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Effects of Argument-Driven Inquiry on Pre-Service Teachers' Self-Efficacy of Science Teaching

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Abstract

The aim of this study was to investigate the effect of the ADI (Argument-Driven Inquiry) instructional model on pre-services teachers' self-efficacy of science teaching. A non-equivalent control group design was used as a part of a quasi-experimental design. Two groups of elementary pre-service teachers were choosing; one group was randomly assigned as experimental group, another as a control group. The ADI intervention was applied by researcher and continued six weeks. Self-Efficacy Belief Instrument (STEBI) was applied for the experimental and the control group as a pre- and post-test. The findings showed that after six week intervention about ADI, the experimental group pre-services teachers demonstrated significant differences from the control group pre-services teachers in their science teaching self-efficacy and outcome expectancy.

Keywords: Keywords: Self-efficacy beliefs, argument-driven ınquiry, pre-service teachers, science teaching

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Argümantasyon Tabanlı Sorgulayıcı Araştırma Yönteminin Öğretmen Adaylarının Fen Öğretimi Öz Yeterlik İnancına Etkisi

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Öz

Bu çalışmanın amacı, Argümantasyon Tabanlı Sorgulayıcı Araştırma (ATSA) yönteminin Fen Bilimleri öğretmen adaylarının fen öğretiminde öz yeterlik inancına etkisini araştırmaktır. Çalışmada yarı-yapılandırılmış deneysel araştırma yöntemi kullanılmıştır. Fen bilimleri öğretmen adayları, iki gruba rasgele deneysel ve kontrol grubu olarak atanmıştır. ATSA yöntemi araştırmacı tarafından altı hafta boyunca uygulanmıştır. Veri toplama aracı olarak Öz Yeterlik İnanç Ölçeği, ön-test ve son-test olarak uygulanmıştır. Araştırmanın bulgularına göre altı haftalık ATSA yönteminden sonra deney grubunda hem Fen Öğretiminde Öz Yeterlik İnancı hem de Fen Öğretiminde Sonuç Beklentisi alt ölçeklerinde kontrol grubuna göre önemli farklılıklar görülmüştür.

Anahtar Kelimeler: Öz yeterlik inancı, argümantasyon tabanlı sorgulayıcı araştırma, öğretmen adayları, fen bilimleri öğretimi

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1. Introduction

Science achievement evaluated by PISA has rapidly decreased from 2002 in Turkey (OECD, 2015). In line with the needs, there have been important reforms in the education system in Turkey. Although the reforms are well intentioned and coincided with the world vision of science education, there are many problems and critics in practice (Cakici, 2001, Irez, 2006). As National Research Council (1996) presented "Teachers are central to education…. changes in teaching must begin before all of the systemic problems are solved.", the changes should start with teachers who are the main implementers of the reforms. (p.26)

In science education, the elementary school age is important to success in science. Research presented that the elementary school provides students to gain fundamental knowledge in science and scientific habits. When students have inadequate foundation in science in the elementary school, their participation and confidence in science decrease (Malcolm, 1989). Also, the way to success in science is through elementary teachers (Malcolm, 1989; Rennie, Goodrum & Hacking, 2001; Tobin, Briscoe, & Holman, 1990). Although the elementary teachers have key role in science education, the studies have showed that many elementary teachers do not feel comfortable and adequate in class (Howitt, 2007; Westerback, 2006). In another study, majority of elementary teachers (%72) felt inadequate in science teaching while this proportion was %24 in reading/language arts teaching (Coburn &Loving, 2002). Furthermore, the perceptions of teachers about themselves are also important to teaching science because some researches have indicated that teachers feeling inadequate in science teaching give poor teaching (Crosby, 1997; Riggs, 1991). Without any doubt, the struggle is to raise self-confident and sufficient elementary teachers in science education. It's just as well that many researches have showed that pre-service courses and applications provide elementary teachers increase their confidence in science teaching (Appleton, 1995; Mulholland & Wallace, 2000; Stoddart, Connell, Stofflett, & Peck, 1993).

To change pre-service teachers' confidence and self-efficacy, many researchers designed science content courses in teacher education program in different fields such as biology (Haines & Blake, 2005; Tessier, 2010), earth and environmental sciences (Avard, 2009,2010; Posnanski, 2007) and physical sciences (Korb, Sirola, & Climack, 2005). Generally, Science Teaching Efficacy Belief Instrument for Prospective Teachers (STEBI-B; Enochs &Riggs, 1990) have been used to investigate changes of pre-service teachers' self-efficacy in quantitative researches in literature. However, there are too little researches that investigated the relationship between laboratory activities and applications with pre-service teachers' self-efficacy in literature especially in chemistry education (Aka, 2016; Azar, 2010). Azar (2010) presented that there should be increase laboratory applications to increase teachers' self-efficacy in science teaching.

The subject of present study is to investigate the effects of Argument-Driven Inquiry (ADI) laboratory instructional method on pre-service elementary science teachers' self-efficacy in Turkish university by using Science Teaching Efficacy Belief Instrument for Prospective Teachers (STEBI-B; Enochs &Riggs, 1990). ADI is a new laboratory instructional method that gives great importance not only for basic aspects of laboratory activities (such an asking questions, designing methods) but also scientific literacy skills and abilities (such as scientific argumentation, writing, peer-review) considered to enhance self-efficacy. Sampson, Grooms and Walker (2011) presented that ADI has iterative seven steps that was presented as follows:

Table1. The steps of ADI instructional model and purposes

Step	Purpose
Identification of Task and the Research Question	Attract of pre-service teachers' attention Activate pre-service teachers' previous knowledge
Develop a Method; Collect and Analyze Data	Give a chance to pre-service teachers to design and practice an investigation. Provide an opportunity to pre-service teachers to decide what type of data they need and how they collect
Generation of a Tentative Argument	Give an opportunity to pre-service teachers to develop tentative argument that include claim, evidence and justification of evidence
Argumentation session	Make pre-service teachers discuss and share their ideas Give a chance to pre-service teachers to get feedback about their argument
Write an Investigation Report	Make pre-service teachers learn how to craft written argument
Double-Blind Group Peer Review	Give a chance to pre-service teachers to understand good quality investigation report Provide an opportunity to pre-service teachers to get feedback from their peers.
Revises Investigation Reports	Make pre-service teachers revise and improve their writing

Due to writing-intensive characteristic of ADI, many researches are related to investigation of effects of ADI on scientific writing in literature (Sampson & Walker, 2012; Sampson, Grooms & Walker, 2010; Walker &Sampson, 2013). Apart from these studies, there is a research that examines the effects of ADI on high school students' biology proficiency in the US (Strimaitis, Southerland, Enderlee, Grooms, & Sampson, 2015). Another study was conducted to investigate the effectiveness of ADI in US college chemistry laboratories (Walker et al., 2012).

1.1. Literature about Self-Efficacy of Science Teachers

Bandura (1994) described self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives". (p.71). Also, he reported that self-efficacy shapes people's feelings, behavior and motivation. A great number of studies have shown that self-efficacy is a significant component of teaching science. Enhancing self-efficacy of teachers improved teacher behavior and students learning (Ashton & Webb, 1986; Enochs, Scharmann, & Riggs, 1995; Henson, 2001). Teachers' self-efficacy plays a key role in academic achievement of students (Saklofske, Michayluk, & Randhawa, 1988). Furthermore, teachers with low self-efficacy generally disfavor teaching science and don not enthusiastic about teaching (Koballa &Crawley, 1985).

In this respect, many researches have been interested in developing self-efficacy of pre-service teachers. A great number of methods and strategies such as student teaching experiences (Palmer, 2006), inquiry approach (Jarrett, 1999; Ketelhut, 2007), hands-on, minds-on teaching experiences (Vural & Hamurcu, 2008; Weinburg, 2007) and drama-based action research (Bencze &Upton, 2006) have been described to increase self-efficacy of pre-service teachers. The

common point of all these studies is those increase active participation and experiences of teachers, develop self-efficacy beliefs of teachers.

In literature, many researches have evidence to prove greater experiences of pre-service teachers, greater self-efficacy beliefs. Due to this reason, we believe that ADI model that involve scientific practices and argumentation may increase self-efficacy beliefs of teachers. Thus, the aim of this study was to investigate the effect of the ADI instructional model on pre-services teachers' self-efficacy of science teaching. The research question was below:

1. What is the effect of the ADI instructional model over traditional laboratory instruction on pre-services teachers' self-efficacy of science teaching?

2. Methodology

To investigate the effect of the ADI instructional model, a non-equivalent control group design was used as a part of a quasi-experimental design (Gay & Airasian, 2000) to compare the effectiveness of instruction using the ADI instructional model to a traditional laboratory instructional model. Two groups of elementary pre-service teachers were choosing; one group was randomly assigned as experimental group, another as a control group. The study was conducted with two groups of elementary pre-services who attended general chemistry laboratory in the 2016 spring semester.

2.1. Participants

Forty-seven freshman elementary pre-services teachers from two groups were participated in this study. The experimental group included 23 pre-service teachers (14 girls and 9 boys) and the control group included 24 pre-service teachers (14 girls and 10 boys). The general chemistry laboratory course was taught in public university of the Turkey. This university requires 4 years of teacher education program for graduation to become elementary science teacher and follows an "elementary science teacher education" curriculum.

2.2. Procedure

Both groups got same general chemistry laboratory course and experiments. However, the experimental group was instructed by ADI, whereas the control group was instructed by traditional laboratory instruction. The intervention was applied by researcher and continued six weeks. The course had four 45 min. laboratory sessions in each week.

The experimental students attended general chemistry laboratory course enrolled four different laboratory activities that were shaped and designed by ADI instructional model. These experiments were developed to investigate general chemistry concepts such as acid-base titration, rate of dissolution, reaction rate and producing electric energy. The experiments and guiding questions were given in Table 2.

Table 2. Descriptions of the experiments

Name of the Experiments	The Guiding Question
Reaction Rates	Why Do Changes in Temperature Affect the Rate of a Reaction?

Acid-Base Titration	What Is the Concentration of Sodium Hydroxide in a Sample?
Producing Electric Energy	Which Metal Strips Can Produce Electric Energy Together?
Rate of Dissolution	Why Do the Surface Area of the Solute, the Temperature of the Solvent, and Amount of Agitation That Occurs When the Solute and the Solvent Are Mixed Affect the Rate of Dissolution?

The handout was given to pre-service teachers at the beginning of the ADI instructional method. This handout included fundamental knowledge, materials and the guiding questions of experiments. The aim of this handout was to active pre-service teachers' previous knowledge related the topic of experiments. Then, pre-service teachers were assigned to groups with four or five people to plan and collect data about investigation of the guiding question. They decided how and which data were needed for the guiding questions. After data collection, pre-service teachers also decided how to present and analyze their data. While answering the guiding questions, pre-service teachers gave scientific argument that includes a claim of them. Also, they prepared evidence and justification of evidence for their claim in groups. Each group presented their tentative argument by pasteboard to whole class (Detailed explanation about what counts as a claim, evidence and justification of evidence is given in the paper of Walker et al., 2012). This tentative argument provides opportunity for pre-service teachers to talk about "what counts" as a good scientific argument and criticizes different claims. With the presentation of their claims, evidence and justification of evidence, the argumentation session started in that time in class. In this argumentation session, pre-service teachers discussed their own argument with their friends. This discussion also gives opportunity to see weaknesses and strengths of their arguments. The ends of experiments, the investigation reports were demanded from pre-service teachers individually. This investigation reports should be included written scientific argument and guiding question. These reports were collected by researcher and then distributed to other groups for evaluation. For this evaluation, the evaluation checklists that involve critics for good written argument were given to groups. The groups filled this checklist by discussing with their group members. Pre-services teachers got also chance to negotiate "what counts" as a good scientific argument in this peer-review process. In the last step, pre-service teachers revised their investigation reports according to peer feedbacks.

In the control group, pre-service teacher performed same four experiments with the experimental group but in a traditional laboratory instruction. Again, the researcher distributed handout to pre-services teacher that involved procedure of the experiments, materials, research question and basic knowledge about topic at the beginning of the course. Pre-services teacher assigned to groups and they do experiment in a group. The researcher not only monitored pre-service teachers also asked some question to guide them. They pursued the procedure to answer research question. After investigation, the investigation reports that included the aim of the experiment, answer of research question and results of the experiment were desired from pre-service teachers. Researcher collected all investigation reports and summarized investigation and answer research question.

2.3. Instrument

Self-Efficacy Belief Instrument (STEBI) was developed by Enochs and Riggs (1990). This instrument involved two subscales that are Personal Science Teaching Efficacy (13 items) Belief

scale and Science Teaching Outcome Expectancy scale (12 items). The instrument likert-type and the likert scale values ranges from 1(strongly disagree) to 5 (strongly agree).

Bıkmaz (2004) translated and adapted the instrument to Turkish. In Turkish version included 20 items based on validation factors. Bıkmaz (2004) calculated the alpha value is 0.78 for the personal science teaching efficacy belief while the alpha value is 0.6 for science teaching outcome expectancy scale. This instrument was applied for the experimental and the control group as a pre- and post-test. It took 20 minutes to complete.

3. Results

In this part, there were two parts namely descriptive statistics and in inferential statistics.

3.1. Descriptive Statistics

Descriptive statistics related to Personal Science Teaching Efficacy Belief (PSTEB) scale and Science Teaching Outcome Expectancy (STOE) scale pre- and post-test scores of the experimental and the control groups were presented in Table 3.

Table 3. Descriptive Statistics of PSTEB and STOE as pre-and post-tests

Group	Subscale	N	Min.	Max.	Mean	SD
Experimental Group	Pre-PSTEB	23	37	60	43.24	5.04
	Pre- STOE	23	16	31	23.22	3.79
	Post-PSTEB	23	42	60	49.82	4.72
	Post- STOE	23	19	36	26.24	2.59
Control Group	Pre-PSTEB	24	38	56	42.15	5.27
	Pre- STOE	24	16	32	24.12	4.58
	Post-PSTEB	24	37	59	44.54	3.72
	Post- STOE	24	18	30	22.80	4.63

3.2. Inferential Statistics

In this part, research questions and outcomes of analysis were given. The research question was analyzed by using two independent-samples Mann-Whitney U test at a significance level of .05.

What is the effect of the ADI instructional model over traditional laboratory instruction on pre-services teachers' self-efficacy of science teaching?

STEBI that had two subscales namely PSTEB and STOE was applied as pre- and post-tests for both groups to answer this question. Mann-Whitney U test was used to compare both the mean pre-test scores and the mean post-test scores for the experimental and the control group. There was not a significant difference between the pre-test scores for the control group (Mdn=42) and experimental group (Mdn=44) (U=240, p >.05) in PSTEB subscale. However; it was found that there was a significant difference between the post-test scores for the control group (Mdn=44) and experimental group (Mdn=50) (U=46, p<. 05) in PSTEB subscale (Table 4).

Table 4. Results of Mann-Whitney U test for PSTEB

Subscale	Group	n	Mean Rank	Sum of Rank	U	p
Pre-PSTEB	Exp	23	25.54	587	240	0.444
	Con	24	24.10	540		
Post-PSTEB	Exp	23	34.00	782	46	0.000
	Con	24	14.42	346		

With regard to STOE subscale, it was found no significant differences between the experimental (Mdn=24) and the control group (Mdn=23.5) for pre-test (U=208, p >.05). But, there was a significant difference for post-test (U=96, p<.05) (Table 5).

Table 5. Results of Mann-Whitney U test for STOE

Subscale	Group	n	Mean Rank	Sum of Rank	U	p
Pre- STOE	Exp	23	26.96	602	208	0.143
	Con	24	21.17	508		
Post- STOE	Exp	23	31.83	732	96	0.000
	Con	24	16.50	396		

4. Discussions and Conclusion

This study had one main purpose that investigates the effect of the ADI instructional model over traditional laboratory instruction on pre-services teachers' self-efficacy of science teaching. The findings of this research produced valuable notion for the elementary pre-service teachers to have greater self-efficacy to teach science. After a six week intervention about ADI, the experimental group pre-services teachers demonstrated significant differences from the control group pre-services teachers in their science teaching self-efficacy and outcome expectancy. Although there is no study related to investigation of the effects of ADI on teaching self-efficacy for pre-services teachers, there are many studies about using different inquiry approaches (Jarret,1999; Ketelhut, 2007; Özdilek &Bulunuz, 2009) and teaching experiences (Palmer, 2006) to improve teaching self-efficacy of pre-services. These studies have close views that greater the experiences, greater the teaching self-efficacy like ADI model.

Some of its limitations should not be forgotten while considering the findings of this study. The main limitation was small sample size that the generalizability of the findings may be restricted. Another limitation was implementer of the study who is experienced in ADI. Calling into question of usability of ADI when conducted by inexperienced implementer. Moreover, some researchers stated that particular characteristics of teachers namely values, beliefs or behaviors were shaped in early years of teacher education program (Plourde, 2002; Watters & Ginns, 1995). By reason of this, the present study was conducted in freshman elementary pre-services teachers. The effect of ADI on teaching self-efficacy may decrease with upper years of teacher education program.

We are aware of that the present study has some deficiencies, but the findings of the study provide some important conclusions for science education. The results suppose that ADI

instructional model help pre-services teachers improve their science teaching self-efficacy beliefs and outcome expectancy. The steps and activities of ADI instructional model such as designing experiments, producing scientific argument, argumentation session, writing investigation report and peer-review feedbacks may support pre-services teachers to improve their self-efficacy. This finding is important because the way to students' success in science is through elementary teachers (Malcolm, 1989; Rennie, Goodrum & Hacking, 2001; Tobin, Briscoe, & Holman, 1990) and also teachers having low self-efficacy in science teaching give poor teaching (Crosby, 1997; Riggs, 1991).

Future researches are needed to conduct this study with large sample size and other science context. Also, the effectiveness of the ADI on teaching self-efficacy should be investigated in upper years of teacher education program.

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Genişletilmiş Özet

1. Giriş

Bandura'ya göre öz yeterlilik, bireyin belli bir performansı göstermesi için gerekli etkinlikleri düzenleyip başarılı bir biçimde gerçekleştirme kapasitesi hakkında kendine ilişkin yargısıdır (Bandura, 1986, s:391). Öz yeterlilik öğretmenin öğretiminde önemli bir role sahiptir. Bazı çalışmalarda düşük öz-yeterliliğe sahip öğretmenlerin gelecekteki değişimlerde başarılı olmada yetersiz olacağına olan inancı doğrultusunda kendi öğretim teknik ve metotlarını değiştirmede motivasyonsuz olduğu bulunmuştur. Öğretmenlerin öz yeterliklerinin geliştirilmesi ile öğrenme konusunda hem öğretmen davranışları hem de öğrencilerin anlamaları gelişmiştir (Ashton & Webb, 1986; Enochs, Scharmann, & Riggs, 1995; Henson, 2001). Ayrıca öğretmenlerin öz yeterliği, öğrencilerin akademik başarılarında önemli rol oynadığı görülmüştür (Saklofske, Michayluk ve Randhawa, 1988). Koballa ve Crawley (1985) yaptıkları çalışmada düşük öz-yeterlik derecesine sahip öğretmenlerin genellikle fen öğretiminde yetersiz ve isteksiz olduğunu ortaya koymuştur.

Birçok araştırmacı, biyoloji (Haines & Blake, 2005; Tessier, 2010), yeryüzü ve çevre bilimleri (Avard, 2009) ve fizik bilimleri (Korb, Sirola, & Climack, 2005) gibi farklı alanlarda öğretmen yetiştirme programlarında öğretmen adaylarının öz yeterlik inançlarını değiştiren çalışmalar yapmıştır. Buna rağmen, özellikle kimya eğitimi literatüründe kimya laboratuvar etkinlikleri ile uygulamalarının öz yeterlik inancına etkisini araştıran çok az sayıda araştırma bulunmaktadır (Aka, 2016; Azar, 2010). Azar (2010) yaptığı çalışmada öğretmenlerin fen öğretimi öz yeterliliğini arttırmak için laboratuvar uygulamalarının arttırılması gerektiğini öne sürmektedir.

ATSA yöntemi laboratuvar eğitimine dayalı bir öğretim modeli olup daha özgün ve eğitici laboratuvar uygulamaları sunan bir metottur. ATSA öğretim modeli yedi basamaktan oluşmaktadır:

1. Görevi ve yönlendirici araştırma sorusunu tanımlamak
2. Araştırma yöntemini tasarlamak ve veri toplamak ve analiz etmek
3. Araştırma sorusuna geçici bir argüman üretmek
4. Argümantasyon, açık ve yansıtıcı tartışma
5. Araştırma raporu yazmak
6. Akran değerlendirmesi yapmak
7. Araştırma raporlarını düzenleyerek tekrar sunmak

ATSA laboratuvar araştırma yöntemi araştırmacının öğretmenlere araştırma problemini sorması ile başlar. Üçlü yada dörtlü grup oluşturacak şekilde düzenlenen öğretmenlerin bu soruya cevap bulabilecekleri verileri toplamaları için metod geliştirmeleri beklenmektedir. Grup olarak verileri topladıktan sonra öğretmenler deneysel ve değişebilir bir argüman sunması için yönlendirilir. Bu argümanlarını kanıt ve iddalara dayandırarak beyaz bir kartona yazmaları istenir. Yazdıktan sonra her bir grubun argümanı tartışma seansında diğer gruplarca doğru veya yanlış tarafları ortaya konularak değerlendirilir. Daha sonra öğretmenlerin bu tartışmalardan sonra evde ödev olarak bir inceleme raporu yazması istenir.

2. Amaç

Bu çalışmanın amacı, Argümantasyon Tabanlı Sorgulayıcı Araştırma (ATSA) yönteminin Fen Bilimleri öğretmen adaylarının fen öğretiminde öz yeterlik inancına etkisini araştırmaktır.

3. Metot

ADI öğretim modelinin etkisini araştırmak ve geleneksel laboratuvar öğretim modeli ile karşılaştırmak için, yarı-deneysel araştırma yöntemi kullanılmıştır. (Gay & Airasian, 2000). Fen bilimleri öğretmen adayları iki gruba rasgele deneysel ve kontrol grubu olarak atanmıştır. Çalışma, 2016 bahar döneminde genel kimya laboratuvarı dersinde ilköğretim fen bilimleri öğretmen adayları ile yürütülmüştür.

3.1 Örneklem

Bu çalışmaya toplam 47 adet ilköğretim fen bilimleri öğretmen adayları katılmıştır. Deney grubunda 23 öğretmen adayı (14 kız ve 9 erkek), kontrol grubunda ise 24 öğretmen adayı (14 kız ve 10 erkek) bulunmaktadır. Genel kimya laboratuvarı dersinde yapılan uygulama, Türkiye'deki bir kamu üniversitesinde yapılmıştır.

3.2 Prosedür

Her iki grup da aynı genel kimya laboratuvarı deneylerini ve dersini almıştır. Ancak, deney grubuna ADI dayalı laboratuvar öğretim yöntemi ile uygulama yapılırken, kontrol grubuna ise geleneksel laboratuvar eğitim yöntemi uygulandı. Uygulama araştırmacı tarafından ve altı hafta boyunca yapıldı. Laboratuvarlar her hafta 45 dk'lık dört ders saati olarak uygulanmıştır.

ATSA uygulamasında kullanılacak deneyler genel kimya laboratuvarı öğretimine uygun 4 deneyi kapsamaktadır. ATSA yöntemi uygulaması araştırmacının öğretmen adaylarına o günkü deneyin konusunu, kullanılacak malzemeleri ve araştırma sorularını içeren yazıları dağıtması ile başlamıştır. Bu yazıda ayrıca o günkü öğretmen adaylarına rehberlik edecek soruda bulunmaktadır. Bu verilen yazı ile öğretmen adaylarının hem rehber soru ile ilgili önceki bilgilerinin aktive edilmesi hem de dikkatlerinin toplanması sağlanmıştır. Öğretmen adayları bu rehber soruya cevap bulabilmek için gerekli incelemeleri dörtlü veya beşli gruplar halinde yapmıştır. Daha sonra grup halinde bu gerekli olan verileri nasıl toplayacaklarına ve hangi yöntemleri kullanmaları gerektiğine karar vermişlerdir. Verileri topladıktan sonra da bilimsel bir argüman sunmak için bu verileri nasıl analiz edeceklerine ve nasıl açıklayacaklarına karar vermeleri gerekmiştir. Ortaya attıkları argümanları ise kendi iddialarını ve kanıtlarını içermiştir. Bu argümanlarını bütün grupların görebileceği şekilde bir kartona yazarak sunmuşlardır. Bu kartondaki argümanları da kendi iddialarını, kanıtlarını ve kanıtlarının gerekçelerini içerecek şekilde hazırlanmıştır. Bu sunma sürecinde bir tartışma seansı ortamı oluşmuştur. Her gruptan bir kişi hazırladıkları posteri diğer grup elemanlarına açıklarken grubun diğer üyeleri de grupları gezerek onların argümanlarını dinlemişti. Tabii bu argümanları dinlerken de diğer grubun üyeleri çeşitli sorular sorarak niye böyle bir argümana ulaştıklarını veya kanıtlarının doğruluğu konusunda çeşitli sorular sormuştur. Bu tartışma seansı öğretmen adaylarına gruplarının ortaya attığı argümanların doğru yada yanlış yönlerini görme fırsatı sunmuştur. Tartışma seansından sonra ise her bir öğretmen adayından bireysel olarak deneyle ilgili bir rapor yazıp haftaya getirmeleri istenmiştir. Bu yazdıkları raporlar araştırmacıda toplanmış ve farklı gruplara dağıtılmıştır. Bu gruplarda da hazırlanan kriterlere uygun her bir raporun değerlendirilmesi yapılıp bu değerlendirme yazıları dönüt olarak verilmiştir. Bu basamakta öğretmen adayları için iyi bir bilimsel argümanın nasıl olacağını beraberce tartışacağı ve değerlendireceği fırsat yaratılmış oldu. ATSA'nın son basamağında ise her bir öğretmen adayı aldıkları dönüte göre yazdıkları raporları düzeltmiştir.

Kontrol grubunda ise daha çok soru sormaya dayalı olan geleneksel laboratuvar öğretim yöntemi kullanılmıştır. Yine uygulamanın sonunda öğretmen adaylarından deneyin amacını, bulduğu sonuçları içeren bir rapor yazması istenmiştir.

3.3.Ölçek

Bıkmaz'ın (2014) Türkçeye adapte ettiği Öz Yeterlik İnanç Ölçeği ön-test ve son-test olarak uygulanmıştır.

4.Bulgular

Araştırma sorusu, Mann-Whitney U testi kullanılarak analiz edilmiştir. Bu bulgular ışığında, *Fen Öğretiminde Öz Yeterlik İnanç* alt ölçeğinde ön-test puanlarında kontrol grubu ile deney grubu arasında anlamlı bir fark bulunmazken ($U = 240$, $p > .05$) son-test puanları arasında ($U = 46$, $p < .05$) anlamlı bir farklılık bulunmuştur. Yine, *Fen Öğretiminde Sonuç Beklentis*i alt ölçeğinde de ön-test puanlarında kontrol grubu ile deney grubu arasında anlamlı bir fark bulunmazken ($U=208$, $p > .05$). son-test puanları arasında ($U=96$, $p<.05$)anlamlı bir farklılık bulunmuştur.

5. Tartışma

Bu araştırmanın bulguları, ilköğretim fen bilimleri öğretmen adaylarının fen öğretimi öz-yeterlik inancının artırılması için önemli veriler sunmuştur. Altı haftalık ATSA uygulamasında sonra, deney grubu öğretmen adayları, fen öğretimi öz yeterliği ve sonuç beklentisi açısından kontrol grubu öğretmen adaylarından önemli farklılıklar göstermiştir. Çalışmada kısıtlı örneklem kullanımı ve uygulamanın ATSA konusunda tecrübeli araştırmacı tarafından yapılması gibi eksikleri olmasına rağmen kimya eğitimine önemli katkı sağlamaktadır.