USING A MODEL-EVIDENCE LINK DIAGRAM
TO EXPLORE NUCLEAR ENERGY:
THE EFFECTS ON SEVENTH GRADERS' RISK PERCEPTION
AND UNDERSTANDING OF THE ISSUES

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DECLARATION OF ORIGINALITY

I, Şükrüye Nazlı Can, certify that

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ABSTRACT

Using a Model-Evidence Link Diagram to Explore Nuclear Energy:
The Effects on Seventh Graders' Risk Perception and Understanding of the Issues

The purpose of the study was to investigate whether teaching about nuclear energy with an evidence-based approach provides a significant change in seventh graders' risk perception and understanding of nuclear energy, their argumentation quality and their decisions about the construction of nuclear power plants in Turkey. The participants of the study were 110 seventh graders in a public school in Istanbul. It was a quasi-experimental study. The control group engaged in the traditional interactive lecture. Experimental group 1 was taught by evidence-based lecture and experimental group 2 engaged in evidence-based activities, including the Model Evidence Link Diagram. Three different instruments were applied as pre- and post-tests. It was found that the students' understanding of nuclear energy changed significantly in all groups, but benefit and risk perception and argumentation quality changed significantly only in group 2. When the scores of all groups were compared, there was a significant difference between the control and group 2 in terms of benefit and risk perception, understanding of nuclear energy and argumentation quality. Finally, the results of a chi-square test showed that regarding the acceptance of nuclear power plant in Turkey, the increase in group 1 and the decrease in group 2 were significant. The results of the study support that evidence-based activity as a better method of delivery than an interactive lecture in terms of improving understanding of nuclear energy, benefit and risk perception and argumentation quality.

ÖZET

Nükleer Enerjiyi Araştrmak için Model Kanıt Diyagramı Kullanmak:
Yedinci Sınıf Öğrencilerinin Risk Algısı ve Konuyu Anlamaları Üzerine Etkisi

Çalışmanın temel amacı nükleer enerjinin kanıta dayalı bir yaklaşım ile öğretilmesinin yedinci sınıf öğrencilerinin nükleer enerji hakkındaki risk algıları, nükleer enerjiyi öğrenmeleri, argümantasyon kaliteleri ve Türkiye'de nükleer santral yapımı konusundaki fikirleri üzerinde anlamlı bir değişiklik yaratıp yaratmadığını incelemektir. Katılımcılar İstanbul'da devlet okulunda okuyan 110, yedinci sınıf öğrencisidir. Çalışma yarı-deneyseldir. Kontrol grubunun öğretimi geleneksel ve etkileşimli bir anlatım ile olmuştur. 1. deneysel grup kanıta dayalı bir anlatım ile ders işlemiştir ve 2. deneysel gruptaki öğrenciler Model Kanıt Diyagramı içeren kanıta dayalı bir etkinlik üzerinde çalışmışlardır. Üç farklı ölçek ön ve son-test olarak uygulanmıştır. Birinci olarak her grubun nükleer enerjiyi anlamalarında anlamlı bir fark olmuştur. Fayda ve risk algısı ile argümantasyon kalitesi yalnız 2. deneysel grupta anlamlı bir şekilde değişmiştir. İkincisi, grupların kazanç puanları arasındaki fark incelendiğinde, kontrol ve 2. deneysel grup arasında fayda ve risk algısı, nükleer enerjiyi anlama ve argümantasyon kalitesi için anlamlı bir fark bulunmuştur. Son olarak ise, ki kare dağılımına göre 1. Deneysel gruptaki Türkiye'de nükleer santral yapımını kabul etme yönündeki karar sayısı anlamlı bir şekilde artarken, 2. Deneysel grupta ise anlamlı bir şekilde azalmıştır. Çalışmanın sonuçları kanıta dayalı aktivitenin interakif ders anlatımına göre nükleer enerjiyi anlamanın, fayda ve risk algısı ile argümantasyon kalitesinin geliştirilmesine daha uygun bir ortam sağladığını desteklemektedir.

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Dedicated to my lovely family,

and to my precious advisor Ebru Muğaloğlu

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BRPQ: Benefit and Risk Perception Questionnaire

MEL: Model-Evidence Link

NEUQ: Nuclear Energy Understanding Questionnaire

SSI: Socio-scientific issues

CHAPTER 1

INTRODUCTION

The National Committee on Science Education Standards and Assessment (1996) stated that citizenship education requires obtaining thinking skills such as argumentation and decision-making. The curriculum of Germany argues that students with decision-making ability can assess new issues of applied science and engage in societal debates (KMK, 2005, p. 14). Moreover, developments in science and technology lead citizens to make decisions about complex issues such as cloning, genetically modified food, energy sources, etc. These issues that have both social and scientific dimensions are called socio-scientific issues (SSI).

SSI are controversial issues with political, social, personal and scientific dimensions (Sadler, 2004; Zeidler, Sadler, Simmons, & Howes, 2005). Having many dimensions makes decision-making in SSI complicated. Yet, there is a need to improve citizens' understanding, argumentation and decision-making skills in SSI. Therefore, SSI have become part of the science lesson curriculum of several countries. Levinson (2008) stated that SSI are generally discussed through media and when schools do not provide sufficient information about the issues like gene cloning, cell projects, global warming, genetically modified foods people cannot even express their opinions and it causes problems in discussion. Moreover, the research reports have shown that regarding SSI students mostly prefer to use authorities' claims in their arguments without criticizing them (Kolstø, 2001). Thus it is significant to teach SSI with evidence-based instruction in science lessons at school which enable students to participate in discussions, develop arguments and make informed and evidence-based decisions.

One of the most crucial SSI is nuclear energy. There is an ongoing discussion about the benefits and risks of nuclear power plants. In the world there are 447 operable civil nuclear power reactors. (“Global Number of Nuclear Reactors”, n.d., para. 1) In Turkey the preparations of the construction of two nuclear energy power plants have started (“Turkiye’nin Nukleer Santral Projeleri”, 2016). Therefore the topic is considered as both local and global socio-scientific issue. Moreover nuclear energy is a topic in national science education curriculum (MoNE, 2013) The main focus of the study is to improve students’ understanding, risk perception of nuclear energy, argumentations and decisions about nuclear energy through evidence-based instruction.

1.1 The purpose of the study

The main aim of the study was to investigate whether teaching about nuclear energy with an evidence-based thinking approach provides a significant change in seventh graders’ risk perception and understanding of nuclear energy, argumentation quality and their decisions about the construction of nuclear power plants in Turkey.

1.2 Rationale of the study

The rationale of the current study is twofold. Firstly, the study emphasized teaching socio-scientific issues (SSI) in science education. SSI correspond the goals of scientific literacy (Sadler, 2011; Zeidler & Sadler, 2011). Scientific literacy refers to understanding knowledge and developing thinking skills, which enable citizens to make decisions about scientific, technological and societal issues (Kolstø, 2001; Oulton, Dillon, & Grace, 2004). Science educators and researchers around the world have emphasized the significance of the SSI for modern science education and suggested embedding them into science classrooms as an important part (cf. American Association for the Advancement of Science [AAAS], 1989; KMK, 2005; National Committee on Science Standards and Assessment, 1996). For instance, the curriculum of England and USA included the subjects related to SSI (NGSS; NGSS Lead States, 2013; QCA, 1999) and National Standards for German literacy are explicitly comprised of SSI (KMK, 2005). In Turkey, the science education curriculum described one of the program missions as; “to improve scientific thinking abilities through socio-scientific issues” (MoNE, 2013, p.2.). Also a review (Topcu, Mugaloglu, & Guven, 2014) showed that only a few studies in Turkey deeply investigated how to teach SSI effectively.

Secondly, nuclear energy has been chosen as a topic to teach seventh graders in Turkey for current study. Nuclear energy is one of the authentic and local SSI because of the fact that first nuclear power plants of the Turkey have been constructed in two cities; Mersin and Sinop. In order to meet the requirements of a democratic society, nuclear energy issue has to be debated in the public. Schools are the first places to enable the citizens argue the SSI. However nuclear energy has a limited part in the curriculum. Although the types of the renewable and non-renewable energy sources is taught in sixth grade the unit does not include the nuclear power plants. How nuclear power plants work is taught in seventh grade (MoNE, 2013), which only lasts two lesson hours in total. This is not sufficient to debate about nuclear energy. Thus, this study aimed to teach nuclear energy by enabling students to debate about based on evidence. Also the studies about nuclear energy are highly connected to benefit and risk perception literature. Therefore the current study also investigated the change in benefit and risk perception of the students after the intervention.

1.3 Significance of the study

Nuclear energy is one of the topics of science education curriculum (MoNE, 2013). Teaching nuclear energy with an evidence-based instruction is a significant point of the current study. The curriculum (MoNE, 2013) and the literature (Evagorou & Osborne, 2013; Sadler, 2004; Sadler & Zeidler, 2005) suggested argumentation as a learning environment especially while teaching SSI topics. In national curriculum of Turkey, it is stated that teachers should encourage students to state their opinions easily, engage in discussions to support their opinions with different reasons and generate counter arguments to refute their friends' claims (MoNE, 2013, p. 3). Yet there are not sufficient materials for teachers to implement argumentation. For the study, an evidence-based teaching material was developed, aimed at improving students' understanding, argumentations and decisions. The evidence-based teaching material, i.e. the Model Evidence Link diagram, was developed in the light of the literature (Chinn & Buckland, 2012).

Another significance of the study is to investigate how to teach nuclear energy effectively. The study focused on the importance of an explicit strategy for teaching SSI. The experiences of the teachers working with SSI in the study of Ekborg, Ottander, Silfver and Simon (2013) showed that only a few teachers were able to develop explicit strategies to teach SSI. Students also encountered some problems working with SSI; one of them is that they were not able to develop adequate strategies for decision-making (Bell & Lederman, 2003). The significance of the current study was to teach SSI with an evidence-based instruction to provide teachers with an exemplary instruction. Thus, the study also investigated the effectiveness of the evidence-based instruction on students' understanding and risk perception of nuclear energy.

1.4 Research questions

The effect of the instruction on the variables: risk perception, understanding of nuclear energy, argumentation quality and decisions about the construction of the nuclear power plants was tested. The research questions of the current study were:

1. Are there any significant differences in seventh graders' risk perception, understanding of nuclear energy and argumentation quality that resulted from the intervention?
2. Are there any significant differences in seventh graders' risk perception, understanding of nuclear energy and argumentation quality between control and experimental groups?
3. Are there any significant differences in seventh graders' decisions about the construction of nuclear power plant in Turkey that resulted from the intervention?
4. Are there any significant differences in seventh graders' decisions about the construction of nuclear power plant in Turkey between the groups?

CHAPTER 2

LITERATURE REVIEW

2.1 Nuclear energy as a socio-scientific issue (SSI)

Socio-scientific issues (SSI) are controversial scientific issues. While SSI are tied to science, they are also related to ethical, economic and political issues (Nielsen, 2012). SSI are authentic and include local, regional and global dimensions that lead people to make decisions (Ekborg et al., 2013). SSI do not have absolute solutions, but they lead to complex discussions among people. Gene therapy, genetically modified organisms (GMO), nuclear energy, cloning, climate change and so on are examples of socio-scientific issues.

Nuclear energy is a SSI in many countries, including Turkey (Kilinc, Boyes, & Stanisstreet, 2013). For instance, Johnson (2009) claimed that nuclear energy produces fewer greenhouse gases that cause global warming. Conversely, the harm of nuclear power plant incidents such as the one at Chernobyl and more recently the Fukushima event spreads for miles. Citizens make decisions about nuclear energy based on their own risk perceptions (Sjöberg, 2000). Another controversy about nuclear energy is whether it is a renewable energy source or not. According to According to Cohen (1983), if the Uranium deposit could be proved to last as long as the relationship between the Earth and Sun is supposed to last (five billion years), then nuclear energy should be included in the renewable energy portfolio. On the other hand, the nuclear waste is considered as a radioactive pollutant that goes against the notion of a renewable energy source (Johnson, 2009). It also has authentic dimensions that the research often focuses on recent construction of new nuclear power plants in their own countries (Kilinc, Boyes, & Stanisstreet, 2013; Kolstø, 2006; Rose & Barton, 2012). Nuclear energy also has political dimensions as a domain of energy policy of the governments and the people make decisions about nuclear energy by their political thought (Kuklinski, Metlay, & Kay, 1982; Yang & Anderson, 2003). Nuclear energy is a widely debated issue in many countries such as Taiwan, Japan, Norway and Turkey. Therefore, as a prerequisite for a democratic society, citizens should be a part of the decision-making process regarding the use of nuclear power. Although citizens need to understand scientific knowledge about nuclear power to engage in the debates about the construction of nuclear power plants, studies showed that citizens generally lack information about nuclear energy and are therefore unable to evaluate it critically (Cohen, 1998; Matsuura & Iırı, 2002; Yalcin & Kilic, 2005). Hence, it is important to educate students about nuclear energy so as to prepare them for discussions about the construction of power plants from a scientific viewpoint (Kucuk, Guven, & Aycan, 2015).

Nuclear power plants are part of the science education curriculum. For instance in national curriculum of Turkey, one of the objectives for seventh graders is to "have students investigate how electricity is generated in power stations", which also contains nuclear power stations, as an example (MoNe, 2013, p. 37). Also in the USA, in order to inform citizens about the risks and benefits of nuclear energy, the CENT program (Citizen Education on Nuclear Technology) was established (Robert & Jean, 2007).

2.2 Benefit and risk perception in SSI

Individuals' risk perception consists of an informal estimation of the probability of an event happening, combined with an evaluation of how concerned they would be about the negative consequences of such an incident (Sjöberg, Moen, & Rundma, 2004). When people have positive feelings towards an activity, they are more likely to judge the risks as low and the benefits as high; conversely, if they have negative feelings towards an activity, they are more likely to have an opposite judgment of high risk and low benefit (Finucane, Alhakami, Slovic, & Johnson, 2000; Slovic & Peters, 2006)

Howes (1975) and Eijkelhof (1986) suggested embedding risk assessment and risk understanding into the science curriculum. Risk perception of pre-service science teachers about genetically modified organisms, nuclear power plants and climate change have been studied in the context of Turkey (Iseri, 2012). The main aim of the study was to reveal the effect of different information sources on the views of the pre-service science teachers about the benefit and risk of nuclear energy. When the results were examined, based on emotion heuristic model (Slovic, Finucane, Peters, & MacGregor, 2004), the students who obtained the information from the sources considered as “high benefit,” which implies including more benefits of the nuclear power. The benefit perception increased and the risk perception decreased as consistent with the emotion heuristic model. On the other hand, the students who attended the meetings of the information sources considered as “high risk”, their risk and benefit perception of increased at the same time. This finding might be explained by the students’ primary beliefs and whether they trust the source of the information.

Christensen (2009) claimed that understanding of risk has a significant effect on decision-making in science education in socio-scientific issues. He emphasized the importance of embedding the understanding the risks in science education. It also pointed out the challenges of teaching risk in science education. In addition to this, Kolstø (2006) indicated that information about the possible risk is essential for the decision-making of adults. Similarly Duggan and Gott (2002) claimed that risk is central in decision-making in their study involving adults. They examined the importance of science for the employees working in science-based industries. The case studies were conducted with a small sample of industries and community action groups. When the concepts of evidence were investigated in action groups and personal decision-making, risk was found for all of them.

Finucane et al. (2000) examined the change in perception of risk and benefit in psychology students through intervention in the sources of the information. They conducted two experimental studies to obtain the effect of time pressure and information, aiming to change the positive perception about an item. The study revealed the inverse relationship between the risk and benefit and the role of affect in judgments of benefit and risk.

Regarding risk perception of nuclear power, Kilinc et al. (2013) investigated the views of the students. The students were selected from three different locations in Turkey. Two of them had been announced as the locations for new nuclear power plants. The findings showed that students from nuclear power plant locations wre more likely to perceive the negative characteristics of nuclear power plants. Few students stated that adoption of nuclear power plants would help to reduce global warming. Although half of the students believed that nuclear power can supply continuous and sufficient energy, approximately three quarters thought that nuclear power stations could damage organisms such as humans living close to the nuclear power plants.

Kirbag Zengin, Kececi, Kirilmazkaya and Sener (2011) investigated the perceptions of primary school students about the use of nuclear power and examined the awareness through the benefits and risks of nuclear power plants. They also aimed to increase awareness of primary school students about the environment in their study. They taught nuclear energy to seventh hgraders using an online argumentation method on Moodle. The instruction lasted three weeks. The teaching sessions were four lessons per week. The researcher reported students' awareness about the use of nuclear energy increased after the instruction.

Another interesting study was conducted by Mukul (2015) with academicians who live in Sinop, where a nuclear power plant will be constructed. The participants were 68 academicians, they were asked 10 questions in the interview and three of the questions were closely related to the risk perception of the academicians. Interestingly, while 75% of the participants thought that nuclear power plant would not damage the people or the environment, almost 70% of them stated that they did not want to live in Sinop after the construction of the nuclear power plant. Also, 61.8% of the participants stated that they did not believe that the waste of the nuclear power plant would be stored in a safe way.

2.3 Understanding of SSI

Zeidler et al. (2005) stated that it is crucial for students to acquire knowledge of science in order to make informed decisions about the societal issues based on science. Whereas scientific literacy is defined as promoting understanding for PISA (OECD, 2007), the SSI approach intends to develop understanding in order to educate students as informed and capable students. Simonneaux (2008) listed the aims of teaching SSI, and one of them is to develop understanding by promoting citizenship education, enabling students to make informed decisions, encouraging them to attend debates and supporting them to cope with complexity, all of which are related to increased scientific literacy. Sadler (2004) also pointed out that the first two steps of negotiating SSI are understanding the content of the issue and learning knowledge about the issue. Sadler and Zeidler (2009) indicated that the aims of PISA and SSI overlap in terms of improving scientific literacy.

In terms of developing understanding, most studies rely on the effect of SSI-based instruction. Several studies showed that students improved their science content knowledge after engaging SSI based instruction (Barber, 2001; Dori, Tal & Tsaushu, 2003; Yager, Lim, & Yager, 2006; Zohar & Nemet, 2002).

Lewis and Leach (2006) stated that when students lack information, they have difficulty in engaging in discussions about SSI. Their study, which included students aged 14-16 years as participants, revealed that regardless of the academic ability of the students, they improved their understanding in a single lesson with appropriate teaching methods. Rudsberg, Ohman and Ostman (2013) with the showed Swedish upper secondary school students' scientific knowledge in arguments was improved after taking part in classroom discussions about SSI. McNeill and Vaughan (2012) conducted a study with high school students in the USA that aimed to develop deep knowledge about climate change and to encourgage students to take action. According to the results of the study, the understanding of the students increased significantly and they started to taking personal actions to prevent climate change. On the other hand, students do not always acquire knowledge through SSI-based instruction. Pinzino (2012) reported some studies where, if the information presented to the students was not consistent with the students’ existing beliefs (e.g. creationism), they tended to reject learning. When students have positive attitudes towards science and sufficient knowledge about nature of science they tend to learn and accept scientific theories (Clores & Limjap, 2006; Ingram & Nelson, 2006)

Kucuk et al. (2015) developed a questionnaire to assess pre-service science teachers' conceptual understanding and knowledge levels about nuclear energy and nuclear power plants. A conceptual understanding test consisting of 15 questions was administered to 223 pre-service science teachers; the knowledge test, comprised of 34 questions, was administered to 441 students. The analyses indicated that knowledge test consisted of four factors which accounted for 56.98% of the total variance and the conceptual understanding test includes three factors which explained 46.35% of the total variance. KR-20 and two-tier reliability coefficients of the knowledge test were 0.86 and 0.85, respectively, and the Cronbach's alpha coefficient of the conceptual understanding test was calculated as 0.77.

2.4 Argumentation and decision-making in SSI

According to Kuhn (1992, 1993) argumentation is the evaluation of theoretical claims in the light of empirical evidence or data from other sources. It is a sophisticated process of generating claims, justifications, reasons and conclusions (Osborne, Erduran, & Simon, 2004; Sampson & Clark, 2008; Simon, Erduran, & Osborne, 2006).

Students have to be able to consider the risks and benefits of alternative solutions, ask questions, assess the totality of evidence and counter evidence and make well-informed decisions. They also have to possess skills which provide them to participate in discussions about issues. Argumentation is one of the ways to develop and practice decision-making skills (Dawson & Venville, 2010). Driver, Newton and Osborne, 2000) also claimed that argumentation is a process that will help students make decisions in the future.

Argumentation is widely used in the research on socio-scientific issues (SSI). In one of the studies, when students engaged in socio-scientific issues-based instruction, classroom interactions and argumentations improved significantly and let them give a positive, more elaborate and in-depth responses with a wider range of explanations by integrating SSI into their lessons (Guiterez, 2015). Also, Tal and Kedmi (2006) conducted a study to teach an authentic socio-scientific issue and they aimed to improve students' higher order thinking skills by the teaching methods that enabled students to participate actively in whole-class and small-group discussions. The findings showed those students’ argumentation abilities increased.

Society of today has to make decisions about recent issues related to energy sources, water quality and quantity, population and population control, all of which are related to SSI (Venville & Dawson, 2010). Decision-making on SSI is a complex process, which requires students to participate in several reasoning or argumentation (Eggert & Bögeholz, 2010). Also, Simonneaux (2008, p.181) described the purpose of teaching SSI as “to improve understanding, to contribute the citizenship education, to help students make informed decisions, to empower them to participate in debates, to help them deal with complexity and to understand the nature of science better.” These purposes are related to increasing the view of scientific literacy, which involves understanding the epistemology of scientific knowledge, explaining science as a way of knowledge, and separating it from faith or acceptance of authority (Zeidler, Sadler, Simmons & Howes, 2005). Zeidler et al. (2005) emphasized that this process enables students to make complex decisions about personal and societal issues based on science.

As Kolstø and Ratcliffe (2008) indicate, in socio-scientific issues, science is involved in a social debate, typically concerning personal or political decision-making related to health or environmental controversies. Decision-making is closely connected to science education because of its increasing existence in modern societies (Papadouris & Constantinou, 2010). People confront decision-making situations in many issues such as global warming, sustainable development, energy generation and consumption, nuclear plants, genetically modified and hormonal products, mobile phones and base stations, and vaccination against various diseases (bird flu, etc.). Although some of these decisions were discussed emotionally and denied, the rest of them are discussed on scientific grounds and could not be determined in terms of conclusion and process. The issues emerged from scientific processes and led to social discussions (Sadler & Zeidler, 2005).

Additionally, Acar (2008) claimed that argumentation is an appropriate instructional tool to improve reasoning and decision-making skills in science classrooms. There are several pedagogic practices that have been suggested for increasing the ability of students to make informed decisions about SSI, including argumentation, in both understanding and decision-making. (Maloney & Simon, 2006; Patronis, Potari, & Spiliotopoulou, 1999; Simon et al, 2006). Patronis et al. (1999) advocated that argumentation is an important part of decision-making when scientific and technological knowledge come into question.

As a core scientific process, argumentation enables the critical evaluation of scientific and technological claims Driver et al. (2000), in order to refute and support the claims, promote the use of evidence (Sandoval & Millwood, 2005) and engage students in a process that foregrounds the significance of participation in decision-making about scientific and technological issues (Jimenez- Aleixandre & Pereiro-Munoz, 2002; Patronis et al., 1999).

Yoon (2008) indicated that although their study was significant in terms of demonstrating the lack of argumentation skills and in supporting educational programs that develop argumentation skills for competent decision-making, a large part of the participants still was unable to understand what affects the competent decision-making.

Socio-scientific contexts have been explored in many research studies, especially in terms of how students engage in argumentation and decision-making within those settings (e.g. Albe, 2009; Evagorou, 2011; Jorde & Mork, 2007; Zeidler & Keefer, 2003). Tal and Kedmi (2006) aimed to teach SSI in an authentic context and their findings showed that, although argumentation abilities, one of the main constituents of the decision-making, increased, there is a long way to create a thinking culture, and the researchers suggested that teachers should change the traditional teaching methods to enable students to participate in decision-making processes. Demircioglu and Ucar (2014) investigated pre-service science teachers' written arguments about the Akkuyu nuclear power plant. The pre-service science teachers were working in Adana, a city near the Akkuyu nuclear power plant. The results showed that pre-service science teachers' knowledge increased after reading an article about the nuclear power plant. Also, students' multiple reasoning modes and argumentation levels increased when these were analyzed in terms of the Toulmin argumentation level, reasoning mode and argumentation levels.

Kolstø (2006) examined the arguments of students who were engaged in the same learning section about the construction of a nuclear power plant. The main focus of the study was to reveal the interaction between the knowledge and the values of the students when they make decisions about SSI. The researcher described five types of main argument: the relative risk argument, the precautionary argument, the uncertainty argument, the small risk argument, pros and cons argument. The research also revealed that students' arguments included both used scientific and non-scientific knowledge. Rose and Barton (2012) investigated two middle school-aged youth debates about the construction of a new power plant, after the students participated in a 13-week unit program. The results of the study showed that, although the scientific knowledge that the children acquired during the course influenced how they made sense of the issue, their deep knowledge derived from personal and public discourses, which was a real factor on how they defined the issue.

Böttcher and Meisert (2011) examined the effect of different learning environments on decision-making abilities in SSI. In order to understand the effect, they compared direct and indirect instruction about complex decision-making strategies and they found that indirect instruction could foster the decision-making strategies of the students about SSI such as genetically modified crops.

The characteristic of SSI combined with social and scientific dimensions play an important role in decision-making and the evaluation and promotion of their decision-making competencies (Sadler & Donnelly, 2006). Hence SSI requires complex decision-making strategies which do not resemble simple casual decisions (Eggert & Bögeholz, 2010; Seethaler & Linn, 2004).

Zeidler et al. (2005) claimed that students have to know both decision-making process and method skills to be able to use these skills in creating ideas about social issues. In this context, SSI develops higher order thinking skills such as decision-making, reasoning and argumentation, etc. (Sadler & Zeidler, 2005; Zohar & Nemet, 2002).

According to the results of the research of Es, Mercan and Ayas (2016), the pre-service teachers in Sinop, where a nuclear power plant was going to be constructed, do not want live in a city with a nuclear power plant. On the other hand, the percentage of pre-service teachers who accepted the construction of nuclear power plant in Turkey was almost the same as the percentage of students who did not accept it.

2.5 Evidence-based instruction based on model-evidence link diagram (MEL)

A Framework for K–12 Science Education (NRC, 2012) emphasized the importance of the coordination of evidence, model and theories as a fundamental practice. The coordination occurs through critical evaluation, which involves criticizing the relationship between evidence and alternative explanations of a particular phenomenon (McNeill, Lizotte, Krajcik, & Marx, 2006).

The model-evidence link diagram (MEL) is an instructional scaffold which helps students to develop the ability of evaluating the links between evidence and alternative models (Figure 1). It was originally developed by researchers at Rutgers University, under the NSF-supported PRACCIS (Promoting Reasoning and Conceptual Change in Science) project (Chinn & Buckland, 2012) for middle schools life science topics. The project team developed four MELs about SSI such as climate change, wetlands and land use, fracking and earthquakes for use in high school classes (Lombardi, 2016). Research showed that the MEL diagram facilitated students' evaluation and argumentation about the connections between evidence and alternative models (Chinn & Buckland, 2012; Lombardi, Sinatra, & Nussbaum 2013). Lombardi, Danielson and Young (2016) emphasized the aim of the MEL diagram was not to teach controversy that referred to the campaign to legitimizes the non-scientific thinking which is not based on scientific facts including evidence. Instead, MEL diagrams provide students with a tool which enables them to evaluate the merit of scientific explanations by comparing them with non-scientific ones. Lombardi (2016) added that critical evaluation helps students to participate in scientific and engineering activities, and the collaborative argumentation was the most important for the present study as a scientific activity.

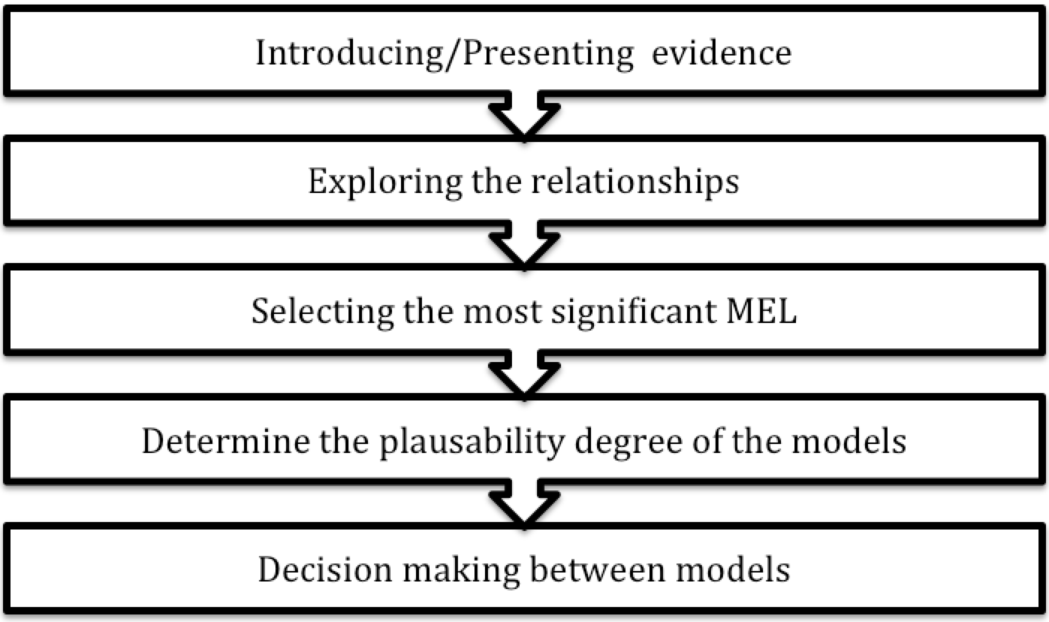


Fig. 1 MEL chart

Using a MEL, students draw arrows in different shapes to indicate the relative weight of the evidence between each piece of evidence and each model. Straight arrows indicate that *the evidence supports the model*; squiggly arrows indicate that *the evidence strongly supports the model*; straight arrows with an "X" through the middle indicate *the evidence contradicts the model*; and dashed arrows indicate *the evidence has nothing to do with the model*.

After the drawing arrows, students use their MEL diagrams in collaborative argumentation and explanatory tasks to deeply evaluate their links and promote understanding. Recent research in science education proved that MELs, in tandem with argumentation and explanation, provide a considerable increase in students' learning. Furthermore, students find MELs engaging and MELs are easy to insert into the hectic pacing of our curricular instruction.

Briefly, the MEL diagram allows students to evaluate the benefit and risk perception of the issue when they compare different models and their evidence. Students also participate in argumentation, evaluating evidence. The last stage of MEL enables students to make decisions about the models. Therefore, the MEL diagram is an appropriate tool to foster argumentation.

CHAPTER 3

METHODOLOGY

This chapter gives detailed information about the sample for the study, data collection tools, the design of the study, treatment, and data analysis.

3.1 Sample of the study

Participants were all seventh graders in public middle schools in Kadikoy, a district of Istanbul. Among 27 public middle schools in Kadikoy, the school where the researcher was working was selected as the implementation school for practical reasons. Thus, convenience sampling was used to determine the school (Gay, Mills, & Arisian, 2012). The middle school consisted of fifth, sixth, seventh and eighth grades. While determining the grade for the intervention, the researcher considered the aim of the study and the content of the national curriculum. The aim of the study was to investigate the effect of teaching about nuclear energy with an evidence-based thinking approach. In the national curriculum, at seventh grade there is an objective related to producing energy from nuclear power plants in the unit on electric energy. Therefore, seventh graders were selected.

At the implementation school, there were 116 seventh graders. However, six of them did not provide all the required data. Therefore, they were excluded from the data analysis. Hence, the sample of the study consisted of 110 seventh graders.

In total there were six classes of seventh grades. In line with the design of the study, they were divided into three groups in a way that did not disrupt the classes. There were three groups: the control group, experimental group 1 and experimental group 2. Each group consisted of two of the six classes. The researcher implemented the instruction as an expert to the experimental groups. In other words, researcher's classes, which she was already teaching, were selected as experimental groups.

Table 1 shows the number of the students in each class and the total number of the students in each group. The number of the students in each class and each group was adequate for conducting a quasi-experimental research design. The minimum number of students in each class was 15 and the maximum was 21, so the number of the students in each class was similar. Each group contained a minimum of 35 students and a maximum of 39, which also demonstrates that the number of the students in each group did not differ significantly from each other. Additionally, the number of the students in each group (35, 36 and 39) is considered sufficient for the quantitative data analysis.

Table 1. Number of Students in Each Group

Groups	Number of students		
	Class 1	Class 2	Total
Control	20	15	35
Experimental group 1	18	18	36
Experimental group 2	21	18	39
Total			110

3.2 Definition of key terms, concepts and variables

3.2.1 Conceptual definitions

- Decisions about the construction of a nuclear power plant: Decisions about socio-scientific issues is a complex process which requires students to participate in reasoning or argumentation (Eggert & Bögeholz, 2010). In this study, "decisions about the construction of nuclear power plants" refers to the positive or negative decisions about the construction of nuclear power plants.
- Benefits and risk perception of nuclear energy: The trade-off between benefits and risk perception determines the acceptability of nuclear energy (Groot, Steg, & Poortinga, 2013).
  - Perceived benefits of nuclear energy: a person believes the use of nuclear energy is mostly beneficial in terms of cheap energy, a secure energy supply, energy self-reliance, or less CO^2 emissions (Groot, Steg, & Poortinga, 2013).
  - Risk perception of nuclear energy: a person who is against nuclear energy considers the negative consequences or risks, such as the increase in the risk of a nuclear accident and health risks (Groot, Steg, & Poortinga, 2013).
- Understanding nuclear energy: The definition includes the understanding of the renewable and eco-friendly characteristics of nuclear energy — the wastes, raw material of nuclear power plants and the energy generation process in nuclear power plants.
- Argumentation quality: Argumentation quality is determined by the number of justifications, the extent of using scientific knowledge, the number of aspects and

synthesis of counterarguments and rebuttals (Tal & Hochberg, 2003; Zohar & Nemet, 2002).

3.2.2 Operational definitions

- Benefit and Risk Perception: The summated scores of responses to the Benefit and Risk Perception Questionnaire (BRPQ), based on a five-point Likert scale determining the risk and benefit perception and given points from 1: strongly disagree to 5: strongly agree.
- Nuclear Energy Understanding: The score that is obtained from the open-ended Nuclear Energy Understanding Questionnaire (NEUQ).
- Argumentation Quality: In order to analyze, an argumentation ability assessment rubric (Tal & Kedmi, 2006) was used. The total score gained from the four dimensions of argumentation quality are; the number of justifications is three, the extent of using scientific knowledge is three, the number of aspects is four and the synthesis of counterarguments and rebuttals is two.
- Decision about construction: Positive or negative answer for the construction of nuclear power plant in Turkey.

3.3 Data collection tools

Data was collected using three different tools: a Benefit and Risk Perception Questionnaire (Kilinc, Boyes, & Stanisstreet, 2013), a Nuclear Energy Understanding Questionnaire and an Argumentation Letter Task. These tools are described in the following sections.

3.3.1 Benefit and risk perception questionnaire (BRPQ)

Kilinc, Boyes & Stanisstreet (2013) developed a questionnaire with the aim of exploring general views of Turkish students about nuclear power generation and global warming. The questionnaire was applied to the students from the sixth to tenth grades in three cities of Turkey. Cronbach's alpha for the questionnaire was calculated as 0.63 indicating an adequate degree of reliability.

The questionnaire was a Likert-type questionnaire with four sections. The first part consisted of three questions to investigate the willingness of the students to take action to prevent climate change. The aim of the second section was to seek students' beliefs about the benefit and risk of electricity generation by nuclear power plants. This part contained 13 questions. The third section included eight questions which investigated the importance of issues related to generation of electricity. The last section contained four items to explore students' thoughts about global warming. In the present study, the only relevant part of the questionnaire was the second section, which probed the students' risk and benefit perceptions about electricity generation by nuclear power plants. Thus, the second part of the questionnaire was used in the current study to measure risk and benefit perceptions of the students.

The Likert-type questionnaire was based on five points from 1: strongly disagree to 5: strongly agree. The summated scores of responses to the questionnaire was 65 points. The high scores indicate high risk perception whereas the low scores indicate the high benefit perception.

In the present study, Cronbach's alpha, calculated for the applied section of the questionnaire, was 0.72, indicating an adequate degree of reliability.

3.3.2 Nuclear energy understanding questionnaire (NEUQ)

The items of this questionnaire were open-ended (see Appendix A). The tool was developed by the researcher (science teacher) and the supervisor (science educator) in order to evaluate the seventh graders understanding of renewable and eco-friendly energy sources in general and nuclear energy in particular.

The questionnaire was designed with respect to related objectives in the sixth- and seventh-grade science education curriculum (MoNE, 2013) and the science textbook (Ozoglu & Misirlioglu, 2015, pp. 200-201). The sixth unit of the sixth-grade science curriculum has an emphasis on the significance of renewable energy sources due to limited supplies of fossil fuels as non-renewable energy sources. Additionally, in the science textbook (Ocal, 2014, pp. 152-153), definitions of the terms "renewable" and "non-renewable" energy sources are provided with examples. Also, in the sixth unit of the seventh grades on electrical energy, one of the objectives includes nuclear power plants as a way of producing energy. The science textbook (Ozoglu & Misirlioglu, 2015, pp. 200- 201) includes a detailed description about how nuclear power plants produce energy and what is used as raw material for producing energy during the process.

NEUQ, based on the science education curriculum and the textbooks, comprised seven open-ended questions. The first two questions assessed the understanding of renewable energy and eco-friendly energy. The third and fourth items were about whether nuclear energy is renewable and eco-friendly, and the last three items were related producing energy by nuclear power plants. The maximum score for each question was two, except for the last one, whose maximum score was three. The maximum obtainable score was 15 in total.

The reliability of the scores was calculated with Cronbach's alpha, and the score for the data was 0.71, indicating a high degree of reliability.

3.2.3 Argumentation letter task

An argumentation task was developed for the present study — a letter with two parts. In the first part, participants indicate their position for the construction of a nuclear power plant in Turkey by marking one of the tick boxes as "yes" or "no". The second part of the task asks students to write a letter to government officials in order to convince them to take action with regard to the student's opinion (see Appendix B). The argumentation quality of the responses were assessed by a rubric that was developed by Zohar and Nemet (2002). They defined four dimensions: the number of justifications, the extent of using scientific knowledge in the arguments, the number of aspects incorporated and synthesis of counter-arguments, and rebuttals. Based on these dimensions, Tal & Kedmi (2006) improved the scoring of the rubric.
The assessment rubric and the score range from 1 to 12 are presented in Table 2.

After the analysis of the argumentation quality, the reliability of the scores was calculated with Cronbach's alpha and the score for the data was 0.79, which is a high degree of reliability. Additionally, inter-rater reliability was studied. A second rater (in addition to the researcher) was also an expert as science teacher. Approximately 15% of the post-tests of Argumentation Letter Task which were randomly selected by the the second rater and the correlation was calculated. Intraclass correlation was 0.81, which revealed that there was an adequate reliability between the raters.

Table 2. Argumentation Ability Assessment Rubric (Tal and Kedmi, 2006)

Criteria	Degree and score			
Number of Justifications	None (0)	One (1)	Two (2)	≥Three (3)
Use of scientific Knowledge		Superficial (1)	General (2)	Specific (3)
Number of Aspects	One (1)	Two (2)	Three (3)	Four (4)
Synthesis: Counter-arguments and Rebuttals	None (0)	Two counter ideas coexist separately, but are not rebutted (1)	A counter argument exists and rebutted yielding a complex, coherent idea (2)	

3.4 Design of the study

The present study was a quasi-experimental study. According to Gay, Mills and Arisian (2012), when it is not possible to choose the groups randomly for the treatment or control group, a true experimental design is impossible, in which case a quasi-experimental design should be conducted. The groups were not randomly selected. In order to implement instruction properly, the researcher, as an expert, had to deliver instruction to the experimental groups. In other words, the classes she already taught during the term were selected as experimental groups. Thus, the remaining classes constituted the control group. Three data collection tools — the Benefit and Risk Perception Questionnaire (BRPQ), the Nuclear Energy Understanding Questionnaire (NEUQ) and the Argumentation Task Letter were administered to groups as pre- and post-tests. In addition to these data collection tools, nuclear energy was taught to all groups for four lessons; these were designed based on three different approaches. The design of the study is presented in Table 3.

Table 3. Design of the Study

Groups	**Pre-test**	**Intervention**	**Post-test**
Control group	BRPQ, NEUQ, Argumentation Letter Task	Traditional interactive lecture	BRPQ, NEUQ, Argumentation Letter Task
Experimental group 1	BRPQ, NEUQ, Argumentation Letter Task	Evidence-based interactive lecture	BRPQ, NEUQ, Argumentation Letter Task
Experimental group 2	BRPQ, NEUQ, Argumentation Letter Task	Evidence-based activity	BRPQ, NEUQ, Argumentation Letter Task

The control group engaged in the traditional lesson plans following the Transformation of Electric Energy topic in the textbook (Ozoglu & Misirlioglu, 2015, pp. 200-201) distributed by MoNE. The teacher taught the topic the way she taught previously. She used the internet and the science textbook to obtain information about nuclear power plants. There was no systematic focus on the evidence and claims related to construction of nuclear power plants and characteristics of nuclear energy.

Experimental 1 engaged in the evidence-based interactive instruction to teach characteristics of nuclear energy and nuclear power plants. Researcher systematically taught arguments for and against nuclear power plants with an emphasis on evidence. She used PowerPoint presentations during her lecture and encouraged students to discuss each argument.

Experimental 2 engaged in an evidence-based activity to learn the characteristics of nuclear energy and nuclear power plants. Students used a model evidence link diagram (MEL) to evaluate evidence and arguments for and against nuclear power plants. During the activity, students linked the evidence with claims and they chose the most plausible argument in the MEL activity. The teacher guided the students to discuss the arguments ~~which~~ they constructed using the MEL diagram.

3.5 The treatment

This study was implemented in the first semester of the 2015-2016 academic year in one of the middle schools in Kadikoy. In total it took six lessons to administer pre- and post-tests and the intervention for the control group and experimental group 1. For experimental group 2 it took seven lessons, including one lesson hour for the MEL preparation activity (see Table 4).

Table 4. Time Table of The Intervention

Lessons (L)	L1	L2	L3	L4	L5	L6	L7
Traditional	Pre-tests	Traditional lecture		Traditional lecture		Post-tests	-
Experimental 1	Pre-tests	Evidence-based lecture		Evidence-based lecture		Post-tests	-
Experimental 2	Pre-tests	Preparation activity		Evidence-based activity		Evidence-based activity	Post-tests

Participants of all groups took the pre-tests in the first lesson. The participants were instructed in the second lesson, except for the participants in experimental group 2. The students in the experimental group 2 engaged in the preparation activity for evidence-based activity. Therefore the implementation of the experimental group 2 finished the activity at the end of sixth lesson and then they filled their post-tests in the seventh lesson. Instructions of the control group and experimental group 1 completed the instruction at the end of the fifth lessons and they were applied the post-tests in sixth lessons.

Time of the treatment period was determined due to the Science Lesson Curriculum (MoNE, 2013). Nuclear energy which is main focus of the study is a part of an objective related producing energy topic. This topic is in the second part of the Electric Energy chapter of seventh graders. In the curriculum, it is suggested to teach the second part of the chapter in eight lesson hours. In the present study the aim was to teach one of the objectives from the second part of the chapter in four lesson hours to all groups.

Three different interventions were administred to control group, experimental group 1 and experimental group 2. The following table indicates information about the interventions administred to control and experimental groups.

Table 5. Treatment Table

Groups		Lesson 1	Lesson 2	Lesson 3	Lesson 4
Control	**Content**	characteristics of nuclear energy		producing energy from power plants	
	Method	watching documentary	searching from internet Lecture	Lecture	Lecture
	Material/Source	Internet	Internet / textbook	Textbook	Textbook
Experimental 1	**Content**	characteristics of nuclear energy		producing energy from power plants	
	Method	Lecture	Classroom discussion	Lecture	Classroom discussion
	Material	Power point slides of MEL1 diagram		Power point slides of MEL 2 diagram	
Experimental 2	**Content**	Characteristics of nuclear energy		producing energy from power plants	
	Method	Collaborative activity	Argumentative discussion	Collaborative activity	Argumentative discussion
	Material	MEL 1 diagram	MEL 1 diagram	MEL 2 diagram	MEL 2 diagram

3.5.1 The traditional treatment

The traditional instruction was used with the control group. It was structured and implemented based on the curriculum (MoNE, 2013) and the textbook (Ozoglu & Misirlioglu, 2015, pp. 200-201) distributed by MoNE. Additionally, the teacher was encouraged to teach the lessons in a way that was similar to her previous lessons. The lessons were video recorded. The transcription of the recordings revealed that at the beginning of the lesson the science teacher used internet as an additional source. Students watched two documentaries via internet. The first one was a detailed documentary about electric power stations and the second one was about a nuclear power plant to be constructed in Turkey. Then the waste of the nuclear power plants was searched via internet and the images of previous disasters of nuclear power plants such as Chernobyl Disaster were shown. After all students had read the related part of the textbook about producing energy from different energy sources, including nuclear power plants (Ozoglu & Misirlioglu, 2015, pp. 200-201), they answered the questions at the end of the chapter. There were questions related to the transformation of energy in power plants. The science teacher also asked questions related to energy in the students' daily life. Some students criticized nuclear power plants and stated their worries about nuclear power plants spontaneously. Students asked about alternative energy sources while criticizing nuclear power plants and the teacher clarified the characteristics of renewable energy sources. Furthermore, students wrote in their notebooks about the generation of electric energy from several energy sources such as hydroelectric power stations, nuclear power plants, thermal power stations, geothermic energy and wind turbines. It should be noted that the teacher also provided information about nuclear waste from power plants that did not appear in the textbook.

The teacher’s role was mainly to give an interactive lecture during the lesson. Students watched documentaries, listened to their teachers, wrote brief information about the topic, asked some questions and answered the teacher's questions. There was no systematic presentation of evidence or arguments for and against nuclear energy during the traditional treatment.

3.5.2 Experimental group 1

The researcher who taught the lessons to both of the experimental groups is a science teacher at the implementation school. The researcher audio recorded the lessons. The instruction of experimental group 1 lasted four lessons. The researcher used two power point presentations during these four lessons. The researcher prepared the presentations based on two MEL diagrams. The content of the first presentation was the same as the MEL diagram 1, which was about the characteristics of nuclear energy and nuclear power plants. Two opposite claims about the nuclear energy were presented. The first claim stated that nuclear energy is renewable and eco-friendly, whereas the second claim maintained that nuclear energy is not renewable and it damages the environment. After the presentation of each claim, evidence for and against was presented elaborately. An argumentative discussion occurred at the end of presentation 1.

The content of the second power point presentation was same with MEL diagram 2, which was about producing energy from power plants. It included two opposite claims. The first one was “Nuclear power plants must be constructed in order to meet the energy needs of Turkey” and the other one was “Turkey should benefit from renewable energy sources such as wind, sun, geothermal and biomass, in order to meet the energy needs of the country”. Elaborations on the evidence for each claim were also provided. An argumentative discussion occurred in the last lesson after the conclusion of the second presentation.

The students were able to ask questions after each slide, which allowed the teacher to teach in depth and remind the students about previous knowledge on renewable energy. The teacher started a whole-class discussion by asking justifications for the opponents after the conclusion of each presentation. The role of the teacher was facilitator of the discussions. She encouraged the students to express their reasoning elaborately. Students could respond to each other's arguments and produce rebuttals with the guidance of the teacher. At the end, they were able to engage in an argumentative discussion.

3.5.3 Experimental group 2

Students of experimental group 2 engaged in evidence-based activities by using the Model Evidence Link (MEL) diagrams. Before using the MEL diagrams, the framework was introduced to students in one lesson. Therefore, the intervention lasted one more lesson hour than the traditional group and experimental group 1. All MEL diagrams used in the current study were developed by the researcher and supervisor, taking into account the related literature (Chinn & Buckland, 2012; Lombardi, Sinatra, & Nussbaum 2013).

MEL Preparation activity

The MEL diagram preparation activity (see Appendix C) aimed to illustrate how to use MEL diagrams. The students worked in pairs during the activity, which was related to an everyday issue with two opposite claims as "It rained" and "It did not rain, workers of the municipality washed the streets". The given claims were designated as Model A and Model B, respectively. Four different pieces of evidence were provided. Students were required to link the evidence with each of the claims with an appropriate kind of arrow. The arrows used in the task are shown in Figure 2.

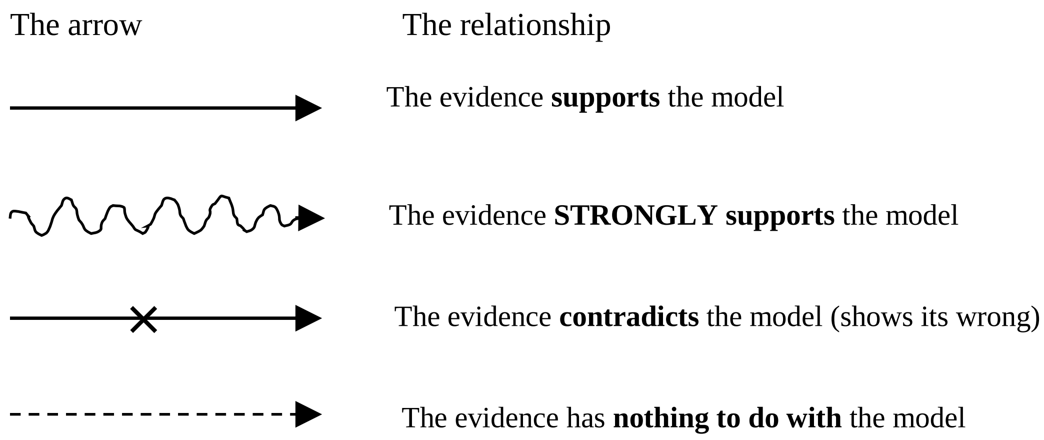


Fig. 2 The arrows and their definition in terms of relationship

After drawing arrows, students selected three arrows which were interesting or important for them and elaborated on the justifications for their selection. As a third activity, they scored the plausibility of each claim with a number from 1 to 10. Finally, they chose one of the statements below:

- Very certain that Model A is correct
- Somewhat certain that Model A is correct
- Uncertain if Model A or B is correct
- Somewhat certain that Model B is correct
- Very certain that Model B is correct

MEL 1 and MEL 2

After the preparation activity, students engaged in the MEL 1 activity related to the characteristics of the nuclear energy. One of the claims was “The nuclear energy is a green energy source which is also renewable”; the other one was “Nuclear energy is not renewable and it damages the environment”. Four pieces of evidence were provided with elaborative text including figures and tables.

All participants of experimental group 2 enrolled in the MEL activity a short time after a preparation activity that enabled students to participate the activity properly. In the first lesson, students worked in pairs and completed MEL 1 collaboratively. In the second lesson, students expressed themselves voluntarily about what they wrote in their tasks for each part of the activity. The teacher’s role was to encourage students to express their ideas and their reasoning. The plausibility scores for Model A or Model B were recorded on the board. Finally, the teacher encouraged the students to state their justifications for their arguments and enabled opponents to discuss their counterarguments.

After finishing the MEL 1 activity, students did the MEL 2 activity, which was mainly about the use of nuclear power plants and renewable energy in Turkey. The claims were “Nuclear power plants must be constructed in order to meet the energy need of Turkey” and “Turkey should benefit from the renewable energy sources such as wind, sun, geothermal and biomass, in order to meet the energy need of the country”.

3.6 Data analysis

In order to answer the first research question, the difference between the scores of the pre- and post-tests were calculated with *paired samples t-test*. When one of the main assumptions of *paired samples t-test* as a normal distribution was violated, *Wilcoxon signed ranks* was run as a non-parametric test (Pallant, 2007).

Assumptions of the *paired samples t-test* and how they met in the study are listed as:

a. Level of measurement: The dependent variable should be measured at the interval or ratio level (Pallant, 2007). The dependent variable in Benefit and Risk Perception Test and Understanding Test are scores of the tests which are continuous data. Hence, this assumption was met.
b. Random sampling: Although, in order to compare groups statistically, sample should be randomly selected, this is not the case in the real life (Pallant, 2007). Therefore, the violation of this assumption does not reveal problems.
c. Independence of observations: The measurement and observations must not influenced by other factors is another assumption (Pallant, 2007). This assumption was also met with collecting data from different classes.
d. Normal distribution: The data should be homogeneous in order to meet this assumption (Pallant, 2007). The results of Kolmogorov-Smirnov and Shapiro-Wilk were evaluated to test this assumption. The control group's scores for Benefit and Risk Perception Questionnaire and all groups' scores for Nuclear Energy Understanding Questionnaire were normally distributed. Although the violation of this assumption for 30+ samples, claimed that does not cause any serious problems, *Wilcoxon signed ranks* test was used to analyze the scores of the rest of the data.
e. Homogeneity of variance: Levene's test was conducted to test the equality of variances in the control group's BRPQ and all groups' NEUQ scores.

The results showed that this assumption was met.

In order to answer the second research question, whether there is a significant difference between the pre-tests of each group for each dimension was explored. The results showed that a significant difference existed between the pre-test scores of control and experimental groups for the Nuclear Energy Understanding Questionnaire. In order to avoid the effect of the existing difference between the pre-test scores of the groups, the gain scores, which are the differences between the pre- and post-tests, were calculated. A *Kruskal Wallis* test was performed as non-parametric test because of the fact that gain scores for each dimension were not normally distributed.

The last research question aimed to reveal the difference in the decisions of seventh graders about the construction of the nuclear power plant. Percentage of the decisions for each group was calculated separately before and after the intervention. Then chi-square test was run to determine if there is a significant difference between the groups' post-tests.

CHAPTER 4

RESULTS

This study has four research questions. In this part, the results are presented due to the research questions.

- Research question 1: Are there any significant differences in seventh graders' benefit and risk perception and understanding of nuclear energy and argumentation quality after the intervention?

4.1.1 Benefit and risk perception of nuclear energy

Descriptive statistics of pre- and post-tests of each group's BRPQ scores are presented in the Table 6.

Table 6. Descriptive Statistics of BRPQ

Group	Outcome	N	M	SD	Min	Max	Range
Control	Pre-test	35	48.18	5.33	33	59	26
	Post-test	35	48.05	6.66	35	61	26
Exp 1	Pre-test	36	49.55	6.93	34	60	26
	Post-test	36	47.72	8.29	29	59	30
Exp 2	Pre-test	39	47.29	6.46	32	59	27
	Post-test	39	50.64	5.54	40	60	20

In order to determine whether there was a significant difference between the pre- and post-test scores of BRPQ, a *paired sample t-test* was conducted for testing the control group's scores. However, due to the assumption of normal distribution was not met for the scores of experimental groups, the *Wilcoxon signed ranks* test was applied to obtain the inferential statistics (see Table 7).

Inferential statistics revealed that there was not a significant difference between the pre- and post-test scores obtained from control group's BRPQ with t (34) = 0.11, p=0.91.

Table 7. Wilcoxon Signed Ranks Results of Experimental Groups' BRPQ

Group	Z	*p*
Experimental 1	-.917[b]	.36
Experimental 2	-3.639[b]	.00*

*p < .05

The differences between the scores of pre- and post-tests of experimental group 2's BRPQ are significant, Z = 3.64, *p* = .00, whereas it is not significant for experimental group 2's BRPQ, Z = .92, *p* = .36.

The effect size for *Wilcoxon signed ranks* test, *r*, was calculated by dividing Z by the square root of *N*. It was found as -0.41, which is considered a moderate effect size.

4.1.2 Understanding of nuclear energy

Descriptive statistics of pre- and post-tests of each group's NEUQ scores are presented in Table 8.

A *paired sample t-test* was applied to all groups' NEUQ scores to determine the difference. The results showed that there is a significant increase in the scores of all groups' NEUQ (see Table 9.). The effect size was calculated for each group and the Cohen's d values were found as .47 for the control group, .86 for experimental group 1 and 1.23 for experimental group 2. The effect size interpretation is small when it is .2, moderate when it is .5 and large when it is .8 (Cohen, 1988).

Due to the interpretation of the Cohen's d value, whereas the effect size of the intervention to the control group is moderate, the effect size of the interventions to the experimental groups is high.

Table 8. Descriptive Statistics of Groups' NEUQ

Group	Outcome	N	M	SD	Min	Max	Range
Control	Pre-test	35	5.66	3.40	0	12	12
	Post-test	35	7.29	3.43	0	13	13
Exp 1	Pre-test	36	4.75	2.35	0	11	11
	Post-test	36	7.17	3.22	1	14	13
Exp 2	Pre-test	39	4.31	2.36	0	9	9
	Post-test	39	7.80	3.21	1	14	13

Table 9. T-Test Results of Groups' NEUQ

Group	t	df	Sig.	Mean Difference	Std. Error Mean
Control	-3.38	34	.00*	-1.62	.48
Exp 1	-4.93	35	.00*	-2.42	.49
Exp 2	-9.5	38	.00*	-3.48	.37

* $p < .05$

4.1.3 Argumentation quality

The descriptive statistics of the argumentation quality scores of each group are shown in Table 10.

Table 10. Descriptive Statistics of Groups' Argumentation Quality

Group	Outcome	N	M	SD	Min	Max	Range
Control	Pre-test	35	3.20	2.04	0	10	10
	Post-test	35	2.60	1.56	0	5	5
Exp 1	Pre-test	36	2.83	1.70	0	7	7
	Post-test	36	3.55	2.33	0	10	10
Exp 2	Pre-test	39	3.61	1.57	0	8	8
	Post-test	39	5.02	2.19	1	11	10

The scores of the argumentation quality were not normally distributed, so a *Wilcoxon signed ranks* test was conducted (see Table 11).

Table 11. Wilcoxon Signed Ranks Results of Groups' Argumentation Quality

Group	Z	*p*
Control	-1.187^{b}	.235
Exp 1	-1.515^{b}	.130
Exp 2	-3.136^{b}	.002*

* $p < .05$

The results of the inferential statistics showed that there is only a significant increase in the scores of the post-tests of the experimental group 2. When the effect size was calculated, the r value was found as -.35 which indicates a moderate effect.

- Research question 2: Are there any significant differences in seventh graders' benefit and risk perception of nuclear energy, understandings and argumentation quality between control and experimental groups?

In order to determine the significance between scores of the groups' post-tests ANCOVA and ANOVA based on gain scores can be applied. ANCOVA was used due to the fact that pre-tests were covariant variable in the experimental design. In this study, but there was not normal distribution among the scores of each group's each questionnaire, for which reason the *Kruskal Wallis* test was performed on the gain scores. Table 12 shows the descriptive statistics of gain scores. Gain scores were calculated as the difference between the scores of post-tests and pre-tests.

According to the results of the *Kruskal Wallis* test, there is a significant difference between the gain scores of the control group and experimental group 2 for each variable. The benefit and risk perception is $p = .04$, the nuclear energy understanding is $p = .02$ and the argumentation quality is $p = .00$.

Table 12. Descriptive Statistics of Gain Scores

Scale	Group	N	M	SD	Min	Max	Range
BRPQ	Control	35	-.13	6.89	-14	13	27
	Exp 1	36	-1.83	9.95	-30	19	49
	Exp 2	39	3.35	5.78	-16	15	31
NEUQ	Control	35	1.63	2.85	-6	7	13
	Exp 1	36	2.42	2.94	-5	9	14
	Exp 2	39	3.49	2.29	-1	9	10
Argumentation quality	Control	35	-.06	2.43	-9	4	13
	Exp 1	36	.72	2.48	-4	7	11
	Exp 2	39	1.41	2.34	-2	7	9

Table 13. Kruskal Wallis Results of Gain Scores for Each Scale

Scale	Comparison	H(2)	*p*
BRPQ	Control – Exp 1	.53	.64
	Control – Exp 2	4.21	.04*
	Exp 1 – Exp 2	7.63	.06
NEUQ	Control – Exp 1	2.80	.09
	Control – Exp 2	5.65	.02*
	Exp 1 – Exp 2	.29	.59
Argumentation quality	Control – Exp 1	3.66	.06
	Control – Exp 2	11.26	.00*
	Exp 1 – Exp 2	1.91	.17

* $p < .05$

○ Research question 3: Are there any significant differences in seventh graders' decisions about the construction of nuclear power plant in Turkey after the intervention?

In order to understand the change, the number of students who accepted, those who did not accept and those who were indecisive about the construction of the power plant for pre- and post-tests of each group are calculated. Afterwards, a chi-square test was performed to understand whether there was a significant change in students' decisions about the construction of nuclear power plants in Turkey after the treatment (see Table 14).

Table 14. Students With Different Decisions on Pre- and Post-tests

		Decision				
Groups	Outcome	Yes	No	Both/ Neither	Total	Sig. level
Control	Pre-test	5	29	1	35	
	Post-test	8	26	1	35	.26
Exp 1	Pre-test	2	34	-	36	
	Post-test	7	29	-	36	.01*
Exp 2	Pre-test	5	28	6	39	
	Post-test	0	37	2	39	.00*

*p < .05

While the number of the students who accepted the construction of nuclear power plants increased in the control and experimental 1 groups, there was a decrease in the experimental group 2. The results of the chi-square test showed that the increase in the experimental group 1 and the decrease in the experimental group 2 is significant.

There is another salient result that the students in experimental group 2 who were indecisive about the construction before the intervention, they all changed their idea and became against to the construction of the nuclear power plant in Turkey.

- Research question 4: Are there any significant differences in seventh graders' decisions about the construction of nuclear power plant in Turkey between the groups?

The difference between the proportions of the students' decisions (see Table 15) for the post-test were calculated with chi-square test (see Table 16).

Table 15. The Proportions of the Students' Decisions

GROUP		YES	NO	UNKNOWN / YES OR NO
Control group	Pretest	% 14,2	% 82,8	% 2,8
	Posttest	% 22,8	% 74,2	% 2,8
Experimental group 1	Pretest	% 5,5	% 94,4	-
	Posttest	% 19,4	% 80,5	-
Experimental group 2	Pretest	% 12,8	% 71,7	% 15,3
	Posttest	% 0	% 94,8	% 5,1

The results indicated that while there is a significant difference among the decisions in post-tests of all groups, a significant difference did not exist between the control group and experimental group 1, as shown in Table 15.

Table 16. Differences in Decision Frequencies

	Pearson Chi-Square	Asymp. Sig.
Between all groups	29.065	.00*
Control-Exp 1	3.697	.16
Control-Exp 2	26.109	.00*
Exp 1 - Exp 2	25.114	.00*

*p < .05

CHAPTER 5

DISCUSSION

This chapter begins with a summary of the study, followed by a discussion based on related literature. The chapter ends with sections on implications and limitations.

5.1 Summary of the study

The aim of the present study was to investigate the effect of teaching SSI using an evidence-based thinking approach on seventh graders' benefit and risk perception of nuclear energy, their understanding of nuclear energy, their argumentation quality and their decisions about the construction of nuclear power plants in Turkey. The effect of the instruction was investigated within and between the three groups comprised of one control and two experimental groups. In all groups, the characteristics of nuclear energy and the operation of power plants were taught. In the control group, conventional teaching based on the textbook and additional online information was carried out. In experimental group 1, an evidence-based lecture was used, and in experimental group 2, an evidence-based activity was used to teach the subject.

5.2 Discussion of the results

This section first presents the results of the study about the effect of the intervention on seventh graders' benefit and risk perception of nuclear energy, their understanding of nuclear energy, their argumentation quality and their decisions about the construction of nuclear power plants in Turkey. Second, it includes comparisons of the effect of teaching systematic evidence-based lessons and traditional instruction on the benefit and risk perception of nuclear energy, the understanding of nuclear energy, the argumentation quality and decisions about the construction of nuclear power plants in Turkey in the light of related literature.

- Effect of the intervention on seventh graders' benefit and risk perception of nuclear energy, understanding of nuclear energy, argumentation quality and decisions about the construction of nuclear power plant in Turkey

The control group received an interactive lecture based on the textbook and internet sources that included two documentaries about nuclear energy and nuclear power plants, and images of previous nuclear power plant disasters and nuclear power plant waste. Descriptive statistics showed that the mean of the post-tests decreased from *M*=48.18, *SD*=5.33 to *M*=48.05, *SD*=6.66, which did not signify a statistically significant change. The higher scores represent higher risk perception. Although the students saw more than one image of previous disasters than the other groups, who were shown just one image of disease in people after the Chernobyl disaster, it did not increase the risk perception of the students. The understanding of nuclear energy increased considerably, with a .00 significant value. This can be explained by the amount of information the teacher provided. Although the information about nuclear energy in the textbook was just one paragraph (Ozoglu & Misirlioglu, 2015, p. 201), the teacher used internet sources, which enabled students to learn more than what is written in the textbook. The teacher also made students write about waste in their notebooks. On the other hand, the argumentation quality of the students in the control group decreased from *M*=3.20, *SD*=2.04 to *M*=2.60, *SD*=1.56, which was not statistically significant. This can be explained by neither students engaged in a discussion nor the evidence and claims that are also ground elements of argumentations were presented to the students in control group. This finding corroborates the results of Venville and Dawson (2010), who indicate that about 75% of the students who did not receive support in the argumentation skills showed low quality argumentation. A lecture is not sufficient to increase students' argumentation quality. Finally, the proportion of the students who accepted the construction of a nuclear power plant in Turkey did not change significantly. The reason might be there is no effect of a lecture-based instruction on students' decision-making.

The evidence-based interactive lecture was implemented to experimental group 1. Two different claims with their evidence were presented to the students and after the presentations, they were encouraged to engage in argumentative discussions. When the findings from the scores of Benefit and Risk Perception Questionnaire (BRPQ) were evaluated, the mean scores decreased from M=49.55, SD=6.93 to M=47.72, SD=8.29, which is not statistically significant. It is worthy of note that the mean scores in the pre-tests were higher than those for the other groups, which indicates the students in experimental group 1 had the highest risk perception about nuclear energy before the intervention. Therefore, risk perception might decrease after the students had learned about nuclear energy.

Also, there was a statistically significant increase in the understanding of nuclear energy in experimental group 1, with a high significance level of .00 Students were provided sufficient and systematic information about nuclear energy and nuclear power plants in terms of evidence for the claims throughout the presentation sessions. The evidence-based interactive lecture might have enabled students to increase their understanding of nuclear energy. Students engaged the argumentative discussions after each presentation, but there was no statistically significant increase in the quality of their argumentation. The students did not constitute their own arguments; they just argued based on the existing claims and the evidence they were given for each claim. In other words, they only stated their opinions, which is not sufficient to develop argumentation qualities. This is similar what Osborne, Erduran and Simon (2004) discussed, that is, that presenting scientific and socio-scientific issues to students is not sufficient to increase the argumentation abilities, even if they have a chance to discuss what was presented. Our finding also corroborates the findings of Hogan and Maglienti (2001) and Zohar and Nemet (2002). Also, the proportion of students who did not accept the construction of the nuclear power plant decreased significantly. The decrease in the risk perception might have been related to the students' acceptance of the construction of the nuclear power plant. The significant increase in the acceptance of a nuclear power plant might be explained by the lack of argumentation skills, which could be the cause of students' making incorrect judgements on the issues.

Students in ~~the~~ experimental group 2 were instructed using an evidence-based activity. They worked collaboratively on MEL diagrams. After working in pairs, they engaged in argumentative discussions as a class. They shared their work with the class at the end of each lesson and defended their positions to their opponents. Findings revealed that a statistically significant change existed in all variables. The significance levels were.00 for benefit and risk perception, .00 for understanding of nuclear energy and .02 for argumentation quality. When the effect size of the intervention was calculated, the value for benefit and risk perception was -.41, which is considered moderate; the t value for understanding was 1.23, which is a high effect size, and the biggest value among the groups and the r value for argumentation quality was -.35, which is a moderate effect. One of the aims of the MELs was to promote collaborative argumentation. Thus, studies which have used MEL revealed that there is a significant change in the conceptual knowledge (Lombardi, Sinatra, & Nussbaum, 2013) and plausibility perceptions and understanding (Lombardi, 2012). Lombardi, Danielsen and Young (2016) also show that the results of the postponed tests revealed there is a long-term effect on the understanding of students who engaged in a MEL activity for a time as short as 90 minutes. MEL is also suggested as an appropriate tool for improving higher order reasoning. In addition to the studies that used MELs, MELs can be considered argumentation-based instruction. When the effects of the argumentation-based instructions were analyzed by McDonald (2014) in a study conducted with teachers, it was found that the teachers constructed high quality arguments after they were instructed based on argumentation. Domac (2011) indicated that argumentation-based instruction increased the argumentation quality of pre-service biology teachers. It was observed in experimental group 1 when the risk perception decreased, the acceptance of a nuclear power station in Turkey increased and in experimental 2 the risk perception increased, the acceptance of a nuclear power plant in Turkey decreased. These findings are consistent with previous studies on the relationship between understanding and risk perception that students with low knowledge level have low risk perceptions, whereas students with a high knowledge level have high-risk perceptions (Bosschaart, Kuiper, & van der Schee, 2013; Botzen, Aerts, & van den Bergh, 2009; Sonmez & Kilinc, 2012). The students in experimental group 2 had the highest understanding scores according to post-tests and also had the highest risk perception. ~~Osborne~~, Erduran and Simon (2004) also showed that students who received argumentation-based instruction explicitly improved their argumentation quality. Finally, the proportion of students who did not accept the construction of a nuclear power plant in Turkey increased significantly after the instruction. Acar, Turkmen and Roychoudhury (2010) state that teaching argumentation explicitly helps students to develop their decision-making skills. The evidence-based activity included the argumentation elements such as claims and evidence. Therefore, the students who engaged in the evidence-based activities increased their decision-makng abilities and they made well-informed decisions.

- Comparison of interactive lecture, evidence-based lecture and evidence-based activity in terms of seventh graders' benefit and risk perception of nuclear energy, understanding of nuclear energy, argumentation quality and decisions about the construction of nuclear power plant in Turkey.

The findings indicated that between the control group and experimental group 2 there was a significant difference in all variables, namely, benefit and risk perception of nuclear energy, understanding of nuclear energy, argumentation quality and decisions about nuclear power plants. In all groups, approximately the same amount of information about nuclear energy and nuclear power plants was included. On the other hand, in the control group and in experimental group 1, information was presented by the teacher, whereas in experimental group 2 students actively and collaboratively worked throughout the intervention to construct arguments related to the characteristics of nuclear energy and the construction of nuclear power plants. Students might read the evidence more than once in order to link them to appropriate claims. It can be said that they were more engaged with the content of the evidence. Moreover, unlike experimental group 1, in the control group there was no systematic presentation of evidence or claims and the students did not even engage in any discussions. Thus, students who were taught in an evidence-based student-centered class performed better in argumentation quality and understanding and perception of nuclear energy than the students in a teacher-centered lecture class.

Regarding decisions and argumentation quality the results of the study are in line with the socio-scientific issues literature. Decision-making about socio-scientific issues is a complex process as stated in the literature (Eggert & Bögeholz, 2010; Seethaler & Linn 2004). Also argumentation is advocated to develop decision-making skills (Acar, 2008; Driver et al., 2000; Dawson & Venville, 2010), only the students in experimental group 2 could increase argumentation quality and risk perception statistically significant which can be interpreted that the decisions of the students in experimental group 2 were the most informed decisions. Nussbaum (2008) emphasized that students are able to engage collaborative argumentation, which enables them to actively compare each other's explanations, criticize and revise. The findings are also consistent with the study of Tonus (2012) conducted in Turkey with primary school students, when they engaged in the argumentation-based instruction about nuclear energy and cloning, the decision-making skills of the students living in the city center and slum area improved.

Regarding understanding and risk perception, students who were taught with an evidence-based activity performed better than students in the traditional class.The literature shows that for complex issues such as climate change, students should explicitly reappraise plausibility judgment in order to reconstruct knowledge sufficiently (Bråten, Strømsø, & Salmerón, 2011; Strømsø, Bråten, & Britt, 2010). A Model Evidence Link diagram was used in the present study for students to make plausibility judgments for each evidence and model. Lombardi, Sinatra and Nussbaum (2013) showed that using MEL significantly increased students' understanding with instruction that lasted less than 90 minutes. The present study supported this finding. The evidence-based student-centered instruction based on

MEL took four lessons (160 minutes), one lesson of which (40 minutes) was spent for a preparation activity. At the end of the intervention, the understanding of students in experimental group 2 was significantly higher than that of the control group.

It is also important to note that, in the literature, there is a supportive link between understanding and argumentation quality (Hogan, 2002; Sadler & Donnelly, 2006; Tytler, Duggan, & Gott, 2001; Zohar and Nemet, 2002). On the other hand, there are many studies that reveal that understanding is not a primary determinant of high quality arguments (Kortland, 1996; Kutluca, 2012; Soysal, 2012). The results of the present study seem to be consistent with the threshold model of Sadler and Fowler (2006), who investigated the use of scientific knowledge during the socio-scientific argumentation. It was conducted with high school students with different levels of knowledge about genetics, college nonscience majors with little genetics knowledge and college science majors with advanced genetics knowledge. Assessment of the argumentation of each group revealed that college science majors outperformed the other groups, whereas the argumentation did not differ among high school students or nonscience majors. The result was explained by Threshold Model of Content Knowledge Transfer. This model supports that there is a relationship between argumentation and content knowledge, but a nonlinear relationship. The model suggests that there are at least two knowledge levels related to the improvement of the argumentation quality. Basic knowledge and advanced knowledge are two levels of understanding. Whereas basic knowledge is needed to constitute an argument, it is not sufficient for a high quality argumentation. Advanced knowledge is necessary for a high quality argumentation. In the present study, experimental group 2 had the highest understanding and they also had the highest argumentation quality. However, the present study did not test the relationship between understanding and argumentation quality statistically. Another interesting point is understanding the justifications of students in terms of the change in their decisions about nuclear power plants. The number of students who accepted nuclear power plant construction increased significantly in experimental group 1 but decreased in experimental group 2. It would have been useful to do interviews with the students to research the reason for this conclusion.

Finally, the results of the present study show that lessons using evidence-based activities improved the understanding, perception and argumentation qualities of the students. Science lessons with evidence-based activities developed the knowledge obtained by students and their argumentation skills. It is suggested that preparing and implementing evidence-based activities should be included in teacher training. Moreover, textbooks should be in line with the evidence-based texts rather than simply presenting claims. The present study indicated that SSI should be taught using evidence-based activities that foster making informed decisions about SSI.

5.3 Limitations of the study

The researcher conducted a quasi-experimental study. Whereas the instructor of the two experimental groups was the researcher, the instructor of the control group was a teacher of the research school. In order to limit differences in content, the researcher and the teacher prepared the lessons together, based on the related objectives of the curriculum. The lessons were video recorded to observe the differences between the instructions.

APPENDIX A

NUCLEAR ENERGY UNDERSTANDING QUESTIONNAIRE

ENERGY TEST

Name-Surname:	**Class:**	**Date:**

There are questions about the energy types below. Please response the questions.

1) What does renewable energy mean? Please define properly.

………

………

………

2) What does green energy (environment friendly) mean? Please define properly.

………

………

………

3) Is nuclear energy a renewable energy type? Why?

Yes ☐ No ☐

………

………

………

4) Is nuclear energy environment friendly? Why?

Yes ☐ No ☐

……

……

……

5) What is the raw material of nuclear power plants?

……

6) What are the wastes of nuclear power plants?

……………………………………………………………………………………

7) How does nuclear power plants work? Please define.

……

……

……

APPENDIX B

ARGUMENTATION LETTER TASK

We want you to contribute to our ongoing research about nuclear power plants. Therefore we ask you to write a letter including your thoughts about the construction of nuclear power plants in Turkey.

Name_Surname: Class: Date:

1) Do you support the construction of nuclear power plants in Turkey?

Yes ☐ No ☐

2) Please write a letter including your position about the construction nuclear power plants in Turkey with the justifications in order to convince the deputies.

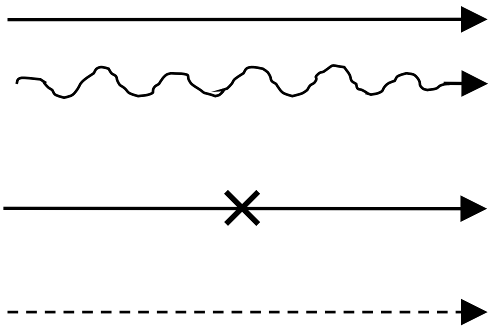
Dear Deputies,

APPENDIX C

MEL PREPARATION ACTIVITY

Name-Surname :____ ________
Date :____

Directions: Draw two arrows from each evidence box. One to each mode..You will draw a total of 8 arrows.



The evidence **supports** the model**.**

The evidence **strongly supports** the model.

The evidence **contradicts** the model.
(shows it is wrong)

The evidence has **nothing to do** with the model.

Evidence #1
It's cloudy.

Evidence #3
Municipal workers wash the streets everyday.

Model A
Today it rained.

Evidence #2
I heard it thunder.

Evidence #4
I saw the municipal vehicle.

Model B
It did not rain, workers of the municipality washed the streets.

Provide a reason for three of the arrows you have drawn. Write your reasons for the three most interesting or important arrows.

A. Write the number of the evidence you are writing about.

B. Circle the appropriate descriptor (strongly supports | supports | contradicts | has nothing to do with).

C. Write the letter of the model you are writing about.

D. Then write your reason.

1. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

2. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

3. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:

4. Circle the plausibility of each model. [Make two circles. One for each model.]

	Great implausible (or even impossible)								Highly plausible	
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10

5. Circle the model which you think is correct. [Only circle one choice below.] Please tick this part on your own (not collaboratively).

Very certain that Model A is correct.	**Somewhat certain** that Model A is correct	**Uncertain** if Model A or B is correct	**Somewhat certain** that Model B is correct	**Very certain** that Model B is correct
Very certain that Model A is correct	**Somewhat certain** that Model A is correct	**Uncertain** if Model A or B is correct	**Somewhat certain** that Model B is correct	**Very certain** that Model B is correct

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