles and electrophiles: the role of charges and mechanisms. *Chemistry Education Research and Practice*, 16(4), 797–810.

Aydeniz, M. & Doğan, A. (2016). Exploring the impact of argumentation on pre-service science teachers' conceptual understanding of chemical equilibrium. *Chemistry Education Research and Practice*, 17, 111-119.

Balaban, A. T., Oniciu, D. C. & Katritzky, A. R. (2004). Aromaticity as a cornerstone of heterocyclic chemistry. *Chemical Reviews*, 104(5), 2777-2812.

Bodner, G. (1991). I have found you an argument: the conceptual knowledge of beginning chemistry graduate students. *Journal of Chemical Education,* 68(5), 385–388.

Caspari, I., Weinrich, M. L., Sevian, H. & Graulich, N.(2018). This mechanistic step is "*productive*": organic chemistry students' backward-oriented reasoning. *Chemistry Education Research and Practice,* 19(1), 42-59.

Cross, D., Taasoobshirazi, G., Hendricks, S. & Hickey, D.T. (2008). Argumentation: a strategy for ımproving achievement and revealing scientific ıdentities. *International Journal of Science Education, 30*(6), 837-861.

Çalık, M. (2005). A cross-age study of different perspectives in solution chemistry from junior to senior high school. *International Journal of Science and Mathematic Education*, **3**, 671–696.

de Arellano D. C.-R. & Towns M. (2014). Students understanding of alkyl halide reactions in undergraduate organic chemistry, *Chemistry Education Research and Practice,* **15**, 501–515.

Dawson, V. M., & Venville, G. (2010). Teaching strategies for developing students' argumentation skills about socioscientific ıssues in high school genetics. *Research in Science Education,* 40, 133-148.

Domin, D. S., Al-Masum, M., & Mensah, J. (2008). Students' categorizations of organic compounds. *Chemistry Education Research and Practice*, 9, 114-121.

Duffy, A. M. (2006). *Students' ways of understanding aromaticity and electrophilic aromatic substitution reactions*, Doctoral dissertation, Mathematics and Science Education, University of California, San Diego.

Ealy, J. & Hermanson, J. (2006). Molecular images in organic chemistry. *Journal of Science Education and Technology*, 15(1). 59–68.

Ealy, J. (2018). Analysis of students' missed organic chemistry quiz questions that stress the importance of prior general chemistry Knowledge. *Education Sciences*, 8(42), 42, doi:10.3390/educsci8020042

Eastwood, M. L. (2013). Fastest fingers: a molecule-building game for teaching organic chemistry. *Journal of Chemical Education*, 90(8), 1038–1041.

Ellis J. W. (1994), How are we going to teach organic if the task force has its way? Some observations of an organic professor, *Journal of Chemical Education*, 71(5), 399.

Erduran, S. (2019). Argumentation in chemistry education: an overview. In S. Erduran (Ed.), *Argumentation in Chemistry Education: Research, Policy and Practice* (pp. 1–10). London: Royal Society of Chemistry.

Flynn, A. B. (2015). Structure and evaluation of flipped chemistry courses: organic & spectroscopy, large and small, first to third year, English and French, *Chemistry Education Research and Practice*, 16, 198-211.

Galloway, K.R., Stoyanovich C. & Flynn, A. B. (2017). Students' interpretations of mechanistic language in organic chemistry before learning reactions, *Chemistry Education Research and Practice, 18(2), 353—374.*

Graulich, N. (2015). The tip of the iceberg in organic chemistry classes: how do students deal with the invisible? *Chemistry Education Research and Practice*,16(1), 9–21.

Gravetter, F. J., & Wallnau, L. B. (2002). Essentials of statistics for the behavioral sciences. (4th ed.) Belmont, CA: Wadsworth.

Grove N. P., Hershberger J. W. & Bretz S. L., (2008), Impact of a spiral organic curriculum on student attrition and learning. *Chemistry Education Research and Practice*, 9(2), 157–162.

Hand, B., & Choi, A. (2010). Examining the impact of student use of multiple modal representations in constructing arguments in organic chemistry laboratory classes. *Research in Science Education*, *40*, 29-44.

Hesse, J. & Anderson, C. (1992). Students' conception of chemical change. *Journal of Research in Science Teaching*, 29, 277–99**.**

Hinkle, D. E., Wiersma, W. & Jurs, S. G.(1998). *Applied statistics for the behavioral sciences*, New York: Houghton Mifflin Company.

Johnstone, A. H. (2006). Chemical education research in Glasgow in perspective. *Chemistry Education Research and Practice*, 7(2), 49–63.

Kaya, E. (2013). Argumentation practices in classroom: pre-service teachers' conceptual understanding of chemical equilibrium. *International Journal of Science Education*, 35(7), 1139–1158

Krygowski, T. M. & Cyranski, M. K. (2001). Structural aspects of aromaticity. *Chemical Reviews* 101: 1385-1419

Msimanga, A. & Mudadigwa, B. (2019). Supporting argumentation in chemistry education in low-income contexts. In S. Erduran (Ed.), *Argumentation in Chemistry Education: Research, Policy and Practice* (pp. 275–292). London: Royal Society of Chemistry.

O'Dwyer, A. & Childs, P. E. (2017). Who says organic chemistry is difficult? Exploring perspectives and perceptions. *Eurasia Journal of Mathematic, Science, Technology and Education*, 13, 3599–3620.

Omwirhiren, E. M. & Ubanwa, A. U. (2016). An analysis of mısconceptıons ın organıc chemıstry among selected senıor secondary school students ın zarıa local government area of kaduna state, nıgerıa. *International Journal of Education and Research*, 4 (7), *247-266.*

Özkan, G. & Selçuk-Sezgin, G. (2012). How effectıve ıs "conceptual change approach" ın teachıng physıcs? *Journal of Educational and Instructional Studies in the World, 2(2), 182-190.*

Pabuçcu, A. & Erduran, S. (2017). Beyond rote learning in organic chemistry: the infusion and impact of argumentation in tertiary education. *International Journal of Science Education*, 39, 1154-1172.

Ratcliffe, M. (2002., What's difficult about A-level chemistry. *Education in Chemistry*, 39(3), 76–80.

Rushton G., Hardy R. C., Gwaltney K. & Lewis S., (2008), Alternative conceptions of organic chemistry topics among fourth year chemistry students. *Chemistry Education Research and Practice*, 9(2), 122–130.

Sekerci, A. R., & Canpolat, N. (2014). Impact of argumentation in the chemistry laboratory on conceptual comprehension of turkish students. *Educational Process: International Journal, 3* (1-2), 19-34.

Sendur, G. & Toprak, M. (2013). The role of conceptual change texts to improve students' understanding of alkenes. *Chemistry Education Research and Practice*,14(4), 431–449.

Sendur, G. (2020). An examination of pre-service chemistry teachers' meaningful understanding and learning difficulties about aromatic compounds using a systemic assessment questions diagram, *Chemistry Education Research and Practice,* 21(1), *113-140.*

Topal, G., Oral, B. & Özden, M. (2007). University and secondary school students' misconceptions about the concept of "aromaticity" in organic chemistry. *International Journal of Environmental & Science Education*, 2(4), 135 –143

Treagust, D.F. & Duit, R. (2008). Conceptual change: a discussion of theoretical, methodological and practical challenges for science education. *Cultural Studies of Science Education*, 3, 297–328

Ünal, S., Coştu, B. & Ayas, A. (2010). Secondary school students' misconceptions of covalent bonding. *Journal of Turkish Science Education*, 7(2), 3–29.

Wandersee, J.H., Mintzes, J.J. & Novak, J.D. (1994). Research on alternative conceptions in science. In: Gabel DL (ed) Handbook of research on science teaching and learning. Macmillan, New York, pp 177–210

Westbrook, S. L. & Marek, E. A. (1991). A cross-age of student understanding of the concept of diffusion. *Journal of Research in Science Teaching*, 28(8), 649–660.

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