



**THE EFFECT OF ARGUMENTATION METHOD ON  
CRITICAL THINKING TENDENCY, LOGICAL THINKING  
ABILITIES AND ACADEMIC ACHIEVEMENT OF  
SCIENCE TEACHER CANDIDATES<sup>iii</sup>**

**Hüseyin Polat<sup>iiii</sup>,**

**Fatma Bilge Emre<sup>2</sup>**

<sup>1</sup>Dr. Science Teacher  
Doğanşehir Söğüt Secondary School,  
Malatya, Turkey

<sup>2</sup>Dr. Faculty of Education,  
Inonu University,  
Malatya, Turkey

**Abstract:**

Today's education system heads toward an understanding which is centred around investigation and questioning to reach scientific literacy. Current science curriculum aims at training science literate individuals who investigate and question, make efficient decisions, solve problems, are self-confident, open to cooperation, establish effective communication, learn throughout life with the awareness of sustainable development and are able to adapt to scientific and technological changes. Argumentation might be an important method to achieve these objectives in science education. Because argumentation is an effective method that affects the ways of thinking. Argumentation is finding evidences to advocate a claim. The evidences sought to support the claim should be selected with a critical perspective. The aim of the present study is to investigate the influence of argumentation method on critical thinking tendency, logical thinking abilities and academic achievement of science teacher candidates. In this study was used in the form of quasi-experimental design. Control and experiment groups did the same experiments. In addition, Activity Papers Based on Argumentation Method were used for the experimental group. In the study, data collection tools were used as pre-test and

<sup>i</sup> ARGÜMANTASYON YÖNTEMİNE DAYALI LABORATUVAR ETKİNLİKLERİNİN FEN BİLGİSİ ÖĞRETMEN ADAYLARININ ELEŞTİREL DÜŞÜNME EĞİLİMİ, MANTIKSAL DÜŞÜNME BECERİLERİ VE AKADEMİK BAŞARILARINA ETKİSİ

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<sup>iii</sup> Correspondence: email [h.polat44@hotmail.com](mailto:h.polat44@hotmail.com)

post-test. MANOVA test was performed for the difference between the post-test mean scores of the control and experimental groups. According to the findings obtained from the study, the effect of argumentation method on critical thinking tendency, logical thinking abilities and academic achievement was interpreted.

**Keywords:** argumentation, critical thinking tendency, logical thinking abilities, higher education

### **Özet:**

Günümüz eğitim sistemi, bilimsel okuryazarlığa ulaşmak için araştırma ve sorgulama merkezli bir anlayışa yönelmektedir. Mevcut fen müfredatı, araştıran ve sorgulayan, verimli kararlar veren, problem çözen, kendine güvenen, iş birliğine açık, etkili iletişim kuran, sürdürülebilir kalkınma bilinciyle yaşam boyu öğrenen ve bilimsel ve teknolojik değişikliklere uyum sağlayabilen fen okuryazarı bireyler yetiştirmeyi amaçlamaktadır. Fen eğitiminde bu hedeflere ulaşmak için argümantasyon önemli bir yöntem olabilir. Çünkü argümantasyon, düşünme biçimlerini etkileyen etkili bir yöntemdir. Argümantasyon, bir iddiayı savunmak için kanıtlar bulmaktır. İddiayı desteklemek için aranan kanıtlar eleştirel bir bakış açısıyla seçilmelidir. Bu araştırmanın amacı, argümantasyon yönteminin fen bilgisi öğretmen adaylarının eleştirel düşünme eğilimi, mantıksal düşünme becerileri ve akademik başarıları üzerindeki etkisini incelemektir. Bu çalışmada yarı deneysel desen şeklinde kullanıldı. Kontrol ve deney grupları aynı deneyleri yaptı. Ayrıca deney grubu için Argümantasyon Yöntemine Dayalı Etkinlik Kağıtları kullanıldı. Araştırmada veri toplama araçları ön test ve son test olarak kullanıldı. Kontrol ve deney gruplarının son test puan ortalamaları arasındaki fark için MANOVA testi yapıldı. Araştırmadan elde edilen bulgulara göre argümantasyon yönteminin eleştirel düşünme eğilimi, mantıksal düşünme becerileri ve akademik başarıları üzerindeki etkisi yorumlandı.

**Anahtar kelimeler:** argümantasyon, eleştirel düşünme eğilimi, mantıksal düşünme becerileri, yüksek öğrenim

### **1. Introduction**

There have been some changes in the current century in respect of development and change of knowledge. When these changes are considered, it is seen that there has been a shift from the behavioural theory of learning to cognitive and social learning theories, from the understanding that the mind of the individual is tabula rasa by birth to the view that some capacities are inherent, and from the idea that "*knowledge develops cumulatively*" to the thought that "*knowledge can be re-structured or abandoned.*" These fundamental changes naturally reveal that learning environments are required to be arranged in the manner where students will be active and enabled to use their reasoning abilities in their activities (Duschl & Osborne, 2002). This change along with the global economic

competition and rapid changes in science and technology compel the countries to introduce changes in the field of education. In consequence, different objectives, approaches and understandings emerge in education. Individuals who do not memorize but access and use the information, feel responsibility, think critically and have macro problem-solving and decision-making abilities are in demand (Çalışkan, 2009; MEB, 2017).

Today's education system heads toward an understanding which is centred around investigation and questioning to reach scientific literacy. Current science curriculum aims at training science literate individuals who investigate and question, make efficient decisions, solve problems, are self-confident, open to cooperation, establish effective communication, learn throughout life with the awareness of sustainable development and are able to adapt to scientific and technological changes (Kutluca et al., 2014; MEB, 2013, 2017; Ulu & Bayram, 2015).

Argumentation might be an important method to achieve these objectives in science education. The concept of argumentation is not a disagreement or conflict, but a process of persuading the other party about the validity of scientific claims. (Aydın, 2013; Docket & Perry, 2015). Argumentation is a verbal activity by which the individuals express their attitudes about developments and a social and cognitive process in which they decide to choose among different circumstances in daily life (Janjua et al., 2014; Van Eemeren et al., 1996). Argumentation is an effective method that affects the ways of thinking. Argumentation is an important feature of critical thinking. It necessitates the investigation of evidences pertaining to any circumstance encountered and consideration of counterargument. Critical thinking leads to a change in mental status by addressing different perspectives (Maloney, 2007). Argumentation is finding evidences to advocate a claim (Docket & Perry, 2015). The evidences sought to support the claim should be selected with a critical perspective. This is because critical thinking includes common abilities related to problem solving, decision making, interpretation, different thinking, evaluation, reasoning and transfer (Carvalho et al., 2015). Conclusions about the extent to which the proposed evidence supports the relationship with the claim and how much it can confirm require critical thinking. In other words, argumentation requires viewing the event with a critical eye (Polat & Emre, 2019a). Literature review shows that there are studies conducted on the effect of argumentation method on critical thinking tendency (Bilasa & Taşpınar, 2018; Çakan Akkaş, 2017; Demirel, 2017; Ecevit, 2018; Meral, 2018; Şahin, 2016; Sevgi, 2016; Tüzün, 2016). Common conclusion of these studies is that the argumentation method exerts an influence on critical thinking tendency.

Another thinking skill on which argumentation method has an influence on is logical thinking skill. Logical thinking is reaching the necessary principles and laws by solving a problem. Piaget states that logical thinking begins with concrete operations stage and continues with abstract operations stage (Ballıel, 2014; Tekbıyık & İpek, 2007). Logical thinking is based on sequential thinking. Sequential thinking refers to the ability to process the ideas, truths and consequences regarding the problems encountered in daily life in orderly prescribed manner (Sert Çıbık & Emrahoğlu, 2008). In order for an

individual to think sequentially, that is to see the ideas related to the problem and the underlying truth, he/she has to have reasoning ability. Argumentation plays an important role in the development of reasoning ability. Because argumentation is an important feature of reasoning and thinking (Simon, 2008). Argumentation and logical thinking abilities are very effective in individuals' decision-making processes in their daily lives. Logical thinking abilities of individuals can be improved with argumentation method. Reasoning ability helps individuals to make logical deductions to solve the problems they encounter (Polat & Emre, 2019b). The review of the studies in the literature reveals that there are some studies on the influence of argumentation method on logical thinking (Aydın, 2013; Dođru, 2016; Ecevit, 2018) abilities. Common conclusion of these studies is that the argumentation method exerts an influence on critical thinking tendency.

There are also studies in the literature revealing that argumentation method has an influence on academic achievement and positively affects academic achievement of individuals (Aslan, 2018; Çakan Akkaş, 2017; Ceylan, 2012; Demirciođlu & Uçar, 2015; Demirel, 2017; Dođru, 2016; Meral, 2018; Polat et al., 2016; Şahin, 2016). However, there are no studies in the literature on the influence of argumentation method on critical thinking tendency, logical thinking abilities and academic achievement of science teacher candidates in conjunction. Following suggestions are made in the light of the findings obtained by filling this gap in the literature. Starting from this point of view, the aim of the present study is to investigate the influence of argumentation method on critical thinking tendency, logical thinking abilities and academic achievement of science teacher candidates. In line with this aim, the study problem is stated as follows;

Does the argumentation method have an influence on critical thinking tendency, logical thinking abilities and academic achievement of science teacher candidates?

Sub-problems of the study are as follows:

- 1) Is there a significant difference regarding the influence of argumentation method on critical thinking tendency of science teacher candidates between the control group and the experimental group?
- 2) Is there a significant difference regarding the influence of argumentation method on logical thinking abilities of science teacher candidates between the control group and the experimental group?
- 3) Is there a significant difference regarding the influence of argumentation method on academic achievement of science teacher candidates between the control group and the experimental group?

## **2. Method**

### **2.1. Model of the Study**

In the present study conducted on the influence of argumentation method on critical thinking tendency, logical thinking abilities and academic achievement of science teacher

candidates, experimental design included in quantitative research methodology was used in the form of quasi-experimental design.

Experimental studies are the best way to establish cause and effect relationships. The effect of an independent variable on one or more dependent variables is investigated in these studies. Experimental design is composed of two groups as control group and experimental group (Fraenkel et al., 2012). Absence of random assignment in quasi-experimental design may threaten internal validity. Teacher candidates who were included in the sample of the present study were sorted by their placement scores in university admission tests and those who had even numbers were registered in Branch A, while those with odd numbers were registered in Branch B. This helps to ensure internal validity.

**Table 1: Study Design**

Group	Pre-test	Procedure	Post-test
<b>Control Group</b>	Critical Thinking Tendency Scale	Laboratory Practices Based on Traditional Method	Critical Thinking Tendency Scale
	Logical Thinking Abilities Scale		Logical Thinking Abilities Scale
	Academic Achievement Test		Academic Achievement Test
<b>Experimental Group</b>	Critical Thinking Tendency Scale	Laboratory Practices Based on Argumentation Method	Critical Thinking Tendency Scale
	Logical Thinking Abilities Scale		Logical Thinking Abilities Scale
	Academic Achievement Test		Academic Achievement Test

The teacher candidates in the control and the experimental groups performed experiments on the subjects of Gases, Chemical Equilibrium, Chemical Kinetics and Thermochemistry within the scope of General Chemistry Laboratory Practices II course and those in the experimental group were also engaged in activities based on argumentation method prepared in accordance with experiment subjects. The study lasted for 5 weeks. The scales were applied to the groups as pre-test and post-test and the significant difference between the groups was examined.

## 2.2. Population and Sample

The sample of this study was composed of 70 teacher candidates who were freshmen in Science Teaching Program in the spring semester of 2017-2018 academic year. There were 35 teacher candidates in each of Branch A and Branch B. Branch A was designated as the control group and Branch B as the experimental group prior to the study.

### 2.3. Data Collection Tools

#### A. The Critical Thinking Tendency Scale of UF/EMI (University of Florida Engagement, Maturity and Innovativeness)

The scale was created in 2002 by the researchers in Florida University based on the California Critical Thinking Tendency Scale suggested by Facione (1999). It was translated into Turkish by Ertaş (2012). The scale consists of 25 items. The Cronbach's Alpha internal consistency coefficient was calculated as 0.91 for the whole scale. The Cronbach's Alpha internal consistency coefficient in terms of post-test scores was calculated as 0.942 for the whole scale in the present study. Necessary permissions were obtained to use the scale.

#### B. Logical Thinking Abilities Scale

The scale was created by Polat (2019) based on Lawson's Test of Logical Thinking Ability to measure logical thinking abilities of science teacher candidates. The test includes 12 multiple-choice and 2 open-ended items. Multiple choice items in the scale consist of two parts. The respondents are asked to mark the correct answer among the choices placed below the question in the first part and in the following part, they are asked to elaborate and explain their answers. Average difficulty in the analysis of the items in the first part of the scale was calculated as ( $P_j = 0.498$ ) and average distinctiveness as ( $r_{jx} = 0.334$ ), while the average difficulty in the second part was calculated as ( $P_j = 0.546$ ) and average distinctiveness as ( $r_{jx} = 0.415$ ). Internal consistency coefficient of the test was found as  $r_x = 0.962$ . This value indicates that the test has a high level of internal consistency.

#### C. Academic Achievement Test

This test was developed by Polat (2019) to test the influence of the argumentation method applied in the process of the study on the academic achievement of teacher candidates. The items in the test were prepared in relation to the subjects of the experiments included within the scope of General Chemistry Laboratory Practices II Course. There are 24 items in the achievement test. Average difficulty index of 24 items in the test was calculated as  $P_j = 0.463$ , the average distinctiveness index as  $r_{jx} = 0.511$  and internal consistency coefficient as  $KR-20 = 0.825$ .

#### D. Activity Papers Based on Argumentation Method

The activity papers prepared for the experimental group cover the subjects of gases, chemical equilibrium, chemical kinetics and thermochemistry. In the preparation of activity papers, the gains expected from teacher candidates regarding argumentation at the end of the process are below:

- Gain 1: They advocate their claim regarding a specific subject with justifications.
- Gain 2: They advocate a given claim by supporting it or justifying it with a counterclaim.
- Gain 3: They create arguments in small groups.

- Gain 4: They evaluate a given argument in terms of its elements and scientific accuracy.

Activity papers were handed out to teacher candidates one week before the experiment to prepare for the argumentation activity to be performed in laboratory environment prior to the experiment. The activities consist of three phases. The first phase is the preparation for the experiment. In this phase, they were reminded of the preliminary information about the experiment and asked to form an argument regarding the given case related to the subject. Activity papers were collected the day before the experiment and reviewed. If misconceptions were found, in-class discussions were directed to them. In the second phase of the activity, teacher candidates were asked to form their arguments relating to the experiments before the experiment. Then the experiments were carried out. In the third phase, additional activities were performed and teacher candidates evaluated their pre-experiment arguments regarding the experiments.

#### **2.4. Data Analysis**

The Critical Thinking Tendency Scale, Logical Thinking Abilities Scale and Academic Achievement Test were administered to teacher candidates as pre-test and post-test. SPSS program (Version 21) was used for analysis. In order to test the significant difference between the groups in terms of their pre-test scores, Independent Samples T-Test was conducted. When T-Test did not meet the assumptions, the non-parametric Mann-Whitney U-Test was conducted.

In order to test the significant difference between the groups in terms of their post-test scores, Multivariate Analysis of Variance (MANOVA) was performed. MANOVA confirms whether the average differences between the groups are accidental or not on the basis of the combination of interconnected dependent variables (Pallant, 2017).

Whether the gains were achieved or not was taken into consideration in evaluation of activity papers based on argumentation method. Scientific accuracy of the answers given to the activities were reviewed and graded in accordance with their conformity with the argumentation gain. Conforming answers were graded 1 and the others were graded 0. Frequency values of the obtained data were provided.

#### **2.5. Internal and External Validity of the Study**

Internal validity refers to the fact that the differences observed on the dependent variable are directly related to the independent variable. Factors threatening internal validity in a study can be enumerated as the characteristics of participants, venue of the study, data collection tool, effect of expectancy, effect of pre-test and implementation (Fraenkel et al., 2012).

The participants were freshman science teacher candidates. Teacher candidates were assigned to their branches according to their exam scores. This means that they are equal in terms of academic achievement. It can be said that the laboratory experiences were similar, as the same experiments were carried out in the laboratory with the same

instructors. The same laboratory was used on different days to eliminate the venue effect. The scales were scored with an optical reader to eliminate the effect caused by the data collection tool. To eliminate the pre-test-post-test effect, no information was given about the implementation, and scales were applied to the groups simultaneously.

External validity of a study is generalization of the results for the population (Fraenkel et al., 2012). Science teacher candidates who formed the sample of this study were studying at a state university in the Eastern Anatolia Region in Turkey. The sample was determined with the convenient sampling method. Although this situation adversely affects the generalizability of the results for a larger population, the results obtained from the study can be applied to populations having similar characteristics to the sample.

### 3. Findings and Interpretation

#### 3.1. Pre-test Results

In the present study conducted on the Effect of Laboratory Activities Based on Argumentation Method on Critical Thinking Tendency, Logical Thinking Abilities and Academic Achievement of Science Teacher Candidates, pre-test results were analysed.

**Table 2:** Descriptive Statistics for Pre-test

Scale	Groups	n	$\bar{X}$	$M_d$	Mode	S	$S^2$
Critical Thinking Tendency Scale	Control Group	30	99.167	97.00	96.00	7.900	62.420
	Experimental Group	35	99.343	99.00	99.00	10.676	113.997
Logical Thinking Abilities Scale	Control Group	32	46.875	47.058	41.176	13.404	179.673
	Experimental Group	32	49.448	47.058	47.058	12.398	153.721
Academic Achievement Test	Control Group	21	57.738	58.333	58.333	5.934	35.218
	Experimental Group	27	41.512	41.666	45.833	11.232	126.177

According to the critical thinking tendency pre-test results (Table 2) are examined, it is observed that central tendency measures of the control and the experimental groups are close to each other. This may mean that the data set fits the normal distribution. Variance analysis was performed on the data set, and no significant difference was observed between the groups. Since the data set meets the parametric test assumptions, t-test was performed to test the significant difference between the groups.

**Table 3:** T-Test Results of Critical Thinking Tendency Pre-test

Groups	n	$\bar{x}$	S	sd	t	$p^*$
Control Group	30	99.167	7.90	63	-.075	.941
Experimental Group	35	99.343	10.676			

$p^* > 0.05$

There is no significant difference between the groups.



For the pre-test results of logical thinking abilities, when the Table 2 is examined, the central tendency measures of the control and experimental groups are close to each other. However, as the control group's coefficient of skewness is 0.076, coefficient of kurtosis is -0.149 and the group contains 32 participants, it may mean that the distribution is normal. This may mean that the data set fits the normal distribution. As the coefficient of skewness of the experimental group is 0.085, coefficient of kurtosis is -0.615 and the group contains 32 participants, it may mean that the distribution is normal. Variance analysis was performed on the data set, and no significant difference was observed between the groups. Since the data set meets the parametric test assumptions, t-test was performed to test the significant difference between the groups.

**Table 4:** T-Test Results of Logical Thinking Abilities Pre-test

Groups	n	$\bar{x}$	S	sd	t	p*
Control Group	32	46.875	13.404	62	-.797	.428
Experimental Group	32	49.448	12.398			

p\* >0.05

Not significant difference is observed between the groups.

Considering the results of the academic achievement pre-test (Table 2) are examined, it is seen that the central tendency measures of the control group are close to each other. Thus, it can be said that the data set fits the normal distribution. When the data set of the experimental group is examined, it is seen that the central tendency measures differ from each other. However, as the coefficient of skewness is -0,237 and the coefficient of kurtosis is 0.344, it may mean that the distribution is normal. This may mean that the data set fits the normal distribution in terms of pre-test results. Variance analysis was performed for data set and it was observed that there was a significant difference between the groups according to the results obtained. As the data set did not meet the parametric test assumptions, Mann-Whitney U test was performed to test the significant difference between the groups.

**Table 5:** Mann-Whitney U Test Result of the Academic Achievement Test Pre-test

Groups	n	Mean Rank	Rank Sum	U	p*
Control Group	21	35.67	749.00	49.00	0.00
Experimental Group	27	15.81	427.00		

p\* < 0,05

According to the result, there is a significant difference between the groups.

### 3.2. Post-test Results

In the present study conducted on the Effect of Laboratory Activities Based on Argumentation Method on Critical Thinking Tendency, Logical Thinking Abilities and Academic Achievement of Science Teacher Candidates, post-test results were analysed.

**Table 6:** Descriptive Statistics of Post-test

Groups	Critical Thinking Tendency			Logical Thinking Abilities			Academic Achievement Test		
	n	$\bar{X}$	S	n	$\bar{X}$	S	n	$\bar{X}$	S
Control Group	21	89.595	12.497	21	42.577	14.397	21	51.984	13.282
Experimental Group	34	97.264	15.576	34	50.692	13.508	34	54.656	12.426

MANOVA test was conducted to test the difference between the control and experimental groups.

**Table 7:** Result of Intergroup MANOVA Test

Scale	Variance	F	p	$\eta^2$
Critical Thinking Tendency Scale	295.261	6.279	0.015	0.106
Logical Thinking Abilities Scale	126.839	1.636	0.206	0.030
Academic Achievement Test	1420.878	15.921	0.000	0.231

MANOVA test was conducted to examine the effect of argumentation method on critical thinking tendency, logical thinking abilities and academic achievement. Dependent variables of the analysis were the scores obtained from critical thinking tendency scale, logical thinking abilities scale and academic achievement test, and argumentation method was the independent variable. Prior to MANOVA, preliminary analyses were performed to control the assumptions of normality, linearity, univariate and multivariate extreme values, homogeneity of variance-covariance matrices, and multicollinearity assumptions. As the variance-covariance matrices were not homogeneous in the analyses ( $p=0.001$ ), Pillai's Trace Statistics was used to test the existence of significant difference between the groups, and a significant difference ( $p=0.00$ ) was observed between the groups. As a result of the MANOVA test, a significant difference was found between control group and experimental group in terms of dependent variables [ $F(3.51) = 5.86, p = 0.002$ ; Pillai's Trace = 0.348;  $\eta^2 = 0.93$ ]. When dependent variables were considered separately, statistically significant differences were found in the critical thinking tendency scale [ $F(1.53) = 6.27, p = 0.015$ ;  $\eta^2 = 0.106$ ] and academic achievement test [ $F(1.53) = 15.921, p = 0.00$ ;  $\eta^2 = 0.231$ ].

In the MANOVA test conducted (Table 7) to test the difference between the groups for the scores obtained from the critical thinking tendency scale post-test, a significant difference was observed between the mean scores of the control group scores and the mean scores of the experimental group to which laboratory activities based on the argumentation method were applied in favour of the experimental group [ $F(1.53) = 6.27, p = 0.015$ ;  $\eta^2 = 0.106$ ]. Calculated impact value ( $\eta^2 = 0.106$ ) is a small impact (Pallant, 2017). Argumentation requires investigation of evidence and consideration of counterarguments when advocating a situation (Maloney, 2007). This shows that argumentation method is effective on critical thinking in science education. (Aktamış &

Atmaca, 2016; Aydın, 2013). When the literature is reviewed, it is seen that there are studies showing similarities to the result obtained in the present (Bilasa & Taşpınar, 2018; Çakan Akkaş, 2017; Demirel, 2017; Ecevit, 2018; Meral, 2018; Sevgi, 2016; Tüzün, 2016) study. According to this result, it can be said that the argumentation method has an effect on critical thinking tendency of science teacher candidates.

In order to test the difference between the groups for the scores obtained from the post-test of logical thinking abilities scale, MANOVA test was conducted (Table 7) and no significant difference was found between the mean score of the control group and the mean score of the experimental group to which laboratory activities based on argumentation method were applied [ $F(1.53) = 1.61, p = 0.206; \eta^2 = 0.030$ ]. However, the post-test scores reveal that the mean score of the experimental group was higher than the mean score of the control group. This can be interpreted as the laboratory activities based on argumentation do not result in a significant difference in the logical thinking abilities of science teacher candidates.

Review of the literature shows that there are no studies in which argumentation method has no significant effect on logical thinking abilities. In the study conducted by Gökçe and Saraçoğlu (2018) on the effect of computer-assisted instruction on the academic achievement in the subject of acids and bases, attitude towards science and technology course and logical thinking abilities of 8th grade students, it was seen that computer-assisted instruction had no effect on the improvement of logical thinking abilities. The result was attributed to the applied method and short duration of the study time. When the studies in the literature are reviewed, it is seen that argumentation method has an effect on logical thinking abilities (Aydın, 2013; Dođru, 2016; Ecevit, 2018). Therefore, differing results obtained in the present study may not be caused by the applied method. When studies in the literature conducted on study time are reviewed, the study of Ecevit (2018) lasted 14 weeks, and the study of Dođru (2016) 8 weeks and the study of Aydın (2013) 14 weeks. Laboratory activities based on argumentation method prepared for the present study lasted 4 weeks. Differing results obtained in the present study may be caused by the shortness of the study period.

In the MANOVA test conducted (Table 7) to test the difference between the groups for the scores obtained from the academic achievement test, a significant difference was observed between the mean score of the control group and the mean score of the experimental group to which laboratory activities based on the argumentation method were applied in favour of the experimental group [ $F(1.53) = 15.921, p = 0.00; \eta^2 = 0.231$ ]. Calculated impact value ( $\eta^2 = 0.231$ ) indicates a big impact (Pallant, 2017). The review of the literature reveals that argumentation method facilitates learning, that the individuals express themselves easily and question the information, and that their learning becomes permanent. It was concluded that this increases the academic achievement (Meral, 2018). There are studies showing parallelism with the result obtained in the present (Aslan, 2018; Çakan Akkaş, 2017; Ceylan, 2012; Demirciođlu & Uçar, 2015; Demirel, 2017; Dođru, 2016; Meral, 2018; Okumuş, 2012; Polat et al., 2016; Yeşildađ-Hasançebi & Günel, 2013)

study. Thus, it can be said that the argumentation-based activity papers have an effect on the academic achievement of science teacher candidates.

### 3.3. Activity Papers Based on Argumentation Method

The data obtained by evaluating the activity papers prepared for experimental group based on argumentation method were provided on a weekly basis.

**Table 8:** Levels of Arguments Created by Teacher Candidates Regarding the Activities

Week	Frequency	Gain 1	Gain 2	Gain 3	Gain 4
Week 1	n	22	17	-	17
	%	78	60	-	60
Week 2	n	-	20	5	20
	%	-	80	20	80
Week 3	n	22	25	16	-
	%	81	92	59	-
Week 4	n	19	22	-	-
	%	79	91	-	-

(-: There is no activity regarding the related gain.)

It is seen that (Table 8) the level of argument creation for all gains has increased at the end of the process except for gain 1. Review of the literature revealed that there are studies similar to the result obtained. In the study conducted by Meral (2018) it was observed that the approach of argumentation-based science learning improved during the study time and argument creation abilities of the students was improved. In the study conducted by Torun and Şahin (2016) it was observed that the level of argument creation of the students increased in the in-class practices where argumentation-based teaching was carried out. In the study conducted by Öztürk (2013) it was seen that the level of argumentation creation improved in socio-scientific subjects and the quality of arguments increased. In the study conducted by Karışan (2011), written reports of teacher candidates revealed that the level of argument improved as the experience increased.

## 4. Recommendations

The suggestions established in the light of the results obtained in the present study conducted on the Effect of Argumentation Method on Critical Thinking Tendency, Logical Thinking Abilities and Academic Achievement of Science Teacher Candidates are presented below:

According to the results obtained from MANOVA test conducted to test the difference between the scores of the groups obtained from Critical Thinking Tendency post-test, there is a significant difference in favour of the experimental group. Based on this result, it can be said that the argumentation method has an effect on critical thinking tendency of science teacher candidates. Argumentation method should be used in in-class activities to improve the critical thinking tendency of science teacher candidates.

According to the results obtained from MANOVA test conducted to test the difference between the scores of the groups obtained from Logical Thinking Abilities post-test, no significant difference was found in favour of the experimental group. This result does not coincide with the studies in the literature. Review of the duration of the studies in the literature and the present study indicate that this situation may stem from the study duration. Attention should be paid to study duration to improve logical thinking abilities.

According to the results obtained from MANOVA test conducted to test the difference between the scores of the groups obtained from Academic Achievement post-test, there was a significant difference in favour of the experimental group. Thus, it can be said that argumentation method has an effect of academic achievement. This result coincides with the studies in the literature. Academic achievement may be increased by way of using argumentation method in in-class activities.

This study is limited to gases, chemical equilibrium, chemical kinetics and thermochemistry subjects within the scope of Chemistry Laboratory Practices II course. It can be applied to other subjects within the scope of the course as well as other courses.

## 5. Conclusion

In the present study conducted on the Effect of Argumentation Method on Critical Thinking Tendency, Logical Thinking Abilities and Academic Achievement of Science Teacher Candidates, following conclusions were reached:

MANOVA test was conducted to test the difference between the control and experimental groups regarding the scores obtained in the post-test of the Critical Thinking Tendency Scale, and a significant difference was found in favour of experimental group. Review of the literature revealed that the argumentation method has an effect on the critical thinking tendency. (Çakan Akkaş, 2017; Demirel, 2017; Ecevit, 2018; Meral, 2018; Torun & Şahin, 2016; Tüzün, 2016). When Table 8 is analysed, it is seen that the level of argument [creation] related to argumentation gains of teacher candidates gradually improved during the study. Thus, it can be said that the argumentation-based activity papers have an effect on critical thinking tendency of teacher candidates. In the study conducted by Bilasa and Taşpınar (2018), it was seen that the argumentation method improved critical thinking abilities and willingness for discussion of English teacher candidates. In the study conducted by Sevgi (2016), it was seen that argumentation method had an effect on the improvement of critical thinking, decision-making and argument creation levels. The results obtained in the present study and in similar studies in the literature coincide. From this point of view, it can be said that the activities based on argumentation method have an effect on the critical thinking tendency of science teacher candidates.

MANOVA test was conducted to test the difference between the groups regarding the scores obtained from Logical Thinking Abilities Scale post-test, and no significant difference was found in favour of the experimental group. The results obtained in the

studies in the literature (Aydın, 2013; Doğru, 2016; Ecevit, 2018) and in the present study do not coincide. In the study conducted by Gökçe and Saraçoğlu (2018), it was seen that computer-assisted instruction did not have an effect on the improvement of logical thinking abilities. The reason was identified as the shortness of the study time. The review of the duration of studies in the literature (Aydın, 2013; Doğru, 2016; Ecevit, 2018) revealed that they were longer than the time spent for the present study. This might be the reason for the result obtained in the present study. From this point of view, it can be said that activities based on argumentation method do not have an effect on the logical thinking abilities of science teacher candidates.

MANOVA test was conducted to test the difference between the groups regarding the scores obtained from the Academic Achievement Test Post-test, and a significant difference was found in favour of the experimental group. The review of the studies in the literature (Aslan, 2018; Ceylan, 2012; Çakan Akkaş, 2017; Demircioğlu & Uçar, 2015; Demirel, 2017; Doğru, 2016; Meral, 2018; Okumuş, 2012; Polat et al, 2016; Torun & Şahin, 2016; Yeşildağ-Hasançebi & Günel, 2013) revealed that there are studies concluding that argumentation method has an effect on academic achievement. According to this result, it can be said that the argumentation method has an effect on academic achievement. Review of argumentation-based activity papers revealed that argument creation abilities of teacher candidates improved during the study. The review of the studies in the literature (Meral, 2018; Öztürk, 2013; Topçu et al., 2014; Torun & Şahin, 2016) revealed that there are studies showing similarity with the result obtained in the present study. A significant difference was found between critical thinking tendency and academic achievement post-test scores of the groups in favour of the experimental group to which argumentation-based activity papers were applied. This result can be attributed to argument creation abilities of teacher candidates during the study.

### **About the Authors**

**Dr. Hüseyin Polat** graduated from Inonu University with a BSc degree in 2010 and got his MSc and PhD degrees 2014 and 2019, respectively. He is a science teacher in Ministry of National Education from 2012. His major research interests for science includes argumentation, science education and teacher education.

<https://orcid.org/0000-0002-6990-0707>

<https://scholar.google.com/citations?user=2EP3RsEAAA&hl=tr>

**Dr. Fatma Bilge Emre** graduated from Inonu University with a BSc degree in 1997, and got her MSc and PhD degrees 2001 and 2007, respectively. She is a research assistant at Faculty of Education in Inonu University from 2001. Her major research interests for science include electrochemical synthesis of conducting polymers, and biosensors and science education with argumentation was another major research interest.

<https://orcid.org/0000-0002-2972-5596>

<https://scholar.google.com/citations?user=361McOAAAA&hl=tr>

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