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The effect of teaching socio-scientific issues with cooperative learning model on pre-service teachers' argumentation qualities[1]

Nejla Atabey, *Muş Alparslan University,* Turkey, *n.atabey@alparslan.edu.tr* ORCID: 0000-0001-8710-3595
Ayten Arslan, *Muş Alparslan University,* Turkey, *a.arslan@alparslan.edu.tr* ORCID: 0000-0001-8832-0276

Abstract. In this study, the effect of teaching socio-scientific issues with cooperative learning model on the argumentation qualities of pre-service teachers was investigated. The study group consisted of 40 primary school pre-service teachers studying at Muş Alparslan University. Exploratory sequential research design was used in this study. In the quantitative dimension of the study, quasi-experimental design with pre-test-post-test control group was carried out. In this context, a control and 2 experimental groups were formed. Jigsaw and learning together methods were implemented with the experimental groups and activities suitable for group works were carried out with the control group. In the qualitative dimension, semi-structured interviews were conducted with the pre-service teachers. At the end of the study, the argumentation qualities of the pre-service teachers were evaluated with descriptive analysis and semi-structured interviews were evaluated with content analysis. Findings revealed that cooperative learning methods, especially jigsaw method, positively affect the pre-service teachers' arguments.

Keywords: Argumentation qualities, cooperative learning, primary school pre-service teachers, socio-scientific issues

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INTRODUCTION

Does global warming threaten our future?, Should we eat genetically modified organisms?, Should cloning work continue ?, Should we use cell phones? These questions brought about by scientific and technological developments are frequently raised in society. These issues encountered in daily life and generally promoted by the media and making the society feel concerned are called socio-scientific issues. Socio-scientific issues are contents that can be evaluated from different perspectives (Eastwood et al., 2012), that have a scientific basis, that require us to make choices, to generate ideas and to make ethical judgments (Ratcliffe & Grace, 2003). Examples of current socio-scientific issues include vaccination, the establishment of nuclear power plants, global warming and stem cell studies. Socio-scientific issues are often biotechnology-based and environmental-based (Sadler & Zeidler, 2004). These biotechnological and environmental dilemmas have been recognized as appropriate content for studying socio-scientific issues and have attracted the attention of many researchers (Topçu, 2008). In addition to environmental issues such as building of nuclear power plants (Demircioğlu & Uçar, 2014; Wu & Tsai, 2007; Yapıcıoğlu & Aycan, 2018) and hydroelectric power plants (Özturk & Leblebicioğlu, 2012), global warming (dosSantos, 2014) or road construction (Patronis, Potari, & Spiliotipoulou, 1999), genetic engineering (Ekborg, 2008; Sadler and Zediler, 2005; Zohar & Nemet, 2002) hunting (Dolan, Nichols, & Zeidler, 2009), the use of mobile phones (Albe, 2008) and the establishment of zoos (Osborne, Erduran, & Simon, 2004) have been the subject of various research.

Individuals who are faced with socio-scientific issues sometimes have to argue about the issue, generate ideas, find solutions to the problem or make a decision. In this process, different ideas or claims may arise and individuals may try to prove their claims. In fact this process can be considered as argumentation. This is because argumentation is defined as the process of reasoning (vanEemeren & Grootendorst, 1996) in which different arguments and evidence are put forward (Chin & Osborne, 2010) to increase the acceptability of an idea. Given that socio-

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scientific issues have a controversial nature, that they do not have a single answer and that they can be evaluated from different perspectives, it can be said that they are appropriate content to be included in the argumentation process for students (Sadler, 2004). Socio-scientific issues-based learning is generally addressed together with discussion, inferences, and argument generation (Polyiem, Nuangchalenn, & Wongchantra, 2011). Therefore, argumentation is one of the most preferred applications in learning environments where socio-scientific issues are discussed (Topçu & Atabey, 2017). In socio-scientific issues-based environments, it is more likely to develop students' argumentation qualities (Rebello & Barrow, 2013) and decision-making abilities (Dawson & Venville, 2009). Students with developed argumentation qualities can participate in discussions about socio-scientific issues more readily and defend their views in a more qualified way (Lin & Mintzes, 2010). However, current research shows that when individuals face dilemmas, they tend to answer as either right or wrong rather than defending their thoughts (Lee, Chang, Choi, Kim, & Zeidler, 2012). One of the reasons of this situation can be attributed to the difficulty of evaluating socio-scientific issues which have different dimensions (Kolsto et al., 2006). Benefiting from argumentation and supporting individuals about the evaluation and discussion of socio-scientific issues will contribute to overcoming this difficulty.

In addition to the studies that use argumentation as a strategy to engage students in socio-scientific issues (Soysal, 2012), there are studies that use the argumentation as a variable to evaluate the effect of socio-scientific issues-based teaching (Tekbıyık, 2015). Soysal's (2012) study can be given as an example for the studies in which argumentation has been used as a strategy. Soysal (2012) investigated the effect of content knowledge on socio-scientific argumentation quality. In this context, argumentation-oriented activities were conducted throughout the teaching process. In the first stage of the implementation, the activities aimed at introducing the argumentation were performed and in the second stage, first small group and then large group discussions were conducted on a different socio-scientific issue scenario each week. At the end of the study, it was found that content knowledge was not an important factor on the socio-scientific argumentation quality. In his study, Tekbıyık (2015) investigated how jigsaw cooperative learning method affects students' decision-making abilities related to socio-scientific issues. Firstly he used jigsaw method to teach nuclear energy issue, then he gave information about argumentation, and lastly he asked students to write down their arguments regarding the establishment of nuclear energy plants in Turkey. Socio-scientific issues were handled in accordance with the jigsaw method, no discussion activities were performed during the implementation of jigsaw method and no information was given about the argumentation in this process. The discussions were carried out during the argumentation writing process after using jigsaw method. At the end of the research, the natural development of the students' argumentation qualities was evaluated. Thus, it was assumed that learning content knowledge and confronting decision-making processes would affect the quality of argumentation. In the present study, argumentation was not used as a strategy, it was used as a variable to investigate the effect cooperative learning methods like Tekbıyık's (2015) study.

Another point that makes the present study different from other studies is the completion of written argumentation forms individually at the end of the cooperative learning process. There are many studies in the literature that evaluate the arguments presented by the group after the group activities (Demirel, 2015; Evagorou & Osborne, 2013). In this process called as cooperative argumentation, students are expected to share their ideas, to question assumptions, to restructure their existing knowledge schemes and to generate knowledge socially (Evagorou & Osborne, 2013). It was found that the students working with the group used more argumentation elements than individual discussions (Demirel, 2015). It is stated that the arguments presented by the groups are higher in terms of both level and mean score. (Çelik & Kılıç, 2017). However, in the present study, the arguments were presented individually at the beginning and end of the implementations. Thus, at the end of the group works, the development of the arguments presented by the students individually was tried to be revealed.

A well-organized learning environment in which students interact with each other is needed to teach socio-scientific issues (Tekbıyık, 2015). For this reason, group works and

argumentation-based activities are generally used in research in which socio-scientific issues are studied (Albe, 2007; Kutluca & Aydın, 2017; Namdar & Shen; 2014, Topçu & Atabey, 2017) because it is stated that group activities provide a better learning environment than individual activities (Johnson & Johnson, 2009). One of the applications in which group work is carried out is the cooperative learning model. Cooperative learning is a learning model that increases students' motivation towards the lesson, develops their problem-solving and critical thinking skills, supports them to gain positive perspectives towards their friends and to develop their social skills (Bayrakçeken, Doymuş & Doğan, 2013). In the cooperative learning process, students collect data by conducting research on the subject and then present them as an inference or a product by combining and interpreting the collected data in an individual way (Sharan, 1980). Throughout the applications, group members go through the processes of recognizing their own and other group members' viewpoints, of accepting and approving the differences between them (Bearison, Magzomes, & Filardo, 1986; Doymuş, Şimşek, & Şimşek, 2005). Cooperative learning as a learning method that enables students to develop positive feelings towards each other (Saban, 2004), helps them learn to be respectful and tolerant to others' opinions and to argue (Senemoğlu, 2001), and reveals different viewpoints of students (Davidson & O'leary, 1990) can make many contributions to education (Tan, Kayabaşı, & Erdoğan, 2002). Considering these characteristics of cooperative learning, it is thought that it will create a suitable environment for teaching socio-scientific issues which have no single answer, have a controversial nature and can be evaluated from different perspectives. Thus, it was decided to use the jigsaw and learning together methods of the cooperative learning model, which is an effective model in the teaching of socio-scientific issues.

The Jigsaw method was developed by Eliot Aronson in 1978 as a method involving different applications of small heterogeneous groups in order to help learning and to foster collaboration among students (Hedeen, 2003). In this method, students are divided into groups of 4-6 and all groups learn the same subject. Each student in the group chooses one of the sub-sections of the subject to learn. The members studying the same sub-section in different groups come together to form "expert groups". In the expert groups, the subject is explained and discussed in detail. The students in the expert groups go back to their original groups after they have learned their subjects thoroughly and try to teach their subjects to the other group members (Sharan, 1980; Slavin, 1988 – cited in Senemoğlu, 2004). Jigsaw is a method that can be used very successfully especially in the teaching of subjects that can be divided into sub-sections (Karnes & Collins, 1997; Tekbıyık, 2015). This method is a teaching method entailing the lowest level of competition (Yılmaz & Sünbül, 2007). When the relevant literature is reviewed, it is seen that that students play an active role in the jigsaw process, that they can move freely in the classroom, that they can present their thoughts clearly, that they understood the lesson better and that their academic success and their interest in and attitudes towards the course increase (Doğan, Uçar, & Şimşek, 2015)

The learning together method was developed by Johnson and Johnson in 1991 and has been used effectively in teaching many subjects (Aksoy, 2011; Arslan & Zengin, 2016; Şimşek, 2007). One of its most important features is the existence of a common purpose of the group. In addition, the critical features of the method include the sharing of all ideas and materials, the distribution of tasks among group members equally, and the ownership of any award or success to be gained by the whole group. When applying the method, first of all, teaching objectives should be determined. Subsequently, attention should be paid to the size of the group, the division of the students into groups, the layout of the classes and the planning of instructional materials in a way that creates addiction. Then, the principles such as assigning roles to the group members, expression of the commitment to positive objectives, self-evaluation, determination of the desired behaviours and evaluation of these behaviours are among the main factors to be considered in the application of the method (Açıkgöz, 1995; 2007; Slavin, 1995). Through the learning together method, students carry out activities related to the subject together, produce interpretations among themselves and learn by discussing in class (Demir & Sezek, 2015). In this way, their interest in lessons increase, lessons become more enjoyable and studying subjects becomes easier (Arslan & Zengin, 2016). Moreover, students convey

information to each other, repeat it, associate new information with their prior knowledge, make information meaningful and increase their academic achievement (Kiemer, Gröschner, Pehmer, & Seidel, 2015; Mayer, 1996).

In the current study, it was decided to use the jigsaw and learning together methods, two of the most preferred learning methods from among the cooperative learning methods (Koç-Damgacı & Karataş, 2015), in the process of teaching socio-scientific issues. At the end of the study, it was attempted to reveal how these methods had affected the pre-service teachers' argumentation qualities. In this way, it is believed that a contribution will be made to the limited research (see Evagorou & Osborne, 2013; Tekbıyık, 2015) focusing on the use of cooperative learning methods in the process of teaching socio-scientific issues.

METHODS

In this section, information is given about the research method, universe, sampling, data collection tools, application procedure, data analysis and findings.

Research Method

In the current study, exploratory sequential research design, one of the mixed methods, was employed. In this design, first quantitative data are collected, followed by the collection of quantitative data and then analyzed (Delice, 2015). Qualitative data are used to elaborate and interpret quantitative data. The prototype model of the exploratory sequential design is shown in Figure 1.

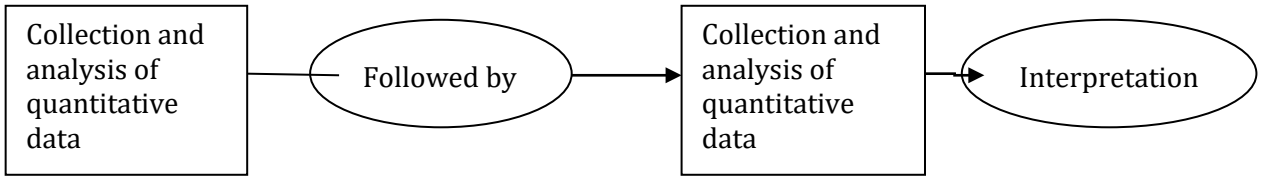

FIGURE 1. *Exploratory research design* (Delice, 2015, p. 77)

It was decided to use the quasi-experimental design with pre-test-post-test control group in the quantitative dimension of the study. In this design, participants are divided into two groups as the experimental group and the control group and they are subjected to evaluations related to the dependent variable before and after the study (Karasar, 2005). In the current study, the effects of the jigsaw and learning together methods, which are two methods of the cooperative learning model, on the dependent variable, which was determined as the change in the argumentation qualities of the pre-service teachers, were investigated. In the current study, activities suitable for the jigsaw method were conducted in one of the experimental groups and activities suitable for the learning together method were conducted in the other experimental group while activities suitable for group works were conducted in the control group. In all the three groups, socio-scientific issues were taught for 12 class hours (each class hour is 45 minutes). The students in the jigsaw group were divided into 4 groups of four while the students in the learning together and control groups were divided in 4 groups of three. The experimental procedure is given in Table 1.

Table 1. *Experimental procedure*

	Pre-experiment	**Experimental procedure**	**Post-experiment**
Groups	**Pre-test**	**Method**	**Post-test**
Groups where group work activities were used	Written argumentation form	Group works	Written argumentation form
Groups where the learning together method was used	Written argumentation form	Learning together method	Written argumentation form
Groups where the jigsaw method was used	Written argumentation form	Jigsaw method	Written argumentation form

In the qualitative dimension of the current study, semi-structured interviews were conducted. The data collected through the interview form were used to elaborate and interpret the quantitative data.

Population and Sampling

The population of the study is comprised of a total of 245 students attending the Department of Classroom Teacher Education in Muş Alparslan University in the fall term of the 2017-2018 academic year. The sampling determined by using the convenience sampling method consists of 40 students. However, the written argumentation forms of the three students having not participated in either the pre-test or the post-test were not included in the data analysis. Of all the participants, 26 (70%) are females and 11 (30%) are males. In the learning together group, there are 7 females and 4 males; in the jigsaw group, there are 13 females and 3 males and in the group where the group works are conducted, there are 6 females and 4 males.

Data Collection Tools

The data of the current study were collected by means of a written argumentation form and a semi-structured interview form developed by the researchers. In this section, information is given about the data collection tools and the data collection process.

Written argumentation form

The written argumentation form was developed by Kutluca (2016). This form includes two different reports emphasizing the relationship between nuclear power plants and the environment. At the end of the form, the students are asked to decide on the establishment of nuclear power plants and to explain and provide justifications for their decisions. This form was administered twice; the first at the beginning of the study and the second at the end of the study. The data of the three students determined not to have completed either the pre-test or the post-test were not included in the analysis. Therefore, a total of 74 written argumentation forms were collected at the end of the study.

Semi-structured interview form

The semi-structured interview form used in the current study to collect data was developed by the researchers. In this interview technique, the pre-prepared questions are asked to the participants. Depending on the direction of the interview, follow-up questions can be asked for the participant to elaborate his/her responses. Semi-structured interview forms are frequently used in qualitative research as they offer certain standardization and flexibility through which they can eliminate the limitation of the data collection tools based on writing and filling in; thus, allow the collection of detailed information (Yıldırım & Şimşek, 2013).

The interview questions were first written by two researchers specialized on the subjects of cooperative learning, socio-scientific issues and argumentation. While preparing the interview questions, a great care was taken for the questions not to be yes/no questions, to be

open-ended and focused questions, not to include any statements in the form that can be directive to participants' responses, for the questions to be multi-dimensional and to include alternative questions (Yıldırım & Şimşek, 2013). In this regard, first, 4 questions were written. After these 4 questions had been written, they were submitted to the review of two other researchers specialized in these fields and on the basis of the feedbacks received from them, it was decided to reduce the number of questions into 2, as it was decided that 2 questions would be enough to elicit the desired data. Then the piloting of these questions was conducted on 5 pre-service classroom teachers having experience on the subjects of cooperative learning, socio-scientific issues and argumentation and not involved in the sampling of the current study. As a result of the piloting, it was decided that there is no need for any change. In the final form, there are two questions to elicit the opinions of the pre-service teachers about the benefits of the cooperative learning model and how it affected their argumentation qualities.

During the interviews, the following points noted by Yıldırım and Şimşek (2013) were taken into consideration. During the interviews, the questions were directed to the participants in the conversation style, the participants were encouraged to answer the questions sincerely and to provide details through follow-up questions. Interventions were made when the participant started to talk about unnecessary and irrelevant topics to control the process. Before the interviews, the participants were informed about the purpose of the interview, its confidentiality and its average time and their permissions were taken for the tape-recording of the interviews. In this way, it was intended to make the participants feel relaxed and safe and thus to enhance the quality of the data to be collected.

Application procedure

The study was started with the determination of the pre-service teachers with whom the learning together, jigsaw and group work activities to be conducted. In the learning together group, there were 11 students; in the jigsaw group, there were 16 students and in the control group where group work activities were conducted, there were 10 students. The applications were conducted within the context of the "Special Teaching Methods" course in the Department of Classroom Teacher Education. During the delivery of the lessons, the socio-scientific issue of nuclear energy was divided into 16 sub-headings. Each week, 4 sub-headings were studied. The applications were completed within 4 weeks and 12 class hours, three class hours a week. Each week, the same sub-headings were instructed to the students in all the three groups; jigsaw, learning together and group works. These sub-headings are presented in Table 2.

Table *2*. *The sub-headings of the subject of nuclear energy addressed in the current study*

	Sub-headings of the Subject of Nuclear Energy
1st week sub-headings	1- What is nuclear energy? 2- How does nuclear energy occur? 3- Types of nuclear reactors 4- Working principles of nuclear power plants
2nd week sub-headings	5- Energy conversion in nuclear power plants 6- Necessity of nuclear energy 7- Economy of nuclear energy 8- Nuclear weapons
3rd week sub-headings	9- Nuclear accidents and disasters 10- Nuclear meltdown 11- Nuclear safety 12- Protection from radiation
4th week sub-headings	13- The state of nuclear energy in Turkey 14- The state of nuclear energy in the world 15- What are the benefits of nuclear energy? 16- What are the harms of nuclear energy?

Application procedure in the jigsaw group

The application was started by informing the students in the jigsaw group about the stages of application, contents of the subjects to be studied, argumentation process and its elements and the activities to be conducted in each week. Then the written argumentation form was administered to them as the pre-test. The pre-service teachers were divided into 4 groups of four. The groups were asked to find a group name so that the establishment of more positive ties between the group members could be promoted. A sub-heading was assigned to each student in the groups and then they did some research on the sub-heading assigned to them. Then, the students who were assigned the same sub-heading formed a new group, called the expert group. The students in the experts groups shared the information they had collected on the subject, then discussed and completed their missing information (if there was any) about the subject. The students specialized on their subject went back to their original groups and shared the information that they had learned with their group members. Then, a randomly selected group was asked to make a presentation about the subject and then whole class discussions were conducted. This application was continued for 12 class hours within 4 weeks, 3 class hours a week.

Application procedure in the learning together group

The application was started by informing the students in the learning together group about the stages of application, contents of the subjects to be studied, argumentation process and its elements and the activities to be conducted in each week. Then the written argumentation form was administered to them as the pre-test. The pre-service teachers were divided into 4 groups of three. The groups were asked to find a group name so that the establishment of more positive ties between the group members could be promoted. Then the following duties were distributed among the group members; spokesperson (when needed, communicate with other groups; if there is any problem experienced, contacts teacher), register (writes down the data obtained), controller (controls whether the group members participate in activities; wants help from the teacher when necessary) and observer (encourages the group members to participate in activities, tries to make them more enthusiastic and writes down his/her observations). These duties were assigned to different students each week. The groups conducted their research together and then shared and discussed the information they had collected within their groups. The pre-service teachers in this group studied the weekly subjects given in Table 1 in tandem with the pre-service teachers in the other groups. The applications were completed within 12 class hours in four weeks, three class hours a week.

Application procedure in the control group where group work activities were conducted

The application was started by informing the students in the group where group work activities were conducted about the stages of application, contents of the subjects to be studied, argumentation process and its elements and the activities to be conducted in each week. Then the written argumentation form was administered to them as the pre-test. The pre-service teachers were divided into 4 groups of three. No external intervention was made in the distribution of the duties. The groups conducted their research on the subject and then a randomly selected group made their presentation and then the whole class discussion was initiated. The pre-service teachers in this group studied the subjects given in Table 1 in tandem with the pre-service teachers in the other groups. The applications were completed within 12 class hours in four weeks, three class hours a week.

Data Analysis

In this section, the analyses of the data collected from the written argumentation forms and semi-structured interviews are presented.

Analysis of the data collected from the written argumentation forms

In the analysis of the written argumentation forms, the CERR (an acronym formed by the first letter of its elements) rubric developed by McNeill and Krajcik (2012) and including the following elements was used: Claim, Evidence, Reasoning and Rebuttal. According to the rubric, the quality of an argument is determined by the existence and content of the elements of claim, evidence, reasoning and rebuttal. The elements of argumentation are explained in the rubric as follows. The claim is an expression of inference or conclusion that is the answer to a question and is referred to as the element most easily expressed by students (McNeill & Martin, 2013). Evidence is defined as the scientific data supporting the claim while reasoning is defined as the defence that uses the scientific principles of reasoning to explain how and why the evidence supports the claim and connects the claim to the evidence. Rebuttal is defined as an element referring to the awareness of the opposing ideas and explaining why these ideas are not correct. Each item is rated between 0 and 2, depending on whether it has sufficient and accurate content. While the lowest score to be taken from the rubric is 0, the highest score is 2. 0 point indicates the lowest quality while 2 points indicate the highest quality. Table 3 contains information about the content of the rubric and examples of the argument statements of the pre-service teachers. As there was no student putting forward a claim at the 1st level, no sample statement is given for this part.

Table 3. *CERR rubric* (*McNeill and Krajcik, 2012).*

	Level		
Element	**0**	**1**	**2**
Claim A claim or a conclusion answering a question asked or a problem directed	Presents no claim or a wrong claim. "*I am undecided about the establishment of nuclear power plants in Turkey.*" Ö. A.12	Presents a correct but an incomplete claim. -	Presents a correct and complete claim. "*In my opinion, nuclear power plants should not be established in Turkey.*" Ö. A.27
Evidence Scientific data supporting the claim. Data should be suitable and adequate to support the claim.	Presents no evidence or presents evidence not suitable for supporting the claim. "*It is not something to be approved by the public because our young girls working in the phosphor factory opened in the Black Sea Region thought that phosphor is a beauty product and thus applied it to their hair, eyebrows and even teeth…after a short while, they lost their hair, eyebrows and even their teeth.*" Ö. A. 35	Presents suitable but incomplete evidence to support the claim. There might be some unsuitable evidence. *"Plutonium emitted by nuclear reactors is poisonous and carcinogenic and it takes 250 years for it to decompose in the environment."* Ö. A. *24*	Presents suitable and adequate evidence to support the claim. *Energy obtained from 1 kg coal is much less than the energy obtained from 1kg uranium. We need tons of coal to produce the energy that can be produced from 1 kg uranium*." Ö. A.16

Reasoning Defences showing why and how data can be used as evidence on the basis of appropriate and adequate scientific principles to support the claim and connecting claim and evidence to each other	Presents no reasoning or presents reasoning not connecting evidence to the claim. "*It seems to be not very ethical to me to approve the establishment of such a threatening thing in a country having a beautiful nature like Turkey.*" Ö. A.16	Presents reasoning connecting evidence to the claim. The evidence is repetitive and/or includes some inadequate scientific principles. "*Global warming is one of the main problems in the world (data). If these nuclear power plants would contribute to the reduction of global warming, then they should be established* (reasoning)" Ö. A. 23	Presents reasoning connecting evidence to the claim. It includes adequate and appropriate scientific principles. *"The amount of fossil fuel is increasing with each day (data). Therefore, less fossil fuel will be used due to the use of nuclear energy (reasoning) and there will be less environmental pollution (reasoning) and more cost-effective energy will be produced. (reasoning)."* Ö. A. 10
Rebuttal Defines and recognizes alternative explanations. Presents counter evidence and reasoning why the alternative explanation is not suitable	Does not recognize the existence of an alternative explanation and does not presents a rebuttal or presents a wrong rebuttal. "*Only way of meeting the energy need is nuclear energy.*" Ö. A. 28	Recognizes the existence of alternative explanations or presents adequate suitable but inadequate counter evidence and reasoning. "*I am always against nuclear energy. Though there are some benefits of nuclear energy, in case of any problem, it can yield serious outcomes. Nuclear energy has some benefits on the condition that its risks are kept under control…."* Ö. A. 13	Recognizes the existence of alternative explanations and presents appropriate and sufficient counter evidence and reasoning. "*Yes, they should be established because there are many sources of energy (counter evidence) but they will run out after a while (rebuttal). Nuclear energy does not emit harmful gases such as carbon dioxide, sulphur dioxide (evidence) … they should be established as they eliminate the negative effects of harmful gases (reasoning)*." Ö. A. 26

The written argumentation forms completed were analyzed by two different researchers at different times. Then the researchers came together and compared their analyses of the first ten forms. The rate of agreement between the researchers was found to be 75%. As an inter-rater agreement above 70% is considered to be enough to establish reliability (Yıldırım & Şimşek, 2013), the remaining forms were analyzed by only one of the researchers. Then pre-test and post-test mean scores were calculated for each of the elements of claim, evidence, reasoning and rebuttal in the written argumentation forms belonging to all the groups (jigsaw, learning together and group work). In this way, it was attempted to elicit how the group work, learning together and jigsaw methods affected the elements of the arguments presented by the students.

Analysis of the semi-structured interview forms

The semi-structured interview forms were evaluated with content analysis. "Content analysis is used to determine the existence of words, concepts, idioms, characters or sentences in one or more texts and to digitize them" (Kızıltepe, 2015, p. 253-254). In content analysis, the data are

analyzed in four stages: identification of codes, finding themes, editing codes and themes, and defining and interpreting findings (Yıldım & Şimşek, 2013). Individual interviews conducted with the students in the groups were tape-recorded. Then, they were transferred to the computer environment and there first separated into the units named with codes and then the related codes were brought together under themes through Nvivo 8 program. The findings were visualized to make themes and codes easier to understand and to present the relationships between them more clearly. In this process, the researchers first individually conducted their analyses on the first 5 forms and then they brought their analyses together and compared them. The rate of agreement between the researchers was found to be 90%; thus, the remaining forms were then analyzed by one of the researchers. The obtained findings are presented below.

RESULTS

In this section, the findings obtained from the analysis of the written argumentation forms and semi-structured interview forms are presented.

Findings Obtained from the Written Argumentation Forms

Mean scores calculated for the element of claim presented by the control and experimental group students in their written argumentation forms completed by them at the beginning and end of the study are presented in Figure 2.

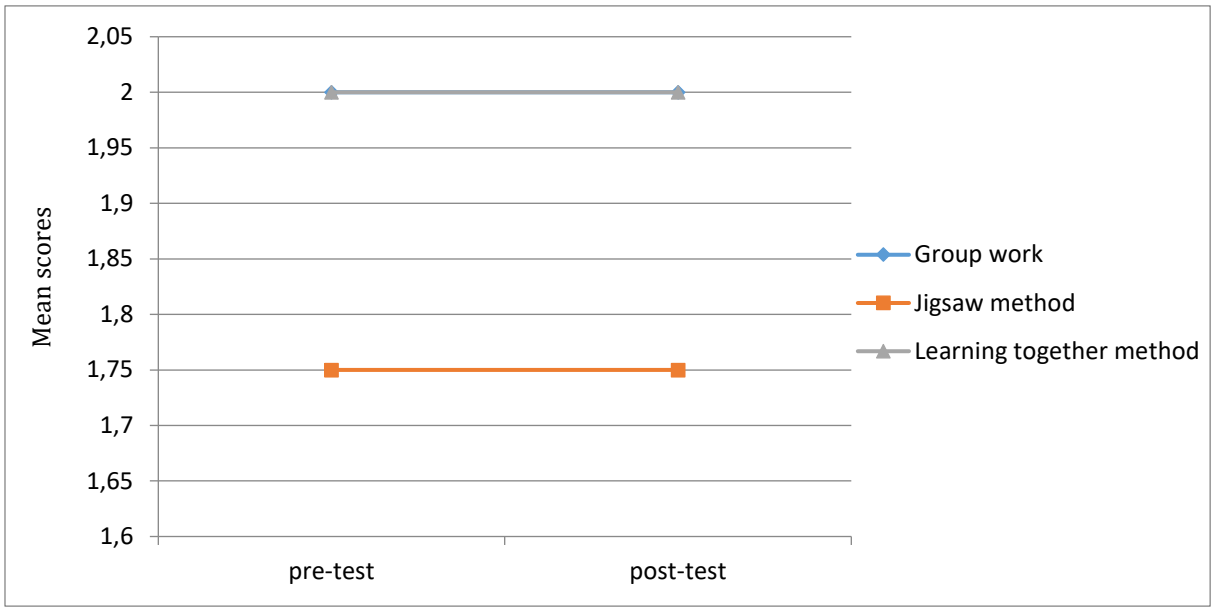

FIGURE 2. *Mean scores calculated for the element of claim*

As can be seen in Figure 2, the claims presented by the students in the groups where subjects were studied according to the group work and the learning together methods at the beginning and end of the study are of the highest quality. On the other hand, mean scores calculated for the claims presented by the students in the jigsaw group at the beginning and end of the study are lower than those of the other groups. Thus, it can be argued that the claims presented by the students in the group work group and the learning together group are higher quality than the claims presented by the students in the jigsaw group both at the beginning and at the end of the study. Students' mean scores calculated for the element of evidence are presented in Figure 3.

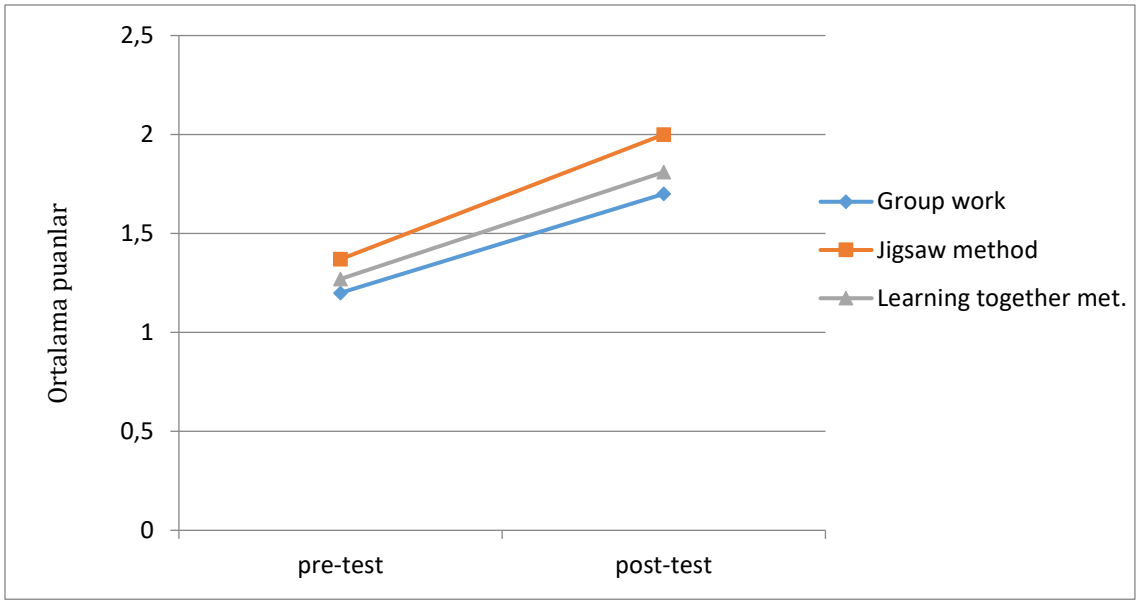

FIGURE 3. *Mean scores calculated for the element of evidence*

As can be seen in Figure 3, while the mean score of the students in the control group for the element of evidence presented in their pre-test written argumentation forms was 1.2, it increased to 1.7 in their post-test argumentation forms. The mean score of the students in the jigsaw group increased from 1.37 to 2 and the mean score of the students in the learning together group increased from 1.27 to 1.81. These findings show that the mean score of the students in the control group increased by 0.5, the mean score of the students in the jigsaw group increased by 0.63 and the mean score of the students in the learning together group increased by 0.54. Moreover, the students in the jigsaw group presented adequate and appropriate evidence at the end of the study (all the students got 2 points for the element of evidence). Thus, it can be argued that the jigsaw method increased the mean score of the students the most while the group work activities increased the mean score the least. Pre-test and post-test mean scores of the students for the element of reasoning are shown in Figure 4.

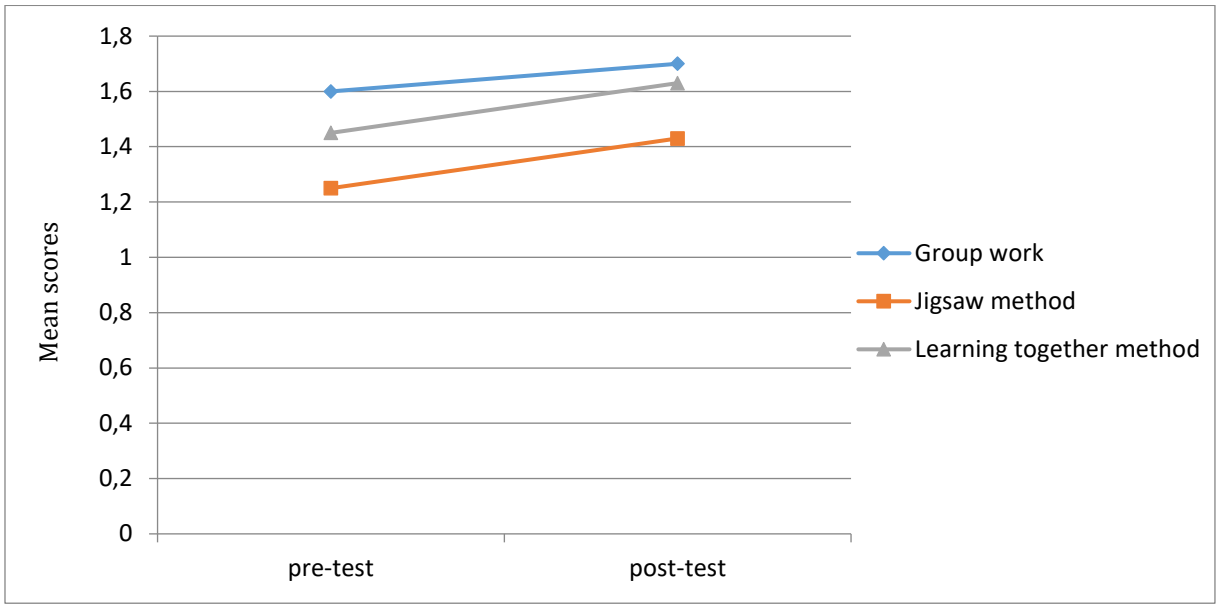

FIGURE 4. *Mean scores for the element of reasoning*

As can be seen in Figure 4, while the mean score of the students in the control group for the element of evidence presented in their pre-test written argumentation forms was 1.6, it increased to 1.7 in their post-test argumentation forms. The mean score of the students in the jigsaw group increased from 1.25 to 1.43 and the mean score of the students in the learning together group increased from 1.45 to 1.63. These findings show that the mean score of the students in the control group increased by 0.1, the mean score of the students in the jigsaw group increased by 0.22 and the mean score of the students in the learning together group increased by 0.18. Thus, it can be argued that the jigsaw method increased the reasoning mean score of the students the most while the group work activities increased the reasoning mean score the least. Pre-test and post-test mean scores of the students for the element of rebutting are shown in Figure 5.

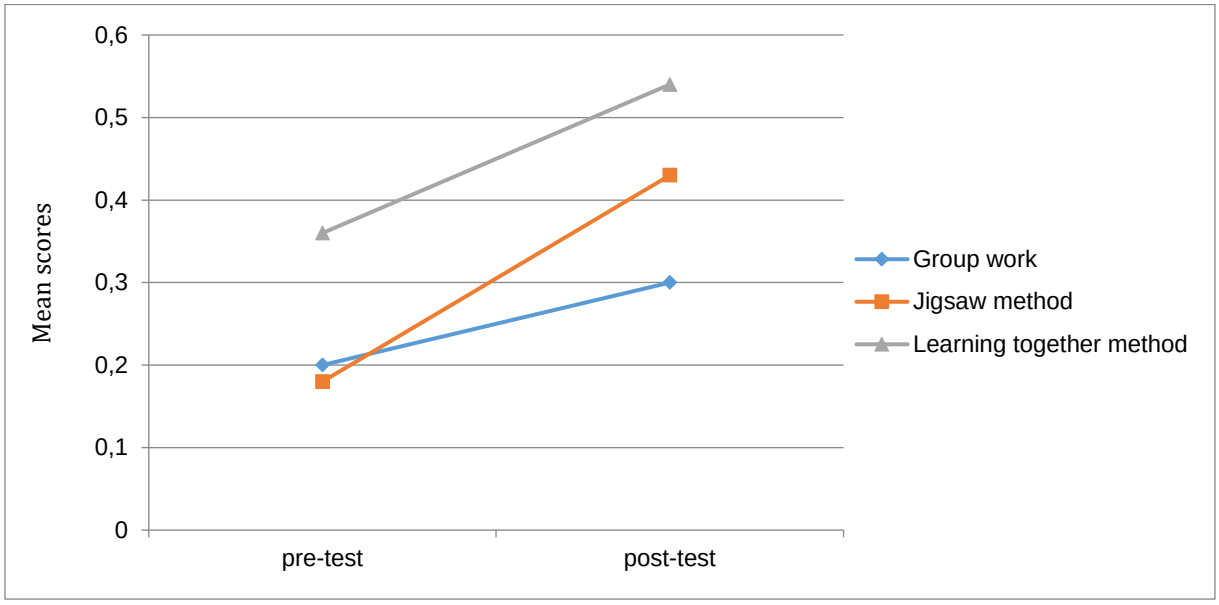

FIGURE 5. *Mean scores for the element of rebutting*

As can be seen in Figure 5, while the mean score of the students in the control group for the element of evidence presented in their pre-test written argumentation forms was 0.12, it increased to 0.3 in their post-test argumentation forms. The mean score of the students in the jigsaw group increased from 0.18 to 0.43 and the mean score of the students in the learning together group increased from 0.36 to 0.54. These findings show that the rebutting mean score of the students in the control group increased by 0.1, the rebutting mean score of the students in the jigsaw group increased by 0.25 and the rebutting mean score of the students in the learning together group increased by 0.18. Thus, it can be argued that the jigsaw method increased the rebutting mean score of the students the most while the group work activities increased the rebutting mean score the least.

In addition to the analyses conducted to see how mean scores for each element of argumentation changed, it was also analyzed how many pre-service teachers in each group changed their claims and in which direction they changed their claims. The findings of these analyses are given in Figure 6.

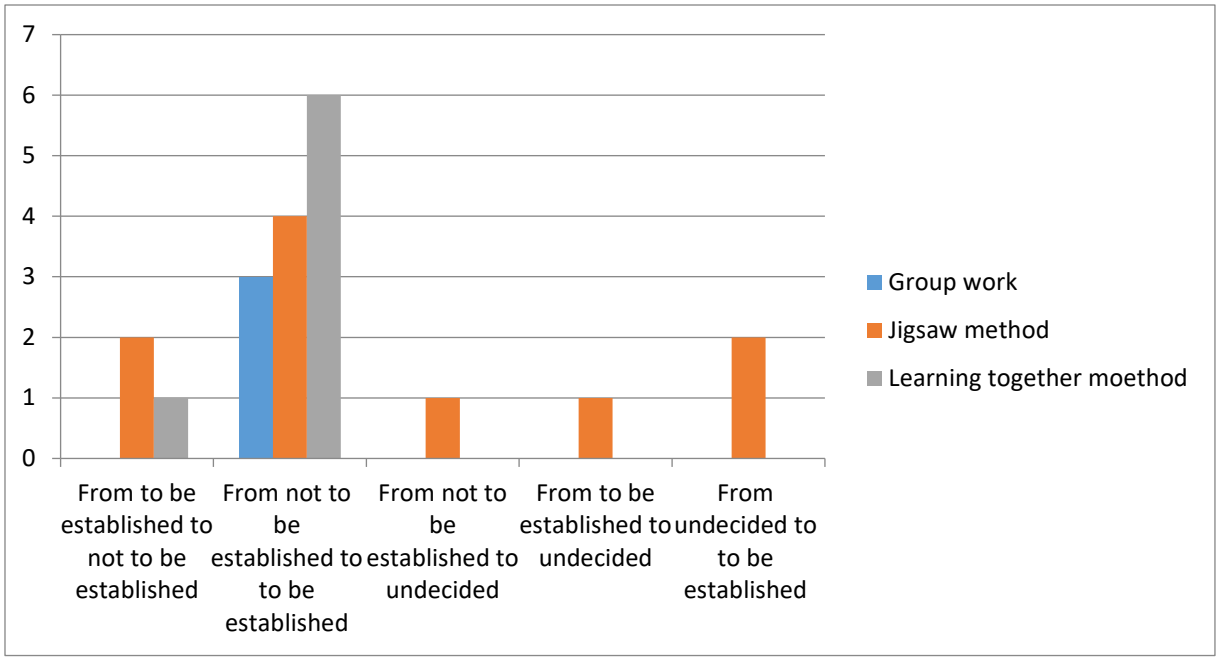

FIGURE 6. *The number of students having changed their claims*

As can be seen in Figure 6, a total of three students in the control group changed their claims at the end of the study. While these three students put forward claims against the establishment of nuclear power plants, at the end of the study they changed their claims and started to support their establishment. In the jigsaw group, it is seen that a total of 10 students changed their claims. While two of these students put forward claims supporting the establishment of nuclear power plants at the beginning of the study, they changed their claims and became against their establishment at the end of the study. In Figure 6, it is also seen that four students in the jigsaw group put forward claims against the establishment of nuclear power plants at the beginning of the study yet they changed their claims and started to support the establishment of nuclear power plants. One student who was against the establishment of nuclear power plants at the beginning of the study in the jigsaw group became undecided at the end of the study while another student who was supporting the establishment of nuclear power plants at the beginning of the study in the jigsaw group became undecided at the end of the study. Another student in the jigsaw group was undecided about the establishment of nuclear power plants yet he/she changed his/her claim and started to support their establishment. In the learning together group, a total of 7 students changed their claims. Six students in the learning together group were supporting the establishment of nuclear power plants at the beginning of the study; yet, they changed their claims and started to support their establishment at the end of the study. While one student in this group was supporting the establishment of nuclear power plants at the beginning of the study, he/she changed his/her claim and took a position against their establishment. In light of these findings, it can be argued while the jigsaw method created the greatest effect on the change of claims, the group work activities created the smallest effect.

Findings Obtained from the Semi-Structured Interview Forms

Another data collection tool used in the current study is semi-structured interview forms. Findings obtained from these forms were analyzed separately for the students in the jigsaw and learning together groups.

Findings obtained from the interviews conducted with the pre-service teachers in the learning together group

The first interview question asked to the pre-service teachers was "How did the learning together method affect your argumentation qualities?" Findings obtained from the interviews conducted with the pre-service teachers to find an answer to this question are given in Figure 7.

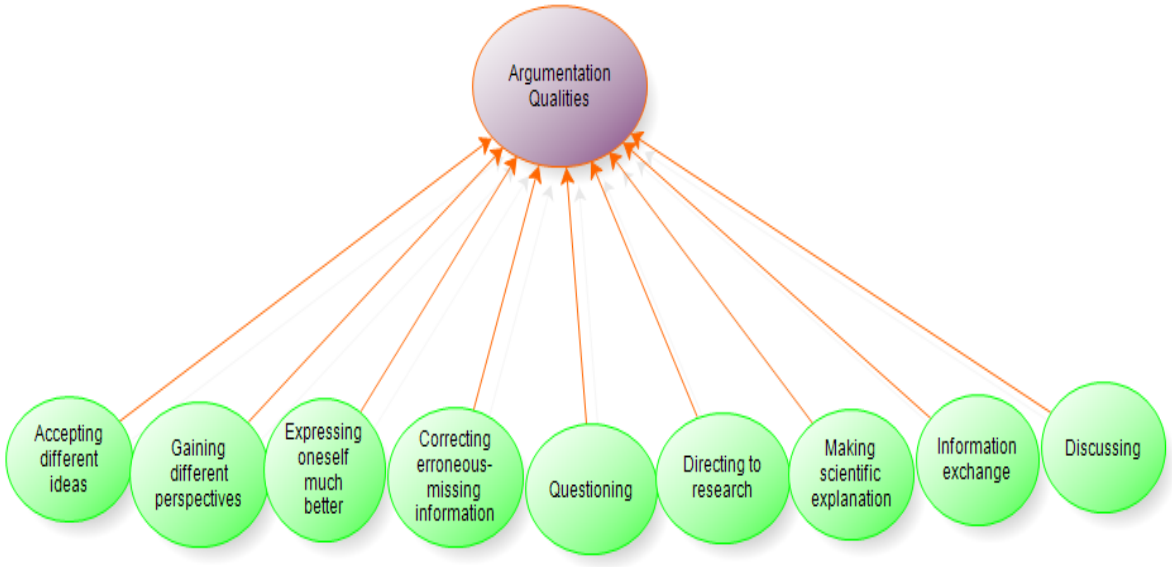

FIGURE 7. *Pre-service teachers' opinions about the effects of the learning together method on their argumentation qualities*

In addition to the pre-service teachers' opinions about the effect of the learning together method on their argumentation qualities, the number of pre-service teachers stating these opinions and pseudo names used instead of their real names are given in Table 4.

Table 4. *Pre-service teachers' opinions about the effect of the learning together method on their argumentation qualities*

Themes	**Codes**	**The pre-service teacher expressing the opinion**
Positive Effects	Accepting different ideas	Adnan, Filiz
	Gaining different perspectives	Murat
	Expressing oneself much better	Adnan, Aynur, Canan, Melis
	Correcting erroneous-missing information	Furkan, Melis
	Questioning	Adnan, Filiz
	Directing to research	Adnan, Filiz, Mert, Murat
	Making scientific explanation	Hale, Selin, Filiz, Adnan
	Information exchange	Zerrin, Canan
	Discussing	Zeki, Zerrin, Murat, Aynur, Adnan

As can be seen in Table 4, the pre-service teachers' opinions about the effect of the learning together method on their argumentation qualities were gathered under the theme of "positive effects". No other theme was obtained in the current study because all the students stated that the learning together method positively affected their argumentation qualities. Under the theme of "Positive effects", the following codes are found: "Accepting different ideas", "Gaining different perspectives", "Expressing oneself much better", "Correcting erroneous-missing information", "Questioning", "Directing to research", "Making scientific explanations",

"Information exchange" and "Discussing". Some excerpts from the statements of the pre-service teachers are given below (The names used are pseudo names):

Filiz: "I have learned to do research on a topic at an academic level, accurately and gradually. I have learned to question and find answers to my questions. I have learned to listen to and convey different ideas."

Adnan: "It affected positively. I have learned researching and questioning. Discussing topics in groups helped me improve my discussion skills and learn to respect different ideas. This enabled me to express myself better."

Aynur: "I can discuss a topic with my friends and comfortably express my opinions to them."

The second interview question asked to the pre-service teachers was "What are the benefits of the learning together method?" The findings obtained from the interviews conducted with the students in the learning together group to find an answer to this question are given in Figure 8 and Table 5.

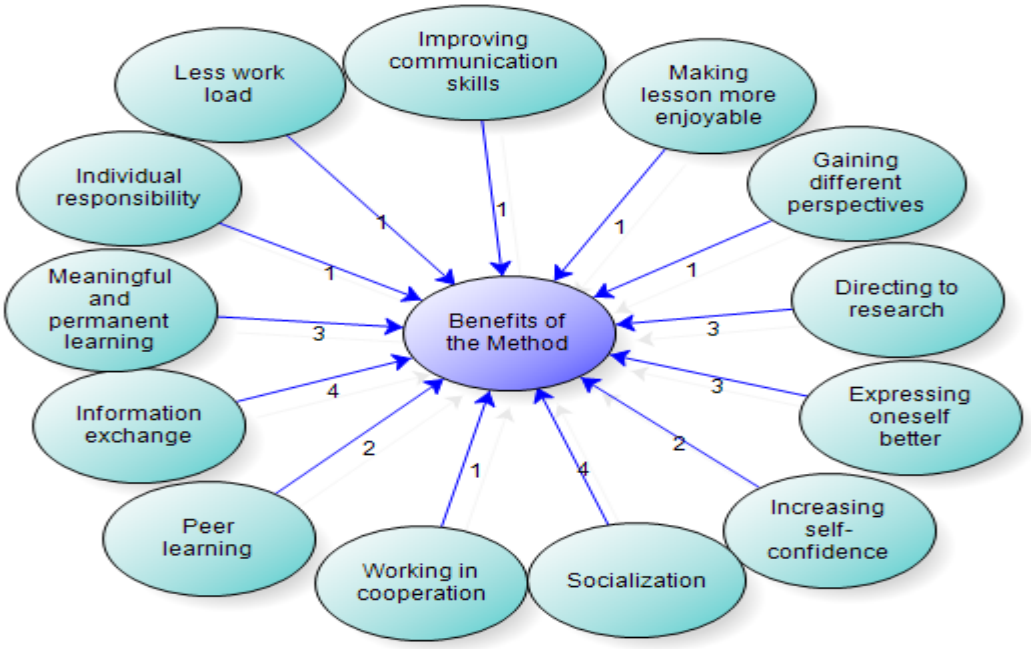

FIGURE 8. *The pre-service teachers' opinions about the benefits of the learning together method*

In addition to the pre-service teachers' opinions about the benefits of the learning together method, the number of pre-service teachers stating these opinions and pseudo names used instead of their real names are given in Table 5.

As can be seen in Table 5, the pre-service teachers' opinions about the benefits of the learning together method were gathered under the theme of "positive effects". Under the theme of "positive effects, the following codes are found: "Less work load", "Individual responsibility", "Expressing oneself better", "Socialization", "Directing to research", "Working in cooperation", "Gaining different perspectives", "Increasing self-confidence", "Meaningful and permanent learning", "Making the lesson more enjoyable", "Information sharing", "Peer learning" and "Gaining communication skills". Some excerpts from the statements of the pre-service teachers are given below (The names used are pseudo names):

Hale: "Learning together has been helpful in providing a homogeneous environment for us to collaborate, to express ourselves better in a friendly environment."

Mert: "It contributed to the integration of our shy class. It made the lesson more enjoyable. It made us more responsible towards our homework."

Zerrin: "To share the topics among us and discuss them in the class were very good. I found the opportunity to socialize with my classmates."

Table 1. *Pre-service teachers' opinions about the benefits of the learning together method*

Themes	Codes	The pre-service teacher expressing the opinion
Positive Effects	Information sharing	Adnan, Murat, Zeki, Zerrin
	Peer learning	Adnan, Furkan
	Meaningful and permanent learning	Canan, Murat, Semra
	Individual responsibility	Mert
	Less work load	Melis
	Gaining communication skills	Semra
	Making the lesson more enjoyable	Mert
	Gaining different perspectives	Canan
	Directing to research	Aynur, Furkan, Murat
	Expressing oneself better	Filiz, Hale, Aynur
	Increasing self-confidence	Aynur, Semra
	Socialization	Zerrin, Mert, Semra, Zeki
	Working in cooperation	Hale

Findings obtained from the interviews conducted with the pre-service teachers in the jigsaw group

The first question asked to the pre-service teachers was "How did the jigsaw method affect your argumentation qualities?" Findings obtained from the interviews conducted with the pre-service teachers to find an answer to this question are given in Figure 9 and Table 6.

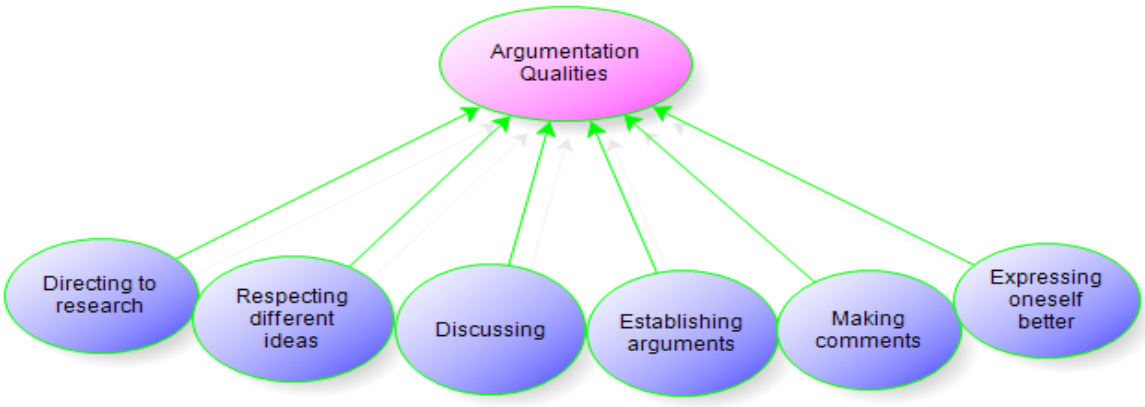

FIGURE 9. *Pre-service teachers' opinions about the effect of the jigsaw method on their argumentation qualities*

In addition to the pre-service teachers' opinions about the effects of the jigsaw method, the number of pre-service teachers stating these opinions and pseudo names used instead of their real names are given in Table 6.

Table 6. *Pre-service teachers' opinions about the effects of the jigsaw method on their argumentation qualities*

Themes	Codes	The pre-service teacher expressing the opinion
Positive effects	Directing to research	Ayça, Berna, Esra, Eda, Gülçin, Kevser
	Respecting different ideas	İbrahim, Semra
	Discussing	Ayça, Didem, İlayda, İbrahim, Kevser, Yeliz
	Establishing arguments	Davut, Esra, Melih
	Making comments	İbrahim, Semra
	Expressing oneself better	Didem, Erva, Esra, İlayda, İbrahim, Kevser, Orhan, Semra, Yeliz

As can be seen in Table 6, the pre-service teachers' opinions about the effects of the jigsaw method on their argumentation qualities were gathered under the theme of "positive effects". Under the theme of "positive effects", the following codes are found: "Directing to research", "Respecting different ideas", "Discussing", "Establishing arguments", "Making comments" and "Expressing oneself better". Some excerpts from the statements of the pre-service teachers are given below (The names used are pseudo names):

Esra: "It has had positive effects on our explaining the research we have conducted on the basis of some justifications and on increasing our interest in research."

Melih: "We have learned how to make introduction to a subject, how reasons are presented and how conclusion is reached."

İbrahim: "I think my skill to express myself in public has improved. I have become more effective in discussion environment because I can listen to my friends patiently and make comments."

The second interview question asked to the pre-service teachers was "What are the benefits of the jigsaw method?" The findings obtained from the interviews conducted with the students in the jigsaw group to find an answer to this question are given in Figure 10 and Table 7.

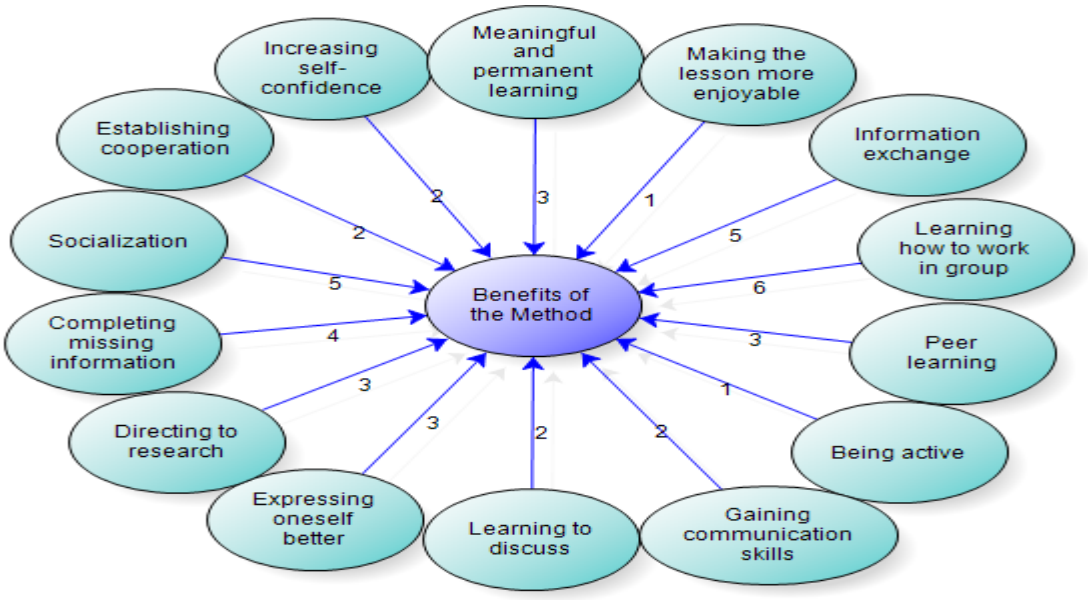

FIGURE 10. *Pre-service teachers' opinions about the benefits of the jigsaw method*

In addition to the pre-service teachers' opinions about the benefits of the jigsaw method, the number of pre-service teachers stating these opinions and pseudo names used instead of their real names are given in Table 7.

Table 2. *Pre-service teachers' opinions about the benefits of the jigsaw method*

Themes	**Codes**	**The pre-service teacher expressing the opinion**
Positive Effects	Learning to discuss	Ayça, Esra
	Expressing oneself better	Esra, Eda, İbrahim
	Directing to research	Gülçin, Kevser, Melih
	Completing missing information	Esra,Gülçin, Melih, Yeliz
	Socialization	Eda, Gülçin, İlayda, Kevser, Orhan
	Establishing cooperation	Berna, Orhan
	Increasing self-confidence	Erva, Esra
	Meaningful, permanent learning	Ayça, Gülçin, İlayda
	Making the lesson more enjoyable	Ayça
	Information exchange	Ayça, Davut, Gülçin, Orhan, Yeliz
	Learning how to work in group	Berna,Erva,Esra,Eda, İlayda,Selin
	Peer learning	Didem, Esra, Melih
	Being active	İbrahim
	Gaining communication skills	Erva, Selin

As can be seen in Table 7, the pre-service teachers' opinions about the benefits of the jigsaw method were gathered under the theme of "positive effects". Under the theme of "positive effects", the following codes are found: "Accepting different ideas", "Learning to discuss", "Expressing oneself better", "Completing missing information", "Socialization", "Directing to research", "Establishing cooperation", "Information exchange", "Increasing self-confidence", "Meaningful and permanent learning", "Making the lesson more enjoyable", "Learning how to work in group", "Peer learning", "Being active" and "Gaining communication skills". Some of the opinions of the pre-service teachers are given below:

Yeliz: "We shared different information with each other. Students studying the same subject came together; new information was added to the information we had learned."

İlayda: "*I found the method useful in terms of both the lesson and the friendship. I did not use to talk to all of my classmates but through this method, my circle of friends has been expanded. I recognized the benefits of working together."*

Ayça: "*Exchanging information in a discussion environment made the learning environment more enjoyable."*

DISCUSSION and CONCLUSIONS

The current study investigated how the teaching of socio-scientific issues with cooperative learning methods affected the pre-service teachers' argumentation qualities. In the current study, one control and two experimental groups were used and one of the experimental groups was instructed with the jigsaw method and the other experimental group was instructed with the learning together method while in the control group, group work activities were conducted. In all the three groups, the same socio-scientific issues were studied for 12 class hours (each class hour is 45 minutes).

Both at the beginning and at the end of the study, the students in the three groups were found to have presented high quality claims. This might be because the claim is defined as the most easily expressed element (McNeill & Martin, 2013). The results of the study conducted by

Topçu and Atabey (2013, 2017) also revealed that students can present high quality claims. Another finding obtained in the current study is that 3 students in the control group, 6 students in the jigsaw group and 6 students in the learning together group stated that nuclear power plants should not be established or that they were "undecided" at the beginning of the study then at the end of the study they changed their opinions and started to support their establishment. This finding is supported by the findings reported by Tekbıyık (2015). In the study conducted by Tekbıyık (2015), the negative opinions of the students at the beginning of the study about the establishment of nuclear power plants turned into positive after they had learned some content knowledge. The change in the students' opinions for the establishment of nuclear power plants can be explained by their prejudices. One of the reasons behind their prejudices is the concerns felt about the possible dangers that can arise in the future and the rumours and events heard from different media can be effective in the formation of these prejudices (Yenilmez & Dereli, 2009). Fears voiced in the Turkish society about the establishment of nuclear power plants and examples of nuclear power plant accidents such as Hiroshima may have caused the pre-service teachers to be prejudiced at the beginning of the study. It can be said that acquiring positive information on the subject such as economic returns of nuclear power plants or security measures that can be taken might have contributed to the elimination or reduction of students' prejudices. Thus, the students changed their negative views about the establishment of nuclear power plants in a positive way. Obtaining different information on the subject can sometimes cause students to change their ideas in a negative direction because while some students who had positive opinions about the establishment of nuclear power plants changed their opinions at the end of the study and started to argue that nuclear power plants should not be established or stated that they were "undecided". This might explain why the mean score obtained for the element of claim of the students in the jigsaw group did not increase much. In the jigsaw group, two students, one stated that nuclear power plants should be established and the other stated that they should not be established, changed their opinions at the end of the study and both stated that they were "undecided", leading to a decrease in the mean score obtained for the element of claim. For example, the student numbered as 23 in the jigsaw group included the following statements in his/her pre-test written argumentation form. "*I want nuclear power plants to be established. In this way, the environment can be protected against pollution. One of the most serious problems in the world is global warming. If nuclear energy plant could contribute to the reduction of global warming, then they should be established*". The same student wrote the following statements in his/her post-test argumentation form: "*I am undecided because although nuclear energy seems to be more environment friendly compared to other sources of energy; for example, it does not produce ash as side-product and it has a large share in electricity production, the accidents occurred in the past frighten me. Even a very small amount of harmful matter emitted in case of an accident can be deadly. Moreover, their construction is highly expensive.*" Though this student did not mention any negative opinions in his/her pre-test argumentation form about nuclear energy, he/she pointed out nuclear accidents and expenses caused by the establishment of nuclear power plants in his/her post-test argumentation form. That is, the student acquired new information contradicting with his/her own claim; yet, he/she did not completely change his/her opinion and rather than supporting the idea that they should be established, he/she stated that he/she was undecided. In a study conducted by Evagorou, Jimenez-Aleixandre and Osborne (2012), it was also found that even if the students acquired new evidence contradicting with their own claims, they went on insisting on their claims, tended to use the new evidence in such a way as to support their own claims or tended to overlook the evidence contradicting with their claims.

Another finding obtained at the end of the study is that the mean scores taken for the elements of evidence and reasoning increased in all the three groups at the end of the study. This finding concurs with the findings of many studies reporting that students' evidence and reasoning scores increased as a result of the activities focusing on socio-scientific issues (Zohar & Nemet, 2002; Topçu & Atabey, 2017). It was seen that the students who obtained information about socio-scientific issues through the activities carried out in the three groups used this information as evidence and reasoning to support their claims. Students' understanding of

content supports their effective use of evidence and reasoning elements (Mcneill, Lizotte, Krajcik, & Marx, 2006). However, a striking finding is that the increase in evidence scores is higher than the increase in reasoning scores in all the three groups. This finding can be attributed to the fact that the reasoning element is more difficult to express than the claim and evidence elements (McNeill & Krajcik, 2012*)* because reasoning is a logical defence of why and how evidence supports the claim, students have difficulty in explaining this logic and using scientific principles for this purpose (McNeill & Krajcik, 2012). Another finding obtained in relation to the elements of evidence and reasoning is that the highest increase was observed in the mean scores taken by the students in the jigsaw group for these elements. In fact, all the students in the jigsaw group were able to provide evidence at the end of the research at level 2. These findings show that the students could present more qualified and high level of evidence and reasoning as a result of jigsaw applications. This can be because of the formation of expert groups in the jigsaw group. The expert groups had the opportunity to have detailed information about the sub-sections of a socio-scientific issue and then to obtain in-depth information from their friends who specialized in other sub-sections in their groups. Thus, they had a greater chance to use the content information they gained about the different dimensions of the subject as evidence and reasoning compared to the other groups. In the study conducted by Tekbıyık (2015), it was found that students could present logical reasoning after the activities performed with the jigsaw method. Tekbıyık (2015) attributed this finding to the students' making decisions on the basis of logical reasoning as they were able to have access to sufficient content knowledge as a result of the jigsaw applications.

In the current study, it was found that the mean score taken by students for the element of rebuttal presented by the students at the beginning of the applications was very low. The element of rebuttal is more difficult to express than the elements of claim, evidence and reasoning, and is the most important element used to determine the quality of an argument (Çelik, 2010). It is stated that the arguments containing this element are of higher quality since refutation requires awareness of counter ideas (Erduran, Simon, & Osborne, 2004) because it is difficult for an opinion change to occur in cases where the rebuttal element is not used (Çelik, 2010). Therefore, it is an expected result that that students had difficulty in presenting the element of rebuttal which requires not only considering their own ideas but also the counter ideas. However, it is an unexpected result that the mean score increase in the rebuttal element was higher than the mean score increase in the reasoning element. This is because the rebuttal element is defined as more difficult to express than the reasoning element. The higher increase observed in the rebuttal element compared to the reasoning element can be attributed to the fact that the students became aware of the opposite ideas and became more qualified in the rebuttal of these ideas at the end of the study. This finding is parallel to the finding reported by Demircioğlu and Uçar (2014). Demircioğlu and Uçar (2014) found that the number of rebuttals presented by the students was on the increase at the end of the study while the numbers of reasons and claims were on the decrease. Moreover, for one question, the number of rebuttals was reported to be higher than the numbers of claims and reasons. This shows that prior to the application the pre-service teachers were successful in defending their own arguments yet not so successful in rebutting counter arguments. On the other hand, at the end of the study the pre-service teachers became more successful in rebutting counter arguments. The reason for this may be the in-depth discussion of different dimensions in the jigsaw group, the recognition of opposing thoughts as a result of the evaluation of the subject from different points of view, and in-group dialogues on whether these ideas are true or not. Further progress observed in the element of rebuttal presented by the pre-service teachers in the jigsaw group can be attributed to the definition of this method as the most appropriate method for teaching subjects with different dimensions (Tekbıyık, 2015). Activities conducted to take into account different perspectives support the production of qualified arguments involving the rebuttal element (Demircioğlu & Uçar, 2014).

Higher frequency values of argument elements in the jigsaw and learning together groups; as stated by the students during the interviews, can be attributed to the positive effects of these methods, such as recognizing different perspectives, expressing oneself better, discussing and

exchanging information. Based on the statements of the pre-service teachers, the reason why the jigsaw method is the method that enhances the argument elements the most can be associated with its benefits such as allowing participants to complete their missing information, expressing themselves better, encouraging students to research, to learn to discuss, to be engaged in peer learning, to work in groups, to exchange information and making meaningful and permanent learning possible. Although the benefits such as information sharing, meaningful and permanent learning, directing to research, better self-expression and peer learning were also mentioned by the students in the learning together group, the other benefits positively affecting the quality of argumentation such as completing the missing information, learning to discuss, being able to make comments and learning to work in groups were not mentioned by the students in this group.

Another important finding of the study is that it was found that the mean scores taken from the elements of argumentation increased not only in the cooperative groups but also in the control group (where group activities were conducted). The pre-service teachers engaged in group activities may have taken the advantages of working together because it has been revealed in different studies that the quality of the arguments produced in group is better than the individually produced arguments (Çelik & Kılınç, 2017; Sampson, 2007). The emergence of different ideas during the group works, offering justifications for these ideas, thus supporting the development of ideas and specifying the elements not presented in the individual arguments after the group work positively affect the argumentation qualities (Çelik & Kılıç, 2017). Group works support the production of more qualified arguments, giving students the opportunity to share their ideas, refute counter arguments and present reasons (Demirel, 2015). Therefore, it can be said that group works are effective in improving the argument quality of students. However, it should be noted that cooperative group works give better results for more qualified arguments because in a collaborative study, the success of the group is sometimes more than the sum of the effects of the individuals in the group (Sampson & Clark, 2009). At that point, it is thought that the results of the current study will be of great significance to prove the effectiveness of cooperative learning environments, especially the jigsaw method, in order to produce more qualified arguments. Future research may focus on how to develop more effective collaborative learning environments to be used in the teaching of socio-scientific issues and how intra-group (the number of group members having different or same opinions, gender distribution within the group, focus on the topic, focus on the data, reasoning and questioning) or individual factors (in-group behaviours and participation of group members) affect these processes. Two methods of cooperative learning were used in the current study. New studies investigating how different methods of cooperative learning model affect the teaching of socio-scientific issues and the development of students' argumentation qualifications can be conducted. In addition, more studies can be added to the limited number of studies conducted on socio-scientific issues and argumentation with pre-service classroom teachers.

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