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THE USE OF JIGSAW COLLABORATIVE LEARNING METHOD IN TEACHING SOCIO-SCIENTIFIC ISSUES: THE CASE OF NUCLEAR ENERGY

Ahmet Tekbiyik

Abstract. *This research examines the influence of Jigsaw, which is a collaborative learning (CL) method, on students' views and decision-making processes concerning the use of nuclear energy. The research included 60 fourth-year undergraduate students attending the science teacher training program of a university in Turkey in the 2013–2014 academic year. In the research, firstly an attempt was made to provide students with scientific literacy on the subject through Jigsaw method. Then the groups formed for the Jigsaw method created argumentative texts in which they expressed their views. In the end, the students developed positive attitudes and supported the establishment of nuclear power plants in Turkey. They had negative views about the use of nuclear energy before teaching. Their views turned to positive after teaching to a great extent. It was seen that gaining enough knowledge to do logical reasoning through teaching was influential on their capability to reach positive decisions. Furthermore, it was revealed that decision-making processes are affected by variables such as scientific literacy, awareness, and suggestions for reducing risks.*

Key words: *collaborative learning, Jigsaw, nuclear energy, socio-scientific issues.*

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Introduction

Expressing opinions about social issues and taking part in decision-making processes are among the most important civic responsibilities of individuals (Aikenhead 1985; Barrue & Albe, 2013; Kolstø, 2001). In this regard, development of decision-making skills is among the objectives of curricula. With the inclusion of controversial socio-scientific issues in science curricula, an attempt is made to develop individuals' decision-making skills and provide them with adequate content knowledge on these subjects (21st Century Science Project Team, 2003; AAAS, 1989; NRC, 1996; Turkish National Science Curriculum, 2013). Socio-scientific subjects include controversial subjects which have both scientific and social aspects and affect social life (Kolstø, 2001; Sadler, 2004).

In recent years, many socio-scientific issues, including biotechnology (Dori et al. 2003), genetically modified foods (Chang & Chiu, 2008; Kılınç et al. 2013; Walker & Zeidler, 2007), effects of mobile phone use on health (Albe, 2008), global warming (Khishfe & Lederman, 2006), and water quality (Barab et al. 2007) have been subject to research. Some socio-scientific issues may occupy the agenda of society by coming to the forefront relative to others as a result of current developments. The use of nuclear energy and an establishment of nuclear power plants has been one of the important controversial agenda items in Turkey in recent years. There is no active nuclear power plant in Turkey. In the Strategic Plan of the Ministry of Energy and Natural Resources dated to 2010, the main target is set to be "providing every consumer with adequate, high quality, affordable, safe, and environmentally friendly energy resources" and "reducing our country's import dependency in energy supply" (RTMENR, 2010). In August 2010, a contract concerning the establishment and operation of a nuclear power plant in Akkuyu, Mersin was signed with the Russian Federation, which indicates the firm attitude of the Turkish Government in this matter. However, the accident at Fukushima Nuclear Power Plant in Japan, which was triggered by the tsunami caused by the 8.9 earthquake taking place in the East Asia in 2011, harmed nuclear

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energy badly and made it more controversial (İşeri & Özen, 2012). The issue of nuclear energy has remained on the agenda up to now. Lastly, during the visit of Putin, the President of Russia, to Turkey on the 1st of December 2014, it was stated that works for the establishment of a nuclear power plant in Akkuyu, Mersin with the support of Russia would be maintained resolutely. All these developments show that the use of nuclear energy is a priority issue for Turkey among other socio-scientific issues. Therefore, it is very important that individuals make decisions in this matter by use of logical reasoning processes.

The studies about the effects of socio-scientific issues conducted in the field of science were summarized by Sadler (2009). Both the literature review carried out by Sadler (2009) and the studies conducted on this subject in the following years show, that variables related to socio-scientific issues have been examined, or interventions have been made in learning environments. The studies have focused on variables such as students' attitudes (Sadler, 2004; Topçu, 2010), decision-making processes (Topcu, Yilmaz-Tuzun & Sadler, 2009), and risk perceptions (Kılınç, Boyes, & Stanisstreet, 2013). In the studies involving intervention in learning environments, attempts have been made to develop students' skills such as argumentation (Albe, 2008; Aydeniz & Gürçay, 2013; Iordanou & Constantinou, 2014; Jimenez-Aleixandre et al., 2000; Khishfe, 2014; Kolstø, 2006; Kortland, 1996; Lee, 2007), content knowledge (Dori, Tal, & Tsaushu, 2003; Klosterman & Sadler, 2010; Yager, Lim, & Yager, 2006), scientific literacy (Morin et al., 2013), or discussion (Lewis & Leach, 2006; Rudsberg, Öhman & Östman; 2013) by using socio-scientific issues as a means mostly. The teaching of socio-scientific issues requires a deep theoretical background (Levinson, 2006). If socio-scientific issues, which have a complex structure with their scientific, logical, and ethical aspects, are offered through traditional teaching practices, next generations cannot be expected to make decisions on these subjects (Kılınç, Boyes, & Stanisstreet, 2013).

Therefore, well-organized learning environments, where students interact with one another are needed in the teaching of socio-scientific issues. In this sense, previous studies have involved group discussions and argumentation-oriented methods where views could be shared mutually (Albe, 2008; Iordanou & Constantinou, 2014; Lewis, & Leach, 2006; Rudsberg, Öhman & Östman; 2013). With group discussions, it is aimed to enable students to take different approaches to subjects and reach decisions by reasoning on arguments and counterarguments. Individuals' strategies of thinking and decision-making on socio-scientific issues are affected by different contexts (Črne-Hladnik et al., 2009; Sadler, 2009). Inadequate content knowledge and misconceptions on subjects are among the negative variables affecting discussion and decision-making processes negatively (Albe, 2008; Lewis & Leach, 2006). Indeed, knowledge acquired in informal learning environments (especially media) prevents logical reasoning based on risk assessment, critical thinking, and autonomous reasoning (Kılınç, Boyes, & Stanisstreet, 2013).

It is known that group learning is more effective than individual learning (Johnson & Johnson, 2009). Group learning brings two important concepts to mind: cooperative learning and collaborative learning. There are small differences between these two concepts, which are usually used interchangeably. Cooperative learning usually refers to practices in which students get involved, and the purpose is to provide them with basic knowledge. Collaborative learning, on the other hand, refers to practices in which college and university students get involved, and the purpose is to provide them with high level skills (Bruffee, 1995). Thus, collaborative learning (CL) was employed in the present research because of the participants' characteristics and the skills examined. In CL, group members contribute to the learning of one another by taking on responsibility. Since face-to-face interaction takes place, it is possible to develop social skills besides cognitive skills in this process (Gillies & Boyle, 2010; Ruys, Van Keer & Aelterman, 2011).

Though many CL methods have been developed so far (Johnson and Johnson, 1999; Sharan and Hertz-Lazarowitz, 1980; Slavin, 1980), Jigsaw (Aronson et al. 1978; Slavin, 1980) is the most appropriate method to apply when a subject to be taught consists of independent portions. Different types of the Jigsaw method such as Jigsaw I, Jigsaw II, Jigsaw III, Jigsaw IV, Reverse Jigsaw, and Subjects Jigsaw are usually applied in a similar structure (Doymus, Karacop & Simsek, 2010). The "Jigsaw I" method used in the present research was developed by Aronson et al. (1978). In this method, students are divided into groups of 4 to 6. All groups learn the same unit. However, the unit is divided into as many sub-sections as the number of individuals in the group. Each member in each group chooses a section of the unit to learn. Every member studies his/her own subject. Then those members from different groups who chose the same subject come together to form "expert groups". In the expert groups, relevant subjects are explained, and in-depth discussions are made. After the students in the expert groups learn their subjects completely, they return to their own groups. They try to teach their subjects to their group mates. In the present research, each group consisted of five people because nuclear energy subjects were divided into five portions.

There are a few studies in which collaborative learning was used in the teaching of socio-scientific issues. Evagorou and Osborne (2013) defined the method they used in their study as "collaborative argumentation". In their learning environment, the students were asked to work in groups, perform common tasks, and offer arguments. The starting point of the practice was a problem: whether the UK government should kill the gray squirrels in order to save the indigenous red. In the end, the groups were seen to be capable of high level argumentation. In other words, group works were carried out in an argumentation-oriented way. Another study was conducted on the subject of "climate change" (Day & Bryce, 2013). In that study, collaborative learning was used for students to engage in discussion. By this means, a shift from discussion involving teacher-student interaction to discussion involving student-student interaction took place. In both studies, collaborative learning method was applied in an argumentation-oriented way, and the purpose was to provide students with social skills rather than knowledge.

The present research intended to make use of such advantages of the collaborative Jigsaw method, as ensuring social interaction and providing content knowledge and literacy. Differently from the previous studies, no persuasive discussion was made during the application of the Jigsaw method. It was left for the argumentative writing activity to be conducted after teaching through the Jigsaw method. It was considered that confronting students with content knowledge and decision-making process could be influential on logical decision-making. In this context, an attempt was made to answer the below-mentioned questions:

1. Does the Jigsaw method have any influence on the development of students' scientific literacy on the subject of nuclear energy?
2. Does the Jigsaw method have any influence on students' views about the use of nuclear energy?
3. What variables are influential on students' decision-making processes concerning nuclear energy?

Methodology of the Research

General Background of Research

A mixed research design incorporating qualitative and quantitative research methods was applied in the research (Creswell & Plano Clark, 2011). While the phenomenological method was employed as a qualitative, 'single group pre-test/post-test' experimental method was used as a quantitative method.

The research process is illustrated in Figure 1. The research process includes the stages of administration of pre-tests, application of Jigsaw method, argumentative text writing, and the administration of post-tests respectively. The data collection process took four weeks in total during the spring semester of 2013–2014 academic year. The stages were implemented at the intervals of one week.

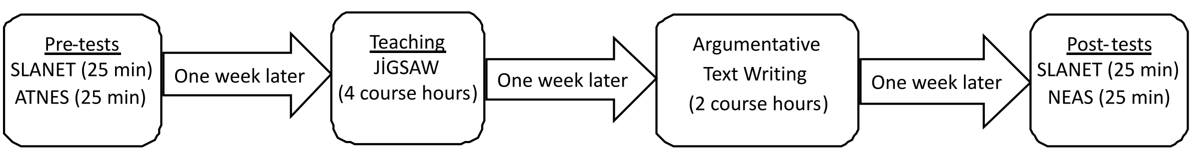

Figure 1: The research process.

Participants

Participants were selected from a science teacher training program of a public university in Turkey. In the senior class, there were only 90 undergraduate students attending the program during 2013–2014 academic year. Of which, only 60 students volunteered to participate in the research. No control group was used because it was not aimed to compare the teaching method employed in the research with another method. All of the participants were included in the experimental group. Since the simultaneous inclusion of a big participant group of 60 people in the Jigsaw activity would lead to some trouble in the teaching process, the participants were divided into two groups of 30 people. They participated in teaching through Jigsaw and argumentative text writing activities in these groups. The same data-collection instruments and the same teaching practices were employed in both groups. The same process was implemented in two separate groups in order to enhance the external validity of the research by forming more collaborative groups. All the participants took pre-tests. However, quantitative analyses were made

ISSN 1648–3898

with 59 participants because one of the participants did not take post-tests.

Instruments

Attitudes towards Nuclear Energy Scale (ATNES)

A data-collection instrument composed of two sections was used in order to quantitatively determine the students' views about the use of nuclear energy and the nuclear power plants planned to be established in Turkey. In the first section, a survey question was addressed to the students for them to express their views about the establishment of nuclear power plants. The question was as follows: "Do you support the establishment of nuclear power plants in Turkey?" Answering choices were as follows: I support; I do not support; I have not been supporting since the Fukushima accident; and I am not interested in that.

The second section of the instrument included the Attitudes towards Nuclear Energy Scale (ATNES) developed by Özdemir and Çobanoğlu (2008). Various instruments have been developed and used for measuring attitudes towards nuclear energy so far. Some of them have been developed for Turkish people (Palabıyık, Yavaş & Aydın, 2010; Gökmen et al., 2012; Seyihoglu, 2012) while some others have been developed for people of other countries (Siegrist, Sütterlin, & Keller, 2014; Yim & Vaganov, 2003; Eiser, Spears, & Webley, 2006; Corner, et al., 2011). Among these scales, the one developed by Özdemir and Çobanoğlu (2008) was deemed appropriate to the nature of the present research. It is a 5-point Likert type scale composed of 20 items and 4 dimensions. While one of these dimensions referred to positive views, the other three dimensions were about negative views. The characteristics of the scale's dimensions and sample items are given in Table 1. The Cronbach's alpha (α) internal consistency coefficients of the dimensions of the Attitudes towards Nuclear Energy Scale vary between 0.62 and 0.85. Özdemir and Çobanoğlu (2008) reported that the Cronbach's alpha (α) internal consistency coefficient of the scale is 0.88.

Table 1. The characteristics of the dimensions of ATNES.

Dimensions	Number of items	Dimension description	Sample items	Cronbach' α
Dimension 1: The establishment of nuclear power plants in Turkey	8	Positive views about the establishment of nuclear power plants in Turkey	If nuclear power plants are established in Turkey, we will have a very important strategic power in our region	0.85
Dimension 2: The effects of nuclear power plants on the environment	6	The negative effects of nuclear power plants on the environment	Nuclear power plants harm water resources	0.62
Dimension 3: Nuclear armament across the world	3	Views that nuclear power plants may lead to an increase in the number of nuclear weapons	Nuclear power plants are established for making nuclear weapons rather than generating electric energy	0.77
Dimension 4: Turkey's energy policies	3	Views that the energy problem of Turkey may be solved by use of renewable energy rather than nuclear power plants	Turkey should turn to renewable energy (wind energy, solar energy) resources rather than nuclear energy	0.64

Scientific Literacy about Nuclear Energy Test (SLANET)

The scientific literacy levels of individuals on subjects affect their attitudes towards science. In this sense, it is likely that their scientific literacy levels on the subjects of nuclear energy and radioactivity affect their attitudes. A test was developed to determine the differences between the scientific literacy levels of the students before and after the teaching process. The test consists of 20 true, false items. These items measure students' basic knowledge levels about nuclear energy, radioactivity, and their real-life applications. The test items were created by the researcher. The items were submitted to experts who were asked to deliver their opinions about the appropriateness of the scale items. An academic who was a science educator specialized in socio-scientific issues, an academic who was a nuclear physicist, and a test development expert expressed their opinions about the test. These experts agreed that the test is capable of measuring literacy of nuclear energy. A pilot study was conducted to determine the reliability of the test. Within the scope of the pilot study, the test was administered to a group composed of 30 final year undergraduate students attending the science teacher training program of a university different from that of the research participants. It was found out in the pilot study that 25 minutes are sufficient to respond the test items. In addition, KR-20 reliability coefficient was found to be 0.92. Some sample questions from the test are as follows:

"*Nuclear power plants run on fission reaction.*"

"*Any uranium atom emits radiation.*"

Argumentative Text

After collaborative learning activities were completed, the groups were asked to create argumentative texts on their subjects. Argumentative texts were used for two purposes. The first one was qualitatively supporting the quantitative findings concerning the changes in the students' attitudes. The second one was making an in-depth examination of what arguments shaped the students' in group decision-making processes. "Argumentative text writing" was adopted as a tool allowing the students to express their views as a group. Argumentative text writing is a type of writing where an author tries to support his/her claim on a subject by using the ways of clarifying ideas and refute counter-claims and concludes the subject accordingly (Coşkun & Tiryaki, 2011). In science, argumentative text writing contributes to students' conceptual development (Sampson, Enderle, Grooms, & Witte, 2013) and develops their scientific skills (Baker et al., 2008) because it enables students to put subjects into mental processes.

The students came together in their original groups to write argumentative texts one week after collaborative learning practices were completed. Firstly, the students were informed about argumentative texts. Since the students had not received any training on argumentative text writing skills until then, minimal argumentative movement (Adam, 1992), which is an argumentative writing type, was used. This text type consists of an initial claim and its supporting arguments, a series of counterarguments, and a conclusion (Roussey, & Gombert, 1996). Complex arguments are obtained by sequencing simple arguments.

The concepts of claim, argument, counterargument, and conclusion were introduced to the students along with examples, and they were asked to create a text by following the same order. The writing assignment was given to the groups as follows: "*Write an argumentative text that contains your views about the use of nuclear energy and establishment of nuclear power plants in Turkey*". In writing the texts, the students had an opportunity to use the notes they had taken during collaborative teaching. Before the groups started writing, the group members discussed and tried to persuade one another. Two course hours were granted to the students to write their argumentative texts.

The texts were subjected to content analysis. NVivo 10 was used in the analysis. NVivo not only analyzes but also sums up the data in models, matrices, graphs, or reports (Cassell et al., 2005). In analyzing the data, coding was done by identifying the common views. Based on such codes, themes representing the data in general were created. In this way, "nodes in tree" were formed via NVivo (Bazeley & Jackson 2013). On the other hand, the same data were coded by a different researcher separately in order to ensure the reliability of the analysis. Intercoder reliability was found to be approximately 88%. This value refers to high coder reliability (Miles and Huberman, 1994). Any disagreement was solved by negotiation. The views fell under 4 themes at the end of the analysis. These themes are scientific literacy, awareness, suggestion for reducing risks, and making decisions.

Procedure

Like in the previous studies (Doymuş, Karacop, and Simsek, 2010; Tarhan et al., 2013), the students were informed of collaborative learning and the Jigsaw technique in the first place. Then the students were divided into six groups. Each group consisted of five people. The students were in their "home groups" to complement one another like the pieces of a puzzle. The article entitled "Nuclear Energy and the Latest Situation in Japan" (Bağdatlıoğlu, 2011) from the *Bilim ve Teknik* (*Science and Technology*) magazine published by TUBITAK (The Scientific And Technological Research Council Of Turkey) was given to the students in hard copy as an information source on the subject. *Bilim ve Teknik* is a monthly popular science magazine intriguing and recent developments in science and technology are presented in everyday language (TUBITAK, 2014).

This source was chosen because it offers a scientifically, economically, and socially objective evaluation of nuclear energy and nuclear power plants. Each group was composed of five people because the above-mentioned article is made up of five independent portions (Figure 2). In addition, the students were provided with the Internet

ISSN 1648–3898

access so that they could do deeper research. First, the subjects were assigned among group members. Then, each member participated in the expert group based on their subjects, meaning that the students who were responsible for the same subjects came together in the expert groups and tried to specialize in their subjects by helping one another. Two course hours were granted to the expert groups to study. In that period, the students helped the learning of one another by working on the same subjects in their expert groups. Then the students returned to their home groups and brought together the subjects they had studied in their expert groups. The students each of whom had specialized in different subjects conveyed their knowledge to other group members and answered their questions. Home group works took two course hours, too. No persuasive discussion was made during home group or expert group works.

The home groups met for argumentative text writing activity one week after the Jigsaw activity. Argumentative text writing procedure has already been described above under the title of *Argumentative Text*.

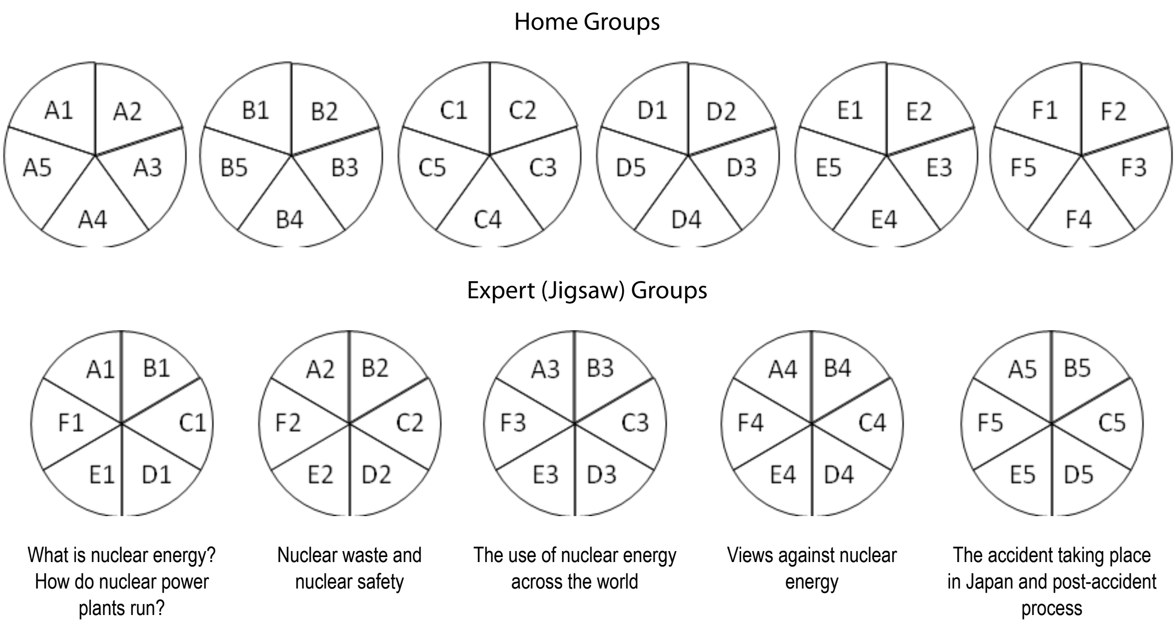

Figure 2: Design of the Jigsaw model in the research.

Results of Research

A survey question was addressed to the students in order to determine their views about the establishment of nuclear power plants in Turkey. The students' views are presented in Table 2. Before the teaching, 37% of the students supported it while 37% did not support it. 19% of the students stated that they had not been supporting it since the Fukushima accident. In other words, their reason for not supporting it was the Fukushima accident. 4 students (7%) were not interested in it. After the teaching, the same survey item was asked to the students again. While the percentage of those students who "supported" it increased to 78%, the percentage of the students not supporting it decreased to 14%. In addition, the percentage of those who stated that they had not been supporting it since the Fukushima accident fell to 8%. 4 students who had said that they were not interested in it in the pre-test made a decision in the post-test. These results indicate that the teaching both was influential on the development of positive views about the establishment of nuclear power plants among the students and created awareness among them.

Table 2. Students' views about the establishment of nuclear power plants in Turkey (n=59).

Views of Students	Pre-test	Post-test
	f (%)	f (%)
I support	22 (37)	46 (78)
I do not support	22 (37)	8 (14)
I have not been supporting since the Fukushima accident	11(19)	5 (8)
I am not interested in it	4 (7)	0 (0)

A paired sample t-test was conducted to see whether or not there were differences between the responses to the dimensions of the Attitudes towards Nuclear Energy Scale (ATNES) and the Scientific Literacy about Nuclear Energy Test (SLANET) in pre-tests and post-tests. The results are given in Table 3. A significant difference in favor of the post-test was detected between the pre-test and the post-test scores obtained from Dimension 1 defining attitudes towards "the establishment of nuclear power plants in Turkey" ($t(58)=-11.74$, $p<.05$). The average was 25.25 in the pre-test, but rose to 32.00 in the post-test. This result shows that the students changed their decisions concerning the establishment of nuclear power plants in Turkey positively at the end of the teaching.

Table 3. Comparison of the pre-test and the post-test scores obtained from the dimensions of the ATNES and SLANET.

Variable	Pre test		Post test		t(58)	p	95% CI		Cohen's d
	M	SD	M	SD			LL	UL	
Dimension 1	25.25	5.19	32.00	5.11	-11.74	.000	-7.89	-5.59	-1.53
Dimension 2	21.54	3.60	18.24	3.44	5.81	.000	2.16	4.44	0.76
Dimension 3	9.73	2.54	7.81	2.59	4.95	.000	1.14	2.67	0.64
Dimension 4	10.80	2.54	9.73	1.95	2.93	.005	.34	1.79	0.38
SLANET	13.83	3.07	15.90	2.18	-5.07	.000	-2.88	-1.25	-0.66

Note. CI = confidence interval ; LL = lower limit; UL = upper limit

The Dimension 2 of ATNES includes views about the negative effects of nuclear power plants on the environment. A statistically significant difference in favor of the pre-test was detected between the pre-test and the post-test scores in this dimension ($t(58)=5.81$, $p<.05$). The average was 21.54 in the pre-test, but fell to 18.24 in the post-test. This result demonstrates that views that nuclear power plants may have negative influences on the environment decreased after the teaching.

The Dimension 3 of ATNES includes views that the use of nuclear energy leads to nuclear armament across the world. A statistically significant difference in favor of the pre-test was detected between the pre-test and the post-test scores in this dimension ($t(58)=4.95$, $p<.05$). The average was 9.73 in the pre-test, but fell to 7.81 in the post-test. This result indicates that the teaching weakened the view that nuclear energy leads to nuclear armament across the world.

The Dimension 4 of ATNES includes views that the energy problem of Turkey can be solved through renewable energy rather than nuclear power plants. A statistically significant difference in favor of the pre-test was detected between the pre-test and the post-test scores in this dimension ($t(58)=2.93$, $p<.05$). The average was 10.80 in the pre-test, but fell to 9.73 in the post-test. This result shows that the teaching process developed views that nuclear energy has advantages over renewable energy.

The influence of collaborative teaching on the students' scientific literacy of nuclear energy was determined through the comparison of SLANET scores. A statistically significant difference in favor of the post-test was detected between the pre-test and the post-test SLANET scores ($t(58)=-5.07$, $p<.05$). The average was 13.83 in the pre-test, but rose to 15.90 in the post-test.

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In the content analysis of the argumentative texts created by the groups, themes were determined in the first place. Four themes came to the forefront in the texts: scientific literacy, awareness, making decision, and suggestions for reducing risks.

The codes falling under each theme were presented separately to make the data interpretable. Data were obtained from 12 "argumentative texts" created by 12 "home groups". In model presentation, the groups from which relevant codes were obtained were indicated on the links.

The model concerning the theme of scientific literacy is given in figure 3. In this model, scientific knowledge about nuclear energy was used by almost all groups in their texts. In other words, the students grounded their claims about nuclear energy on a scientific basis. Scientific knowledge samples presented by the groups are as follows:

In nuclear power plants, energy is obtained through fission reaction. This energy does not transform into electric energy directly. It is used for heating the water vapor that rotates turbines (5).
Nuclear power plants run as U-235 isotope undergoes fission when a neutron is made to hit it (8).

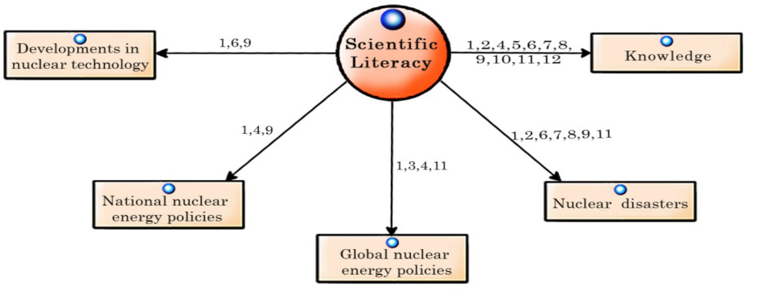

Figure 3: The model concerning the "scientific literacy" theme in the argumentative texts.

As is seen above, the knowledge presented by the students was mostly aimed at explaining the working principles of nuclear power plants. The groups (1, 2, 6, 7, 8, 9, 11) included nuclear accidents in their argumentative texts, too. They mostly made mention of the Fukushima accident. Some sample statements are as follows:

The nuclear accident taking place in Japan made tremendous impact in many countries and worsened the attitudes towards nuclear power plants more (1).
The pressure emerging from rising water as a result of the tsunami in Fukushima heated the reactor and caused a disaster (6).

Nuclear accidents were used for posing counterarguments about risks. In the model concerning the theme of scientific literacy, the groups expressed their views about global (1, 3, 4, 11) and national (1, 4, 9) nuclear energy policies, too. Some sample statements are as follows:

According to 2009 data, nuclear power plants meet almost 17% of the energy need in the world (11).
It does not seem possible for Turkey to meet its energy need from natural gas, petroleum, or coal (9).

The groups also focused on how global nuclear energy policies could affect national policies. The last code used in regard to scientific literacy in the argumentative texts is "developments in nuclear technology". Three groups delivered views on this subject (1, 6, 9). Some sample statements are as follows:

With today's technology, reactors that can turn themselves off automatically when the system overheats are produced (6).
Today, there are storage methods whereby nuclear waste can be stored safely (9).

It is seen that the students are knowledgeable about nuclear technology. Their statements focus on the working principles of power plants and technologies for storing waste and thus reducing risks.

Another theme determined in the content analysis of the argumentative texts is awareness. The theme of awareness consisted of two categories: risks and limitations (Figure 4). The code used most in the category of risks is health problems (1, 3, 4, 6, 9, 10, 12). Sample expressions about this code are as follows:

Nuclear energy is very harmful to human health (12).
It is thought by scientists that even though the number of people killed in nuclear accidents is few, the genetics of the next generation is affected badly (6).

The students were seen to have increased worry because of the possible harmful effects of radiation on human health. Another code in this category is "harmful to the environment" (1, 3, 6, 7, 9, 12). Six groups made mention of the possible harmful effects of nuclear energy on the environment. Some sample statements in this matter are as follows:

…it may have a negative impact on living beings and lead to extinction or mutation (9).
…one reason why people opposite is that natural resources may be harmed during the establishment of nuclear power plants (7).

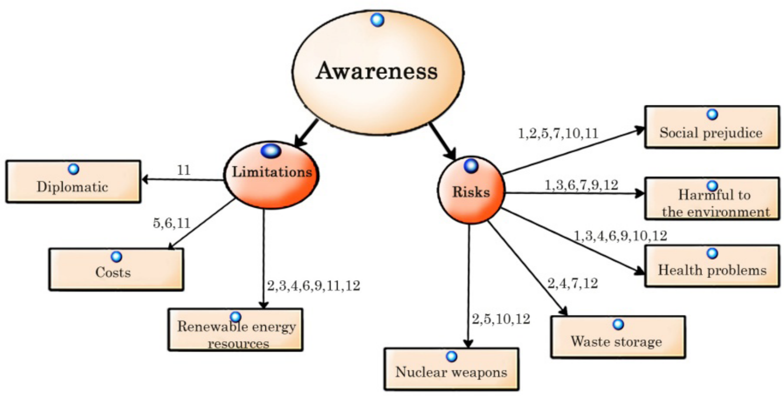

Figure 4: The model concerning the "awareness" theme in the argumentative texts.

One of the codes used in the category of risks is "social prejudice". Six groups delivered their views in this matter. Some sample views are as follows:

People oppose the nuclear power plant projects in Sinop and Mersin. Raising awareness of people about this subject is the state's duty (9).
Since our people are not knowledgeable of nuclear power plants, they think that explosion may occur anytime there (10).

These sample statements show that social prejudice in this matter results from people's lack of sufficient knowledge. Other codes used in the category of risk are waste storage and nuclear weapons. Some sample statements about these codes are as follows:

…the main problem is that radioactive waste emerging in this process is left around rather than disposal (7).
Uranium enrichment for nuclear energy may be misused and lead to armament. The use of energy for this purpose may bring humanity to a close (12).

ISSN 1648–3898

Among the worries of the students concerning nuclear energy are radioactive waste and risk of transformation of nuclear technology into weapons of mass destruction.

Another category of the theme of awareness is limitations. Three different codes came out in this category: These codes are renewable energy resources, costs, and diplomatic limitations. Sample statements concerning these codes are respectively as follows:

Renewable energy resources such as solar energy and wind energy may meet the energy need (3).
Reactors, which are used as part of the system in nuclear power plants have high costs (6).
Today, the establishment of nuclear power plants is a diplomatic problem, rather than a technological problem (11).

The students indicated the insufficient use of renewable energy resources and high costs of nuclear power plants among the limitations of the establishment of nuclear power plants. In addition, the students stated that nuclear technology may pose a threat to other countries and thus harm diplomatic relations.

The third theme determined in the content analysis is making decision. The theme of making decision shows whether or not the groups were able to reach a decision by evaluating arguments and counterarguments in particular. Two categories were determined in regard to this theme. These categories are "positive decision" and "indecisive". That is to say, no group reached a "negative decision" about the use of nuclear energy. The model concerning this theme obtained through content analysis is shown in Figure 5.

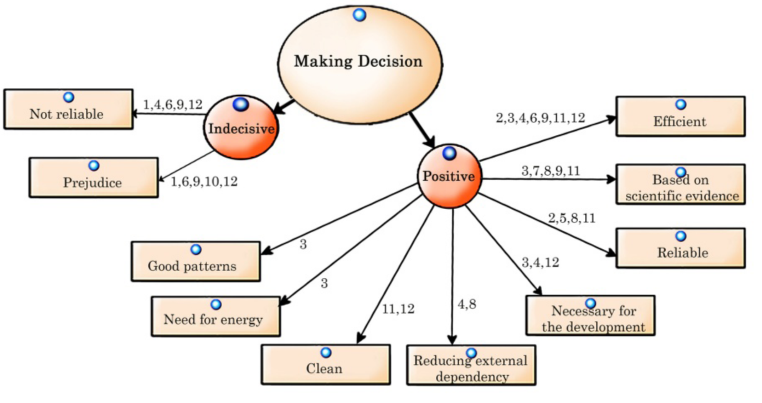

Figure 5: The model concerning the "making decision" theme in the argumentative texts.

"Efficient" was the most frequently used code in the category of positive decision (2, 3, 4, 6, 9, 11, 12). Some sample statements about this code are as follows:

We need 325 kg of coal to keep a 100 Watt lamp on for a year ceaselessly. However, the same energy can be obtained from less than half a gram of uranium (2).
The energy that can be obtained from one ton of coal can be obtained from 1 gr of uranium. Nuclear energy is much more efficient than other alternatives (11).

The groups stated that nuclear energy is more efficient than fossil fuels such as coal. Other most frequently used two codes used by those who made positive decisions are "based on scientific evidence" (3, 7, 8, 9, 11) and "reliable" (2, 5, 8, 11). Sample statements related to these codes are as follows:

Although nuclear power plants seem to be a serious threat to health, they may be prevented from threatening human health by bringing them under control through "passive safety" (3).
Indeed, when the safety requirements of nuclear power plants are fulfilled, they do not have any negative impact on human health. For example, only water vapor is emitted from nuclear power plants (8).

The sample statements indicate that adequate safety measures may be taken, and risk in nuclear power plants may be reduced through arguments based on scientific evidence. Other codes used in the category of making positive decision are "necessary for the development", "reducing external dependency", "clean energy", "need for energy", and "good patterns". Some sample statements about these codes are as follows:

As all developed countries do it, we should do it, too (4).
It makes a country act in an independent and influential way (8).
It can be used for minimizing the pollution resulting from the use of fossil fuels (12).
Energy requirement increases as a result of ever-increasing world population and industrialization. We need major energy resources to meet such need (3).
75% of electricity is obtained from nuclear energy in France, where the use of nuclear energy is most efficient (3).

Based on the codes used and views given above, it is clear that the students think the most efficient way of meeting the increasing need under today's conditions is nuclear energy. Another category under the theme of making decision is "indecisive". The codes used under this theme are "prejudice" (1, 6, 9, 10, 12) and "not reliable" (1, 4, 6, 9, 12). The sample statements of the groups using both codes are as follows:

Though its use by developed countries seems to be proper, its use by underdeveloped and developing countries is not proper (6).
We may fail in the absolutely safe storage of detrimental substances such as uranium and its isotopes under present conditions where even the storage of food waste is such a big problem (4).

These statements show that the groups took into consideration counterarguments in decision-making processes, and some groups failed to reach a definite decision as a result. It is clear that prejudices and security concerns affect decisions to a great extent.

The last theme determined in content analysis is "suggestions for reducing risks" (Figure 6). The codes used under this theme are "public awareness" (1, 3, 5, 10), "hard construction" (1, 8, 9, 11, "safe waste storage" (3, 7, 9, 11), and "construction far from life area" (3).

The people who react to the emission of radiation from nuclear power plants do not know that many natural resources around us emit radiation, too (5).
If all sorts of safety measures are taken, the establishment of power plants poses no risk (8).
… inadequate systems and waste demolish human health. These systems should be developed after they are understood well (9).
Risks may be reduced if these facilities are constructed far from settlements (3).

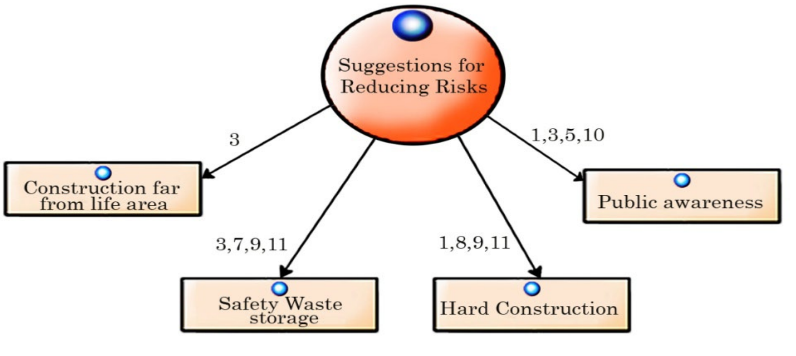

Figure 6: The model concerning the "suggestions for reducing risks" theme in the argumentative texts.

This theme includes the views to refute or weaken the counterarguments of the groups about the use of nuclear energy. The groups stated that risks may be reduced by raising awareness of people, using solid structures in the construction of power plants, bringing waste under control, and constructing nuclear plants as far as possible from settlements.

Discussion

Development of Scientific Literacy of Nuclear Energy

This research examined the influence of Jigsaw, which is a CL method, on students' views and decision-making processes about the use of nuclear energy. The Jigsaw method used in the research was influential on the development of scientific literacy of nuclear energy among the students (Table 3). Within the scope of the Jigsaw method, the subject was divided into portions. Each group member specialized in the subject for which s/he was responsible and helped other group members learn such subject. By this means, it was made sure that the students had knowledge about different aspects of a subject within a limited teaching period. The scientific literacy average was 13.83 in the pre-test, but rose to 15.90 in the post-test. The literature contains studies reporting that collaborative learning is influential on success in understanding basic science concepts (Doymuş, Karacop, & Simsek 2010; Tarhan et al. 2013). In addition, collaborative learning is reported to be effective in providing individuals with scientific literacy of socio-scientific issues (Day & Bryce, 2013). The argumentative texts, where the students delivered their views about nuclear energy, indicated that scientific literacy developed through the Jigsaw method. The analysis of the texts demonstrated that the students used "scientific literacy" in their decision-making processes (Figure 3). Almost all groups presented scientific knowledge about nuclear energy in their texts. 7 out of 12 groups presented knowledge about how nuclear accidents take place. A couple of groups gave information about nuclear energy policies in Turkey or worldwide. Three groups made mention of developments in nuclear technology. Such information presented by the students indicates that the codes determined in the analysis are very similar to the titles of the topics for which the students were responsible in the Jigsaw groups. This relationship is clear in Figure 7.

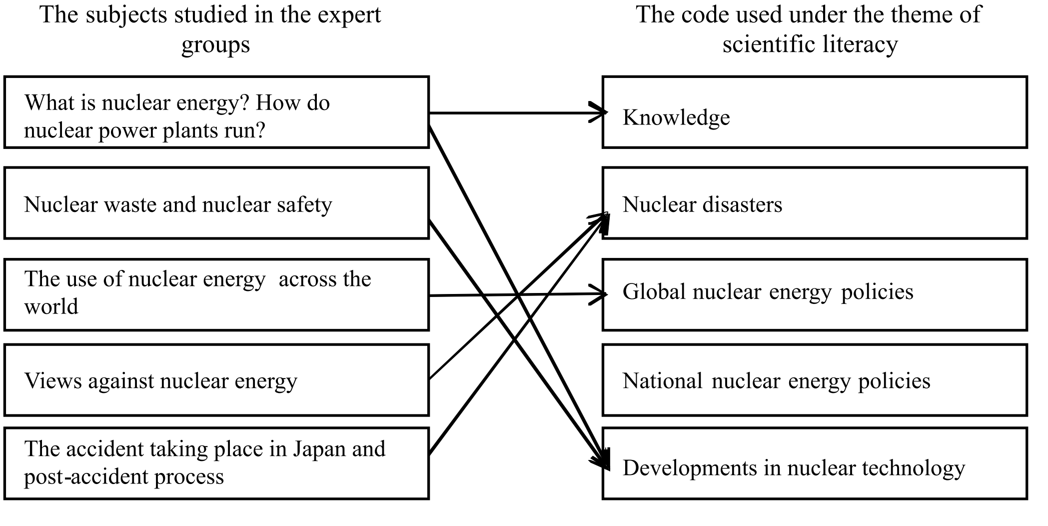

Figure 7: The relationship between the subjects studied in the expert groups and the codes used by the students under the theme of scientific literacy.

All the subjects studied by the students in collaborative learning groups were used in the argumentative texts. That is to say, the knowledge acquired in the groups was used by the students in their decision-making processes. That clearly demonstrates that the knowledge acquired through collaborative learning is influential on decision-making process. Furthermore, the existence of scientific literacy codes in the argumentative texts reveals that the students were able to do logical reasoning in their decision-making processes.

The Factors Influential on Decision-Making Processes and Changes in Attitudes

The decisions of the students about the establishment of nuclear power plants in Turkey were determined through a survey question in the first place. The views delivered by the students were supported by the data obtained from ATNES. The factors influential on such views were examined in the argumentative texts. In this way, an attempt was made to reveal the decision-making processes of the students from the general to the specific. Before the teaching, in response to the question, "Do you support the establishment of nuclear power plants in Turkey?" 37% of the students said that they supported it, but 37% told that they did not support it. 19% of the students, on the other hand, stated that they had not been supporting it since the Fukushima accident. In other words, their reason for not supporting it was the Fukushima accident. 4 students (7%) said that they were not interested in the issue of nuclear energy. While the percentage of those students who "supported" it increased to 78%, the percentage of the students not supporting it decreased to 14% after the teaching. In addition, the percentage of those who stated that they had not been supporting it since the Fukushima accident fell to 8%. After the teaching, none of the students told that they were not interested in the issue. Some studies in the literature report that collaborative learning is effective in making students who are not interested in socio-scientific issues have a view about them (Day & Bryce, 2013). The Dimension 1 of ATNES is directly related to that. The significant difference in the positive views concerning the establishment of nuclear power plants in Turkey in favor of the post-test indicates that the teaching was both effective in the students' acquisition of positive views about the establishment of nuclear power plants and created awareness among them, that is, indicated the decreased number of the students delivering negative views due to the Fukushima accident after the teaching. The decisions of the students about nuclear power plants manifested themselves in the argumentative texts, too. As is seen in the Figure 5, none of the groups reached a negative decision. Almost all groups made positive decisions. The most important reason for making such decisions was the efficiency of nuclear energy. Among other featured reasons were being based on scientific evidence and reliability. In this sense, it is clear that the students were able to present reasons to support their positive decisions.

The Dimension 2 of ATNES includes views about the negative effects of nuclear power plants on the environment. In this dimension, a statistically significant difference in favor of the pre-test was detected between the pre-test and the post-test scores. The number of views that nuclear power plants may have negative effects on the environment decreased after the teaching. That was seen in the argumentative texts under the theme of awareness (Figure 4). The codes of "harmful to the environment" and "waste storage" used in the category of risks represent the concerns of the students that nuclear power plants may have detrimental effects on the environment. These concerns decreased after the teaching. Thus, it is safe to say that collaborative learning provided the students with awareness.

The Dimension 3 of ATNES includes views that nuclear energy activities lead to nuclear armament across the world. In this dimension, a statistically significant difference in favor of the pre-test was detected between the pre-test and the post-test scores. The code of nuclear weapons was used as a risk factor under the theme of awareness in the argumentative texts. "Nuclear weapons" was one of the subjects studied by the Jigsaw groups under the title of nuclear safety. This may be why the students included it in their argumentative texts. The collaborative teaching process weakened the view that nuclear energy leads to nuclear armament across the world.

The change in the attitudes of the students towards Turkey's energy policies is seen in their responses to the Dimension 4 of ATNES. This dimension includes views that the energy problem of Turkey can be solved through renewable energy rather than nuclear power plants. A statistically significant difference in favor of the pre-test was detected between the pre-test and the post-test scores. In the argumentative texts, national energy policies fell under the theme of scientific literacy, and renewable energy fell under the theme of awareness. The students gained knowledge of national energy policies in the teaching process and became aware of renewable energy. Furthermore, the collaborative teaching process developed the view that nuclear energy has advantages over renewable energy.

In general, the students included knowledge representing scientific literacy in their argumentative texts in their decision-making processes firstly. The students used such knowledge to produce counterarguments against negative views about nuclear energy. They tried to support positive views by raising awareness and making risk analyses. They expressed the supportive views influential on their decisions. At this stage, they laid great emphasis on the measures that may be taken to reduce risks because they noticed that risks of using nuclear energy reinforced negative views (Figure 6). The first one of these measures was argued to be raising public awareness to reduce prejudices. The second measure was told to be ensuring hard construction. It was argued that constructing buildings resistant to natural disasters such as earthquake would increase the reliability of nuclear power plants. This code was used against nuclear accidents in particular. Safe waste storage and construction of nuclear power plants far from settlements were offered as measures for reducing risks. In this process, the students succeeded in offering arguments that both supported their own views and weakened the possible counter-views. The findings of the present research support the previous research finding that students who work in groups can create high level arguments (Evagorou & Osborne, 2013). One of the few studies in which students' skills of creating arguments about the use of nuclear energy were examined was conducted on pre-service physics teachers studying at two separate Turkish universities (Aydeniz & Gürçay, 2013). The research concluded that although the students participating in it had negative views about the establishment of nuclear power plants, they did not have adequate scientific knowledge to support their views and thus failed to create strong arguments. Aydeniz and Gürçay (2013) attribute that to the fact that the methods used in teaching socio-scientific issues fail in the construction, evaluation, and justification of knowledge. It can be said that the teaching process used in the present research provides students with argumentation skills and can form the basis for the solution of this problem mentioned in the literature.

Conclusions and Implications

The use of nuclear energy is a priority issue for Turkey among other socio-scientific issues. Therefore, it is very important that individuals make decisions in this matter by use of logical reasoning processes. The present research intended to make use of such advantages of the collaborative Jigsaw method as ensuring social interaction and providing content knowledge and literacy. Differently from the previous studies, no persuasive discussion was made during the application of the Jigsaw method. Instead, argumentative text writing activity was conducted after the jigsaw to reveal factors affecting the process of students' decision-making. The Jigsaw method used in the research was influential on the development of scientific literacy of nuclear energy among the students. Furthermore, knowledge acquired through collaborative learning played an important role on the decision-making process.

Before the teaching process, most of the students had negative views on the use of nuclear energy, but they did not have enough knowledge or literacy for their argument. Teaching process was designed to make sure that students were not directed to make positive or negative decisions, rather, help students comprehend the subject and have logical reasoning for their argument. After the teaching process, however, most of the students' views changed from negative to positive. What is important here is that when students have adequate content knowledge, they can reach decisions with reasoning.

During the application of the Jigsaw technique, no discussion session was formed which could have an effect on the decision making processes of the students in the research. This method may be enriched by launching a discussion in collaborative groups. The teaching method and design used in the research can set an example for the teaching of other socio-scientific issues and help students in the process of making reasonable decisions. These can be applied in teaching other socio-scientific issues.

The research results imply that prejudices toward the use of nuclear energy can be seen the main source of negative views. When enough knowledge is provided, individuals are likely to reach reasonable decisions based on their thinking of the possible advantages and disadvantages of using nuclear energy. In the research, the negative views of the students about the establishment of nuclear power plants in Turkey turned into positive when attention was paid to taking risk factors under control. Thus, risk perception decreases when students are provided with scientific evidence supporting safe-use of nuclear energy. Concerns about risk factors such as waste safety, nuclear armament, or negative effects on the environment may be reduced in this way. Furthermore, the collaborative teaching process helped the students to be able to compare alternative energy sources. Based on their comparison, students argued that nuclear energy has advantages over renewable energy. Since the present research was carried out with a limited number of students, it is suggested to conduct a similar study with a larger sample to increase the generalizability of the results. Additionally, research participants are selected only from science teacher training program. Considering that the subject is a publicly discussed dilemma, the effectiveness of using the teaching process to teach about nuclear energy can be examined by some other program students and also within different education levels.

Argumentative texts used in this research represent only group perspectives, leaving individual views out of the design. It is suggested that group members may have influence on each other perspectives and as a result, group decisions can differ from individual perspectives. So, this research suggests that student perspectives should be studied individually.

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