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The Relationship between Argumentation Skills and Cognitive Flexibility of Pre-Service Science Teachers

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Abstract

The present study aims to investigate the relationship between pre-service science teachers' argumentation skills and cognitive flexibility levels. Within the scope of the study, an argumentation-based science laboratory application was applied to first year science teaching students for 4 weeks. The arguments were assessed by eight faculty members and doctoral students. The Argumentation Assessment Rubric (Choi, 2008) was used to assess the quality of the written arguments. The quality of the arguments and descriptions used by the students in the reports were evaluated as total writing scores. The "Cognitive Flexibility Inventory" developed by Dennis and Vander Wal (2010) was employed to assess the cognitive flexibility levels of pre-service teachers. Simple Correlation analysis and Simple Linear Regression analysis methods were used to determine the relationship between the sub-dimensions of cognitive flexibility inventory and argumentation skills of pre-service science teachers and the effect of cognitive flexibility levels on argumentation skills. The results showed that there was a significant relationship between pre-service teachers' cognitive flexibility levels and argumentation skills.

Keywords: Argumentation, Argumentation skills, Cognitive flexibility, Science education, Pre-service teachers, Science laboratory.

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Ethical: This study followed all ethical practices during writing.

Contents

Contribution of this paper to the literature
This study contributes to the literature in terms of showing that if pre-service teachers gain the ability to view cognitively flexible towards the problems they will encounter in the teaching processes, they can enable to take their argumentation skills to a higher level.

1. Introduction

To keep up with the developments in today's information and technology age and to compete with other countries, countries aim to equip their citizens with the qualities required by the age. To be able to do this in the 21st century when knowledge is seen as power, they need individuals who can distinguish necessary information from complex information, who can put together parts, have developed intuition, empathy, and understanding, and have a social, cultural, and political identity (Genc & Eryaman, 2008). To raise individuals with these qualifications and competencies, the curricula in education systems were restructured, and novel teaching methods started to be applied. From this direction, the science curriculum in our country has been prepared with the focus of inquiry-based learning method, which is based on the constructivist learning approach (MoNE, 2017). One of the inquiry-based practices that have great importance in science classes is the argumentation method (Kabataş-Memiş & Cakan-Akkaş, 2016).

Argumentation-based teaching approaches have been developed to enable students to have effective learning experiences with the argumentation method. One of these approaches is "Science Writing Heuristic," developed by Keys, Hand, Prain, and Collins (1999) which was first translated into Turkish as "Learning Science by Doing and Writing (LSDW)" (Günel, Memis, & Büyükkasap, 2010) but then re-translated in the following years as "Argumentation-Based Science Learning (ABSL)," which was more suitable for its nature (Kıngır, Geban, & Günel, 2011). ABSL is a learning/teaching approach based on verbal/written argumentation, which helps students to experience in science classes the processes that scientists follow during their experiments and to construct scientific concepts in their minds (Ulu, 2018).

ABSL provides learning environments that help students to reflect on concepts in light of new knowledge by making use of their prior knowledge, concepts, beliefs, and experiences (Sabanci-Yalcin, 2019). ABSL is a reflection of the dialogue and argumentation process in which scientists engage when constructing a theory or a concept (Poock, Burke, Greenbowe, & Hand, 2007).

The argumentation is a process that runs around arguments (Kuhn & Udell, 2003). An argumentation process consists of reasons or statements to criticize or support a claim made on any topic and arguments defined as relational situations between the claims supported or refuted (Fettahlıoğlu, 2013).

According to the Turkish Language Association (TDK), the word argument means "evidence, claim, assertion". It has been used by scientists with various meanings. An argument can occur as an individual activity through thinking and writing, or as a social activity taking place within a group; it involves putting forward reasons for an event or situation and testing the reasons for the event/situation from different perspectives on appropriate evidence (Driver, Newton, & Osborne, 2000). Toulmin (1958) argues that an argument is a collection of evidence and theories put forward to justify a claim, refute or support an explanatory prediction (Toulmin, 2003). According to Işıker (2017) an argument can also be accepted as a form of proof used to draw a conclusion from the available data in order to support, verify, or strengthen a claim or idea. While an argument includes a claim, data, rationale, and backing that contributes to an idea, argumentation refers to the sum of these components. Based on these definitions, we can say that an argument is one of the components that make up an argumentation process (Cınar, 2013).

A simple argument is created with basic components such as claims, data, and rationale, whereas a complex argument includes, in addition to these basic components, backings, qualifiers, and rebuttals as auxiliary components. The number of components used in an argument determines the quality of that argument (Uğurlu, 2019).

The argumentation process, which consists of arguments, is the process of convincing the other party through evidence of the correctness of the claim that is defended individually or as a group (Aydın, 2013). According to Toulmin (2003), argumentation is the process of using data, rationale, backing, and rebuttal to convince people of the validity of a particular claim. According to Öğreten and Uluçınar, it is an approach that leads one to think like a scientist (Oğreten & Uluçınar-Sağır, 2014).

The argumentation model was developed by Toulmin (1958). Studies on the use of the argumentation method in science teaching mostly employed Toulmin's argumentation model (Toulmin, 2003). The model reveals the connections among a "claim" supported by data (evidence), "warrant" (the chain of reasoning) between the evidence and the claim, the "backing" that supports the reasoning, "qualifiers" that determine the limits or conditions of the presented claim, and "rebuttals" that identify exceptions to the claim (Osborne, Erduran, & Simon, 2004). Suggesting that argumentation is an integral part of the reasoning process both in everyday life and in science, Toulmin presented a model that defines the components of argumentation and shows the relationships among them Figure 1. In this model, the essential components of an argument are claim, data, and the warrant; more complex arguments include backing, qualifiers, and rebuttals in addition to these (Toulmin, 2003).

Supporting Toulmin's argumentation model, Kaya and Kılıç (2008) argue that the data, claim, and warrant, which are the essential elements of an argument, form the basis of an argument, and the backing, rebuttals, and qualifiers contribute to the validity of the argument (Kaya & Kılıç, 2008).

Toulmin (2003) defines the components in an argument as follows: Data: Also called grounds or evidence, these support the claim. Claim: A statement, result, thought, or opinion that represents the point of view. Warrant: The warrant is the link between the data and the claim. It consists of basic principles and rules. Backings: Reasons that support the warrant are called backing. They help strengthen the claim. Qualifiers: They limit the cases where the claim is accepted as true. They enable a persuasive argument by strengthening the link between data, warrant, and claim. Rebuttals: They present counter-arguments or identify exceptions to the claim.

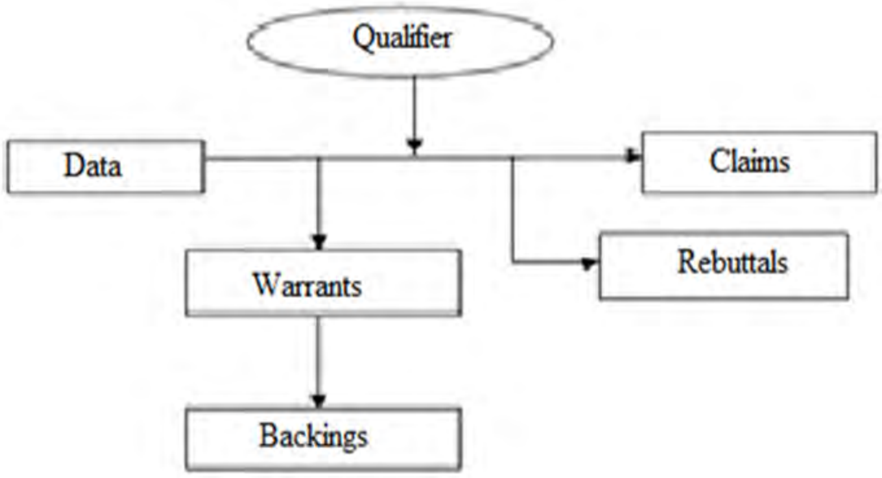

Figure 1. Toulmin's argumentation model (Toulmin, 2003).

According to the argumentation model developed by Toulmin, the individual makes a series of evaluations about a situation or event he/she encounters. Following these evaluations containing facts and evidence, the individual makes a claim. Providing data to back the claim, the individual presents a warrant to both establish a link between the data and the claim and strengthen the claim. If the warrant put forward by the individual does not convince the other party, the backing is used to support the reasons. Nevertheless, the other party can refute the claim by using rebuttals. A scientific argumentation containing rebuttals is of higher quality than an argumentation that consists only of claims (Balcı, 2015).

Jimenez-Aleixandre and Erduran argue that argumentation, which is an integral part of science, should be incorporated into science education (Jiménez - Aleixandre & Erduran, 2007). Köseoğlu, Tümay, and Budak (2008) suggest that argumentation is an effective teaching method that can support scientific literacy and an important scientific thinking skill that needs to be developed (Köseoğlu, Tümay, & Budak, 2011). For this reason, studies that deal with argumentation in the context of learning have focused on how to improve argumentation skills (Uçar, 2018). This is because, argumentation, as emphasized in the curricula, is a scientific discussion technique that requires skills such as reasoning, arguing, and counter-arguing, and making inferences based on evidence (Kül, 2019). Toulmin (1958) considers the mentioned argumentation skills as a combination of claim, data, backing, qualifiers, and rebuttals (Toulmin, 2003). On the other hand, Foong and Daniel (2013) claim that these argumentation skills, which are highly important for science education, can manifest themselves by analyzing information, evaluating evidence, and producing and presenting an argument.

According to Uçar (2018), argumentation skills refer to one's ability to form arguments that include a theory, evidence, an alternative theory, a counter-argument, and rebuttals to back one's claims.

Kuhn describes these skills as a combination of the skills of asserting, showing evidence, counter-arguing, and refuting (Kuhn, 1991), Marttunen and Laurinen as the ability to formulate sufficient and relevant arguments about claims or opinions (Marttunen and Laurinen (2006); as cited in Uçar (2018)) and Lin and Mintzes as making a claim, justifying the claim, being aware of counter-arguments, elaborating the reasons, backing the reasons, refuting counter-arguments, and showing evidence (Lin & Mintzes, 2010).

Indeed, many researchers have drawn attention to the importance of developing argumentation skills in educational settings so that learners can cope with the complex problems of today's world, make appropriate decisions, and become active stakeholders of the information society (Uçar, 2018).

Argumentation skill is seen as a prerequisite for individuals to develop scientific thinking skills and, as a result, to have a more realistic and critical perspective on personal and social issues and to make better decisions (Demirel., Somyürek, & Yılmaz, 2017).

It is emphasized that argumentation skills have an important role in acquiring and the application of high-level thinking skills such as critical thinking, problem solving and decision making skills (Uçar, 2018). Considering these skills, which are aimed to be gained in science education, it is seen that the argumentation method is supportive in science education (Aydın & Kaptan, 2014). With an effective science education, it is possible to find solutions to daily life problems (Gölcük, 2017). Accordingly, cognitive flexibility, like argumentation, is an important phenomenon in science education in terms of having the capacity to think that there are more than one solution to problems or changing situations and to choose between alternatives (Soylu, 2019).

Cognitive flexibility can be defined as the ability to adapt to new situations, to switch from one thought to another, or to approach different problems with multiple strategies (Asıcı & İkiz, 2015). Batting defines cognitive flexibility as the skill of using the most effective learning strategy for specific content or of determining the problem-solving steps to solve a certain problem (Batting, 1979). Cañas, Fajardo, and Salmerón (2006) define cognitive flexibility as the ability to adapt one's cognitive processing strategies to new and unexpected conditions (Cañas et al., 2006). Spiro and Jehng (1990), on the other hand, define cognitive flexibility as the ability to spontaneously restructure one's knowledge, in many ways, to give an adaptive response to radically changing situational demands.

According to Martin and Anderson (1998), what is important in cognitive flexibility is not seeing the right option but seeing the options before making a choice. They state that cognitive flexibility includes three basic elements: a) being aware of alternative ways and options, b) being able to adapt to new situations (willingness to be), c) feeling self-efficacy in situations when one is flexible.

Cognitive flexibility has been theoretically explored by Spiro et al. According to Spiro et al., in the cognitive flexibility theory, "cognitive" refers to the recall of pre-existing knowledge from memory at the time of the acquisition of new knowledge, while "flexibility" refers to the flexible use of acquired knowledge in various fields (Spiro, Feltovich, Jacobson, & Coulson, 1992).

The cognitive Flexibility theory was developed for the attainment of expert-level performance by providing advanced knowledge-acquisition in ill-structured knowledge domains by taking advantage of the possibilities of developing technology (Karadeniz, 2004). The cognitive flexibility theory is associated with the transfer of knowledge and experience. This requires knowledge to be handled from different perspectives and with various experiences. The fact that cognitive flexibility depends on learning makes cognitive flexibility important. It is extremely important to structure knowledge according to the situation and to build on what has been previously learned.

Students should be able to flexibly adapt their knowledge to different situations. However, if knowledge is oversimplified, students will view the content from a single point of view. To solve this problem, the cognitive flexibility theory emphasizes the need for different representations of knowledge in teaching. The material is organized and employed in different ways to increase advanced knowledge acquisition, to make students cognitively flexible, and to equip students with different perspectives. Thus, with different representations of knowledge, the cognitive structure is rearranged from different angles many times (Karadeniz, 2004).

It has been reported that people with high levels of cognitive flexibility are observed to be flexible in terms of communication, aware of their options in communication and problem situations, assertive, sensitive, self-confident in communication, and are tolerant of conflicts and uncertainties (Martin & Rubin, 1995). Similarly, cognitively flexible individuals are aware of alternative solutions and can choose the optimal solution, have self-control, and are analytical and open to innovation (Jonassen & Grabowski, 1993).

The cognitive flexibility required for harmonious and balanced thinking to replace discordant thinking consists of two sub-dimensions. The first sub-dimension is the ability to generate alternative solutions. This refers to the ability to generate solutions to difficult situations. The second sub-dimension is the ability to control. This sub-dimension refers to the belief that difficult situations can be taken under control (Dennis & Vander Wal, 2010).

In terms of relations with people, teaching, unlike some other professions, is a profession that is carried out in relation and interaction with a wide range of people (Celikten, Sanal, & Yeni, 2005). For this reason, those who do the teaching profession should know how to respond to different situations and develop alternative solutions in problem situations, and they should have cognitive skills. In short, high levels of cognitive flexibility are one of the most important traits that a teacher should have (Cuhadaroğlu, 2013).

Likewise, according to Anderson (2002), individuals with high cognitive flexibility levels do not have absolute and strict rules: they adapt more easily to new situations and are open to change. Research has shown that individuals with increased academic knowledge and expertise working within a certain routine with few changes experience a decrease in their cognitive flexibility levels. On the other hand, it is thought that experience in the teaching profession positively affects the teacher's cognitive flexibility because the more experienced the teacher gets, the more people and life events he/she is expected to meet and encounter (Cuhadaroğlu, 2013).

In 21st century teacher education, it is important to develop cognitive flexibility skills in order to train teachers with advanced thinking skills and can adapt to changing situations (Esen-Aygün, 2018). At the same time, it is emphasized that argumentation skills have an important role in gaining high-level thinking skills such as critical thinking, problem solving and decision making and in the application of these skills (Uçar, 2018). In this context, it was investigated, the relationship between pre-service science teachers' argumentation skills and cognitive flexibility levels, in this study. Within the scope of the research, argumentation-based science teaching was carried out with science teacher candidates.

2. Method

2.1. Research Design

This study is in the relational screening model in that it reveals the relationship between the argumentation skills of pre-service science teachers and their cognitive flexibility levels. In the relational screening model, it is aimed to determine the existence and/or degree of co-variance between two or more variables (Karasar, 2008).

2.2. Working Group

The study group of this research consisted of 48 men (40 women (83.3%) and 8 men (16.7%)) teacher candidate studying at Faculty of Education, Department of Science Education in the 2018-2019 academic year. The reason why the study group was limited to 48 people is that this study is a continuation of another experimental study consisting of 48 pre-service teachers who received argumentation-based training for 4 weeks.

2.3. Data Collection Tools

2.3.1. Cognitive Flexibility Inventory

In order to determine the cognitive flexibility levels of the participants, the Cognitive Flexibility Inventory (CFI-Cognitive Flexibility Inventory), developed by Dennis and Vander Wal (2010) and adapted into Turkish by Sapmaz and Doğan (2013), was used. The inventory consists of two sub-dimensions named "alternatives" and "control" and a total of 20 items. The internal consistency of the measurements obtained from the inventory was calculated with the help of Cronbach's alpha reliability coefficient and it was found that $\alpha = 0.90$ for the "alternatives" sub-dimension, $\alpha = 0.84$ for the "control" sub-dimension, and $\alpha = 0.90$ for the whole inventory. In addition, the test-retest reliability coefficient was calculated in testing the reliability, and it was calculated as 0.78 for the "alternatives" sub-dimension, 0.73 for the "control" sub-dimension, and 0.75 for the entire inventory. The validity of the inventory was examined by obtaining evidence for criterion-based and construct validity. Based on the Exploratory Factor Analysis, the "Alternatives" sub-dimension explained 36.18% of the total variance and the "control" sub-dimension explained 13.49% of the total variance. Based on Confirmatory Factor Analysis, it was determined as RMSEA: 0.054; $\chi 2$ /df: 2.44; GFI: 0.92; AGFI: 0.90; NFI: 0.96; RMR:0.054.

It can be said that the reliability and validity of the measurements obtained from the CFI based on these values are high. In this study, Cronbach's alpha reliability coefficients were found as $\alpha = 0.806$ for the "alternatives" sub-dimension, $\alpha = 0.809$ for the "control sub-dimension, and $\alpha = 0.843$ for the entire inventory, based on the measurements obtained from this inventory applied to prospective teachers.

In the measurement of argumentation skills, Argumentation-Based Learning Science (ABLS) Report Evaluation Rubric (Choi, 2008) was used.

2.3.2. ABSL Report Assessment Rubric

The ABSL was a uniform approach adopted in all sections. Within this approach, students were asked to generate research questions, design an observation procedure or experiment to investigate the research questions, collect data, generate evidence, form a claim in relation to the research questions and evidence, and reflect on the investigation procedure as well as changes in their ideas during the activity. At the end of each activity, students filled out activity reports where they were asked to display the research question, design, claim, evidence, and reflections. topics studied to middle school students (Kuhn & Udell, 2003).

To determine the argument formation skills of pre-service teachers, the arguments they created were analyzed by 8 lecturers and doctoral students applying the ATPPC report rubric used in the work of Choi (2008) where the quality of the arguments and descriptions used by the students in the reports were evaluated as total writing scores.

Table 1. Levels evaluation scale.

Argument Levels	Criterion	Score
Level 1	Only Estimation	1
	Using Data	2
	Data and Rationale	3
Level 2	Only Estimation	1
	Using Data	2
	Data and Rationale	3
Level 3	No Specific Claim	1
	Specific Claim	2
	Claim + Data	3
	Claim + Data + Rationale	4
	Claim + Data + Rationale + Supporting	5
Level 4	Using Only Data	1
	Data + Rationale	2
	Data + Rationale + Supporting	3
	Counter Claim + Data	4
	Counter Claim + Data + Supporting	5

The type of inter-rater agreement adopted for this study was percentage of absolute agreement calculated by the number of times raters agree on a rating, then divided by the total number of ratings. Thus, this measure can vary between 0 to 100%. In this study, percentage of absolute agreement between any pairs of scores for each report ranged from 90% to 95%.

The arguments made by the students are classified in 4 levels. At the first level, pre-service teachers were asked to evaluate a claim and to support this claim with data. At the second level, they were asked to evaluate and indicate the cause of an existing claim. At the third level, it was requested to create claims and to support these claims with data. The difference between this level and the others is that the pre-service teachers need to create and justify their own claims in the given issue. At the fourth level, they were asked to make a counter argument and to support this with data Table 1.

2.4. Data Analysis

The aim of this study is to determine the relationship between the sub-dimensions of cognitive flexibility inventory and argumentation skills of pre-service science teachers and the effect of cognitive flexibility levels on argumentation skills. For this purpose, Simple Correlation analysis and Simple Linear Regression analysis methods were used. While simple correlation analysis does not provide information in the context of cause and effect, it gives an idea about the level and direction that the variables change together (Büyüköztürk, 2013). In the correlation analysis, before calculating the Pearson Product Moments Correlation coefficient, the necessary normality assumption was examined and it was seen that the assumption was met (Shapiro-Wilk statistic for the total score from the cognitive flexibility inventory = 0.969, df=48, p=0.236; Shapiro-Wilk statistics for the Alternatives sub-dimension of the cognitive flexibility inventory = 0.961, df=48, p=0.114; Shapiro-Wilk statistic for the Control sub-dimension of the cognitive flexibility inventory = 0.954, df=48, p=0.058; Shapiro-Wilk statistic for the total score obtained from the argumentation skill rubric = 0.975, df=48, p=0.396). Simple regression analysis is an analysis for estimating the dependent variable based on an independent variable that is related to the dependent variable (Büyüköztürk, 2013). When estimates are made using a regression equation, only the relationship between the dependent and independent variable is assumed to be linear, and no assumptions about the distributions of these variables need to be tested (Kirk, 2008). However, in the interpretation of the standard error of the estimation in the regression based on the least squares estimation method, some assumptions need to be tested. For this reason, the assumption of normal distribution of the measurements of the dependent (argumentation skill score) and independent variable (cognitive flexibility score) was tested and it was found that the assumption was met (Shapiro-Wilk statistic for the total score from the cognitive flexibility inventory = 0.969, df=48, p=0.236; Shapiro-Wilk statistic for the total score obtained from the argumentation skill rubric = 0.975, df=48, p=0.396).

2.5. Experimental Proses

In this study, within the scope of the General Chemistry Laboratory course, a unit was taught to the 1st year students of Science Education for 4 weeks, with the Argument-Based Science Teaching method, and the arguments formed by the pre-service teachers were evaluated at the end of the application. In addition, the Cognitive Flexibility Inventory was applied to the pre-service teachers to whom the application was made.

3. Results

The descriptive statistics of the scores obtained from the measurement tools used to measure the cognitive flexibility levels and argumentation skills of the pre-service teachers are presented in Table 2.

Table 2. Descriptive statistics of CFI and argumentation skills rubric.

Parameters	N	Min	Max	$\bar{X}$	S.D.	Skewness	Kurtosis
CFI-Alt.	48	55	90	75.94	8.05	-0.654	0.111
CFI-Control	48	13	46	32.21	8.38	-0.387	-0.842
CFI-Total	48	78	136	108.15	13.85	-0.264	-0.772
Argumentation	48	28	65	48.65	9.74	-0.142	-0.746

As seen in Table 2, the highest score that can be obtained from the CFI sub-dimensions is 91 and 49 for "alternative" and "control" respectively, while the mean score of the pre-service teachers participating in the research is 75.94 in the "alternative" sub-dimension; 32.21 in the "control" sub-dimension; and the mean score of CFI total score was found 108.15. While the scores that can be obtained from the argumentation skills rubric can vary between 0 and 100, it has been observed that the scores of the teacher candidates participating in the research vary between 28 and 65.

Table 3. The results of simple correlation analysis to determine the relationship between the sub-dimensions and total score of the cognitive flexibility inventory and argumentation skills.

Parameters	Statistical notation	CFI-Alt.	CFI-Control	CFI-Total	Argumentation
CFI-Alt.	r	1	0.419*	0.835*	0.354
	p		0.003	0.000	0.014
	N	48	48	48	48
CFI-Control	r	0.419*	1	0.849**	0.390**
	p	0.003		0.000	0.006
	N	48	48	48	48
CFI-Total	r	0.835*	0.849*	1	0.442*
	p	0.000	0.000		0.002
	N	48	48	48	48
Argumentation	r	0.353*	0.390*	0.442*	1
	p	0.014	0.006	0.002	
	N	48	48	48	48

Note: *$p<0.05$; **$p<0.01$.

The results of the simple correlation analysis calculated to determine the relationship between the sub-dimensions and sub-dimensions of the cognitive flexibility inventory and argumentation skills are given in Table 3.

It can be said that as the general cognitive flexibility level, control and alternative sub-dimension scores increase, argumentation skills increase. There is a moderately positive and significant relationship between pre-service teachers' argumentation skills and general cognitive flexibility levels (G.CFI) ($r = 0.442$), control sub-dimension of cognitive flexibility ($r = 0.389$) and alternatives sub-dimension of cognitive flexibility ($r = 0.353$) ($p<.05$). It can be said that as the general cognitive flexibility level, cognitive flexibility scale control and alternative sub-dimension scores increase, argumentation skills increase.

The results of the Simple Linear Regression analysis performed to determine the effect of pre-service teachers' cognitive flexibility levels on their argumentation skills are presented in Table 4.

Table 4. Simple regression analysis results on determining the effect of cognitive flexibility levels on argumentation skills.

Variable	B	S.H.	β	t	p
Constant	15.052	10.140		1.484	0.145
Cognitive Flexibility Level	0.311	0.093	0.442	3.341	0.002*
$R = 0.442$ $R^2 = 0.195$ $F(1.47) = 11.159$ $p = 0.002$*					

Note: *$p<0.05$.

When Table 4 is examined, as a result of simple linear regression, cognitive flexibility levels of teacher candidates on argumentation skills is a statistically significant predictor variable ($p<0.05$). It is seen that the cognitive flexibility level regression coefficient is 0.311. Accordingly, a one-unit increase in cognitive flexibility scores causes an increase of 0.311 units on argumentation skills. Accordingly, as the cognitive flexibility levels of pre-service teachers increase, their argumentation skills also increase.

In this model, it is seen that the independent variable has a 19.5% effect on the dependent variable. In other words, approximately one-fifth of pre-service teachers' argumentation skills can be explained by their cognitive flexibility levels.

4. Discussion and Conclusions

According to the results of our study, whose overall purpose is to examine the relationship between pre-service science teachers' argumentation skills and cognitive flexibility, there is a positive relationship between argumentation skills and cognitive flexibility.

In the study, it was observed that those with a higher level of cognitive flexibility had higher levels of argumentation skills.

As regards the relationship between argumentation skills and the "control" sub-dimension of cognitive flexibility, participants who could control difficult situations had higher levels of argumentation skills. Similarly, as regards the relationship between argumentation skills and the "alternatives" sub-dimension of cognitive flexibility, participants who could view events from different perspectives and generate alternative solutions to difficult situations had higher levels of argumentation skills, although the level of argumentation skills related to the "alternatives" sub-dimension of cognitive flexibility was lower than that related to the "control" sub-dimension of cognitive flexibility. Finally, it was observed that participants with higher scores from the overall CFI had higher levels of argumentation skills, and the level of argumentation skills related to the overall CFI was higher than those related to "alternatives" and "control" sub-dimensions.

A thorough search of the literature on cognitive flexibility shows that studies have focused on many different issues. In these studies, a positive relationship was found between cognitive flexibility and problem-focused coping (Johnson, 2016), a lower cognitive flexibility was associated with a lower ability to cope with stressful life events (Zong et al., 2010), a significant relationship was found between cognitive flexibility level and impulsive, logical, and dependent decision-making strategies depending on the educational level (Bilgic & Bilgin, 2016), attentional performance and cognitive flexibility were positively associated with meditation practice and levels of mindfulness (Moore & Malinowski, 2009), cognitive flexibility positively predicted openness to change and academic performance (Lin, 2013), cognitive flexibility was positively associated with intellectual flexibility and self-compassion, and negatively related to dogmatism, and there was no significant relationship between preference for consistency and cognitive flexibility (Martin, Staggers, & Anderson, 2011), adolescents with high levels of social self-efficacy expectations were found to be more cognitively flexible than other adolescents and authoritarian parenting was reported to be an obstacle to cognitive flexibility (Bilgin, 2009), and cognitive flexibility and self-compassion were found to have a positive and significant relationship with constructive problem-solving and insistent-persistent approach, which are the sub-dimensions of problem-solving skills (Sarıkaya, 2019).

Considering the relevant literature, there are results indicating that argumentation contributes to academic performance (Ceylan, 2010; Oğreten & Uluçınar-Sağır, 2014; Uluay & Aydın, 2018), promotes decision-making skills (Gülhan, 2012; Patronis, Potari, & Spiliotopoulou, 1999), improves conceptual understanding (Dawson & Venville, 2010; Yeh & She, 2010), positively affects communication skills (Kabatas, 2017; Kuhn, Goh, Iordanou, & Shaenfield, 2008), is effective in teaching socio-scientific subjects (Karışan, Yılmaz-Tüzün, & Zeidler, 2017; Lin & Mintzes, 2010), contributes to the development of critical thinking skills (Demiral, 2014; Kunsch, Schnarr, & van Tyle, 2014), and improves problem-solving skills (Mcghee, 2015; Oh, 2004). In the light of these, we can say that people who use the argumentation method in their daily lives can effectively use the above-mentioned high-order thinking skills, as well as argumentation skills (i.e., claiming, backing, refuting, and showing evidence) when they encounter a problem or need to evaluate a situation or event. Similarly, Demiral stated that the argumentation method, which has made important contributions to science education, supports students to acquire questioning and argumentation skills (Demiral, 2014).

Based on all these studies, we can expect the people with advanced argumentation skills, to have high levels of "cognitive flexibility" ability, which can be expressed as the ability of to cope effectively with new and difficult situations, to be aware of options, to produce alternative thoughts and ideas, and to adapt to new situations (Asıcı & İkiz, 2015). From this point of view, we believe that improving the cognitive flexibility levels of pre-service teachers may be effective in the development of argumentation skills, which are extremely important in science education. It is important to equip students with these skills because argument and criticism are at the heart of science, combining the "handling" work of scientific research with the "rational" work of emerging scientific ideas and theories (as cited in Karadeniz (2016)).

5. Recommendations

Within the framework of these results, it would be beneficial to increase the lessons and lesson hours in which the argumentation method, which has been explained and applied more comprehensively in the teacher training process, whose positive contributions to science education have been revealed in many studies, and to strengthen the infrastructures of the classrooms and science laboratories necessary for pre-service teachers to develop their argumentation skills. Again, in terms of contributing to the development of argumentation skills, practices that will support the development of cognitive flexibility skills can be included in teacher training programs.

References

Anderson, P. (2002). Assessment and development of executive function during childhood. *Child Neuropsychology, 8*(2), 71-82.Available at: https://doi.org/10.1076/chin.8.2.71.8724.

Asıcı, E., & İkiz, F. E. (2015). A pathway to happiness: Cognitive flexibility. *Mehmet Akif Ersoy University Journal of the Faculty of Education, 1*(35), 191 -211.

Aydın, O. (2013). *The effectiveness of providing education in the education of science and technology teachers.* Doctoral Thesis, Hacettepe University, Institute of Social Sciences, Ankara.

Aydın, O., & Kaptan, F. (2014). Effect of argumentation on metacognition and logical thinking abilities in science – technology teacher candidate education and opinions about argumentation. *Journal of Educational Sciences Research, 4*(2), 163-188.Available at: https://doi.org/10.12973/jesr.2014.42.10.

Balcı, C. (2015). *The effect of scientific argumentation based learnings in teaching of "Cell division and inheritance" units to 8th grade sstudents.* Master Thesis, Adnan Menderes University, Science Education, Aydın.

Batting, W. T. (1979). Are the important "individual differences" between or within individuals? *Journal of Research in Personality, 13*(4), 546-558.Available at: https://doi.org/10.1016/0092-6566(79)90015-1.

Bilgic, R., & Bilgin, M. (2016). Analysis of the relationship between the cognitive flexibility levels and decision strategies in adolescents based on sex and education level. *Uşak University Educational Research Journal, 2*(2), 39-55.

Bilgin, M. (2009). Some variables predicting cognitive flexibility. *Cukurova University Faculty of Education Journal, 3*(36), 142-157.

Büyüköztürk, S. (2013). *Manual of data analysis for social sciences.* Ankara: Pegem Academic Publishing.

Cañas, J., J., Fajardo, I., & Salmerón, L. (2006). Cognitive flexibility In. Karwowski W. (Eds), International encyclopedia of ergonomics and human factors (pp. 297-300). Boca Raton: Taylor and Francisa

Celikten, M., Sanal, M., & Yeni, Y. (2005). Teaching profession and features. *Erciyes University Faculty of Education Journal of Social Sciences Institute, 2*(19), 207-237.

Ceylan, C. (2010). *Implementing the science writing heuristic (SWH) approach in science laboratory activities.* Master Thesis, Gazi University, Institute of Education Sciences Ankara.

Choi, A. (2008). *A study of student written argument using the science writing heuristic approach ın ınquiry based freshman general chemistry laboratory classes.* Doctoral Thesis. The University of Iowa, Iowa City, by ProQuest LLC

Cınar, D. (2013). *The effect of argumentation based science instruction on 5th grade students' learning outcomes.* Master Thesis, Necmettin Erbakan University, Institute of Educational Sciences, Konya.

Cuhadaroğlu, A. (2013). Predictors of cognitive flexibility. *Cumhuriyet International Journal of Education, 2*(1), 86-101.

Dawson, V. M., & Venville, G. (2010). Teaching strategies for developing students' argumentation skills about socioscientific issues in high school genetics. *Research in Science Education, 40*(2), 133-148.Available at: https://doi.org/10.1007/s11165-008-9104-y.

Demiral, U. (2014). *Investigating argumentation skills of pre-service science teachers in a socio-scientific issue in terms of critical thinking and knowledge level: GM case.* Trabzon: Karadeniz Technical University, Institute of Educational Sciences.

Demirel, T., Somyürek, S., & Yılmaz, G. (2017). Investigation of middle school students' written argumentation skills about geometric objects and volume measurement. *Journal of Ahi Evran University Kirsehir Education Faculty (KEFAD), 18*(1), 191-211.

Dennis, J. P., & Vander Wal, J. S. (2010). The cognitive flexibility inventory: Instrument development and estimates of reliability and validity. *Cognitive Therapy and Research, 34*(3), 241-253.Available at: https://doi.org/10.1007/s10608-009-9276-4.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*(3), 287-312.Available at: https://doi.org/10.1002/(sici)1098-237x(200005)84:3%3C287::aid-sce1%3E3.0.co;2-a.

Esen-Aygün, H. (2018). The relationship between pre–service teachers' cognitive flexibility and interpersonal problem solving skills. *Eurasian Journal of Educational Research, 18*(77), 105-128.Available at: https://doi.org/10.14689/ejer.2018.77.6.

Fettahlıoğlu, P. (2013). Argumentation-based learning-teaching approach. Learning-Teaching Approaches and Practice Examples (pp. 157-198). Ankara: Pegem A. Publishing.

Foong, C.-C., & Daniel, E. G. (2013). Students' argumentation skills across two socio-scientific issues in a Confucian classroom: Is transfer possible? *International Journal of Science Education, 35*(14), 2331-2355.Available at: https://doi.org/10.1080/09500693.2012.697209.

Genc, S., & Eryaman, M. (2008). Changing values and new education paradigm. *Journal of Social Sciences of the Afyon Kocatepe University, 9*(1), 89-102.

Gölcük, A. (2017). *The effect of science education that is supported by scientific stories on students' creativity and affective properties.* Master Thesis Hacettepe University, Institute of Educational Science, Ankara.

Gülhan, F. (2012). *The investigation about the effect of argumentation on socio-scientific issues in scientific literacy for eighth grade students, tendency in the argumentation, decision making skills and science-social problems of sensitivity.* Master Thesis. Marmara University, Institute of Educational Sciences, Istanbul.

Günel, M., Memis, E. K., & Büyükkasap, E. (2010). Effects of the science writing heuristic approach on primary school students' science achievement and attitude toward science course. *Education and Science, 35*(155), 49-62.

Işıker, Y. (2017). *The effect of the argumentation based teaching method on students' academic success, scientific process skills and attitude within the context of the chapter: Let's get to know substance.* Master Thesis, Fırat University, Institute of Educational Sciences, Elazığ.

Jiménez - Aleixandre, M. P., & Erduran, S. (2007). Argumentation in science education: An overview. In S. Erduran & M. P. Jiménez - Aleixandre (Eds), Argumentation in science education: Perspectives from classroom - based research (pp. 3-27). Dordrecht, The Netherlands: Springer.

Johnson, B. T. (2016). *The relationship between cognitive flexibility, coping and symptomatology in psychotherapy.* Master Thesis Graduate School, Marquette University, Milwaukee, Wisconsin.

Jonassen, D. H., & Grabowski, B. (1993). *Handbook of individual differences, learning and instruction.* New Jersey: Lawrence Erlbaum Associates Publishers.

Kabataş-Memiş, E., & Cakan-Akkaş, B. N. (2016). Inquiry based application in preschool education: An example for the subject of density. *Online Science Education Journal, 1*(1), 17-29.

Kabatas, M. E. (2017). Opinions of teacher candidate on small group discussions ın argumentation applications. *Kastamonu Journal of Education, 25*(5), 2037-2056.

Karadeniz, S. (2004). Cognitive flexibility hypertexts and hypermedia. *The Turkish Online Journal of Educational Technology – TOJET, 3*(2), 119-124.

Karadeniz, A. (2016). A modelıng study on the skıll of argumentatıon *The Journal of Academic Social Science, 4*(36), 258-266.

Karasar, N. (2008). *Scientific research method.* Ankara: Nobel Academic Publishing.

Karışan, D., Yılmaz-Tüzün, O., & Zeidler, D. L. (2017). Quality of preservice teachers argumentation in socioscientific issues context. *International Journal of Human Science, 14*(4), 3504-3520.

Kaya, O., & Kılıç, Z. (2008). Argumentative discourse for the effective teaching of science. *Journal of Ahi Evran University Kirsehir Education Faculty (KEFAD), 9*(3), 89-100.

Keys, C. W., Hand, B., Prain, V., & Collins, S. (1999). Using the science writing heuristic as a tool for learning from laboratory investigations in secondary science. *Journal of Research in Science Teaching, 36*(10), 1065-1084.

Kıngır, S., Geban, Ö., & Günel, M. (2011). Students' ideas about the implementation of the argumentation based science inquiry approach in their chemistry course. *Journal of Ahmet Keles Faculty of Education, 32*(2), 15-28.

Kirk, R. E. (2008). *Statistics: An introduction* (5th ed.). Belmont, CA: Thomson Learning.

Köseoğlu, F., Tümay, H., & Budak, E. (2008). Paradigm changes about nature of science and new teaching aproaches. *Journal of Gazi Educaiton Faculty, 28*(2), 221-237.

Köseoğlu, F., Tümay, H., & Budak, E. (2011). Developing chemistry teacher candidates' understandings on argumentation-oriented teaching. . *Journal of Turkish Science Education, 8*(3), 105-119.

Kuhn, D. (1991). *The skills of argument.* Cambridge, UK: Cambridge University Press.

Kuhn, D., & Udell, W. (2003). The development of argument skills. *Child Development, 74*(5), 1245–1260.Available at: https://doi.org/10.1111/1467-8624.00605.

Kuhn, D., Goh, W., Iordanou, K., & Shaenfield, D. (2008). Arguing on thevcomputer: A microgenetic study of developing argument skills in a computer-supported environment. *Child Development, 79*(5), 1310-1328.

Kül, T. (2019). *Influence of argumentation-based teaching on scientific skills and argumentation skills of 7th grade students.* Master Thesis, Afyon Kocatepe University, Institute of Social Sciences, Afyon.

Kunsch, D. W., Schnarr, K., & van Tyle, R. (2014). The use of argument mapping to enhance critical thinking skills in business education. *Journal of Education for Business, 89*(8), 403-410.Available at: https://doi.org/10.1080/08832323.2014.925416.

Lin, S.-S., & Mintzes, J. J. (2010). Learning argumentation skills through instruction in socioscientific issues: The effect of ability level. *International Journal of Science and Mathematics Education, 8*(6), 993-1017.Available at: https://doi.org/10.1007/s10763-010-9215-6.

Lin, Y. W. (2013). *The effects of cognitive flexibility and openness to change on college students' academic performance.* Doctoral Thesis, La Sierra University, School of Education Sciences, Riverside.

Martin, M. M., & Rubin, R. B. (1995). A new measure of cognitive flexibility. *Psychological Reports, 76*(2), 623-626.Available at: https://doi.org/10.2466/pr0.1995.76.2.623.

Martin, M. M., & Anderson, C. M. (1998). The cognitive flexibility scale: Three validity studies. *Communication repots, 11*(1), 1-9.Available at: https://doi.org/10.1080/08934219809367680.

Martin, M. M., Staggers, S. M., & Anderson, C. M. (2011). The relationships between cognitive flexibility with dogmatism, intellectual flexibility, preference for consistency, and self-compassion. *Communication Research Reports, 28*(3), 275-280.Available at: https://doi.org/10.1080/08824096.2011.587555.

Marttunen, M., & Laurinen, L. (2006). Collaborative learning through argument visualisation in secondary school. *Trends in Learning Research,* 119-138.

Mcghee, M. (2015). *The effects of argumentatıon scaffoldıng in a problem-based learnıng course on problem-solvıng outcomes and learner motıvatıon.* Doctoral Thesis Electronic Theses, Treatises and Dissertations. Florida state Unıversıty College of Educatıon, Florida State University Libraries.

MoNE. (2017). *Science course (Primary School 3,4 and Secondary School 5, 6, 7, 8) curriculum.* Ankara: Board of Education and Discipline.

Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition, 18*(1), 176-186.Available at: https://doi.org/10.1016/j.concog.2008.12.008.

Oğreten, B., & Uluçınar-Sağır, S. (2014). Examining the effectiveness of science teaching based on argumentation. *Journal of Turkısh Scıence Educatıon*, *11*(1), 75-100.

Oh, S. (2004). *The effects of constraint based argumentation scaffolding and epistemological beliefs on ill structured diagnosis-solution problem solving*. Doctoral Thesis. University of Missouri-Columbia, US.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching*, *41*(10), 994-1020.Available at: https://doi.org/10.1002/tea.20035.

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision-making on a socio-scientific issue: Implications for teaching. *International Journal of Science Education*, *21*(7), 745-754.Available at: https://doi.org/10.1080/095006999290408.

Poock, J. R., Burke, K., Greenbowe, T. J., & Hand, B. M. (2007). Using the science writing heuristic in the general chemistry laboratory to improve students' academic performance. *Journal of Chemical Education*, *84*(8), 1371-1379.Available at: https://doi.org/10.1021/ed084p1371.

Sabanci-Yalcin, O. (2019). *The effect of argument-based inquiry approach on preservice primary school teachers understanding of science concepts and argumentation skill*. Master Thesis. Hacettepe University, Instute of Educational Sciences, Ankara.

Sapmaz, F., & Doğan, T. (2013). Assessment of cognitive flexibility: Reliability and validity studies of Turkish version of the cognitive flexibility inventory. *Ankara University Journal of Faculty of Educational Sciences*, *46*(1), 143-162.Available at: https://doi.org/10.1501/egifak_0000001278.

Sarıkaya, N. (2019). *Analyzing of interpersonal problem solving among adolescents in terms of cognitive flexibility and self-compassion*. Master Thesis Necmettin Erbakan University, Institute of Educational Sciences, Konya.

Soylu, F. (2019). *Investigation of the relationship between preschool teachers' attitudes towards science education and cognitive flexibility levels*. Master Thesis. Kütahya Dumlupınar University, Institute of Educational Sciences, Kütahya.

Spiro, R. J., & Jehng, J. C. (1990). Cognitive flexibility and hypertext: Theory and technology forthen onlinear and multidimension altraversal of complex subject matter. In. Nix, D. And Spiro, R. (Eds), Cognition, Education, and Multimedia: ExploringIdeas in High Technology (pp. 163-205). New York: Taylor and Francisa.

Spiro, R. J., Feltovich, P. J., Jacobson, M. J., & Coulson, R. L. (1992). Cognitive flexibílity, constructivism, and hypertexfu random access ınstruction for advanced knowledge acquisition in lll-structured domains. In Steffe L. and P., Gale J. (Eds.), Constructivism in Education (pp. 24-33). New York: Taylor and Francis.

Toulmin, S. E. (1958). *The uses of argument*. Cambridge, UK: Cambridge University Press.

Toulmin, S. E. (2003). *The uses of argument* (Updated ed.). New York: Oxford Universty Press.

Uçar, B. (2018). *The effect of argument maps supported by peer feedback on students' argumentation skills [The effect of argument maps scaffolded with peer feedback on students' argumentation skills]*. Master Thesis. Hacettepe University, Institute of Educational Sciences, Ankara.

Uğurlu, K. S. (2019). *The effect of the argumentation based chemistry experiment designing on pre-service science teachers' understanding of nature of science]*. Master Thesis. Bursa Uludag University, Institute of Educational Sciences, Bursa.

Ulu, C. (2018). The relationship between the quality of the arguments created by the students in science and concept teaching levels. *International Journal of Science and Education*, *1*(1), 11-24.

Uluay, G., & Aydın, A. (2018). The effect of argumentation based learning process on academic achievement in teaching of force and motion unit to 7th grade students. *Abant İzzet Baysal University Education Faculty Publication*, *18*(3), 1779-1799.

Yeh, K.-H., & She, H.-C. (2010). On-line synchronous scientific argumentation learning: Nurturing students' argumentation ability and conceptual change in science context. *Computers & Education*, *55*(2), 586-602.Available at: https://doi.org/10.1016/j.compedu.2010.02.020.

Zong, J.-G., Cao, X.-Y., Cao, Y., Shi, Y.-F., Wang, Y.-N., Yan, C., & Chan, R. C. (2010). Coping flexibility in college students with depressive symptoms. *Health and Quality of Life Outcomes*, *8*(1), 1-6.Available at: https://doi.org/10.1186/1477-7525-8-66.