DEVELOPING PRESERVICE SCIENCE TEACHERS' SOCIOSCIENTIFIC REASONING THROUGH SOCIOSCIENTIFIC ISSUES-FOCUSED COURSE

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ABSTRACT

DEVELOPING PRESERVICE SCIENCE TEACHERS' SOCIOSCIENTIFIC REASONING THROUGH SOCIOSCIENTIFIC ISSUES-FOCUSED COURSE

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The purpose of this study was to investigate how preservice science teachers' (PSTs) socioscientific reasoning changes in response to participation in a socioscientific issues-focused course. Socioscientific issues (SSI) are complex, uncertain, lack clear-cut solutions; require ongoing research and examining from multiple perspectives. Individuals should recognize the complexities associated with SSI, examine them from multiple perspectives and, appreciate the need for ongoing inquiry to negotiate and resolve them.

For the purpose of this study, design based research with qualitative approach was used. A single group design was used to investigate the change in participants'

socioscientific reasoning before, during, and after SSI-focused course. A total of 33 PSTs enrolled in the Science-Technology-Society course were involved in the study. A semester-long course was designed with three phases. The course included teacher-led whole classroom discussions, teacher-guided group activities, and independent group activities. Data were collected through pre-post interviews, open-ended questions, reflection papers, video/audio recordings, and written reports.

An initial analysis of interview data resulted in development of depth rubric to assess socioscientific reasoning in addition to the previous rubric. Results revealed that there was a significant improvement in PSTs' socioscientific reasoning in terms of complexity, inquiry, and multiple perspectives before and after SSI-focused course. The results after first and second phases also revealed that PSTs' socioscientific reasoning in terms of complexity, inquiry, and multiple perspectives developed gradually during the SSI-focused. The teaching and learning activities in SSI-focused course were discussed as potential source for the development of socioscientific reasoning among participants.

Keywords: Socioscientific Issues, Socioscientific Reasoning, Complexity, Inquiry, Perspectives

ÖZ

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ SOSYOBİLİMSEL KONULARDA MUHAKEME YETENEKLERİNİN GELİŞTİRİLMESİ

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Mart 2014, 278 sayfa

Bu çalışmanın amacı fen bilgisi öğretmen adaylarının sosyobilimsel konularda muhakeme yeteneklerinin sosyobilimsel konular üzerine tasarlanmış bir ders ile nasıl değiştiğini araştırmaktır. Sosyobilimsel konular karmaşık ve belirsiz bir yapıya sahiptir. Çözümleri kesin ve tek değildir. Karar verme ve çözüm bulma sürecinde farklı boyutlar ve görüşler incelenmeli ve bilgi araştırılması yapılmalıdır.

Bu çalışmanın amacına uygun olarak tasarım tabanlı araştırma modeli kullanılmıştır. Fen bilgisi öğretmen adaylarının muhakeme yeteneklerindeki değişim sosyobilimsel konular üzerine tasarlanmış ders öncesinde, sırasında ve sonrasında incelenmiştir. Sosyobilimsel konular üzerine tasarlanmış ders üç

aşamadan oluşmaktadır. Katılımcılar bir dönem boyunca öğretmen rehberliğinde sosyobilimsel konularla ilgili makaleler okumuşlar ve bu konularla ilgili durum çalışmaları yapmışlardır. Grup olarak sosyobilimsel konular üzerine tartışma ve karar verme süreçlerini içeren aktiviteler içerisinde bulunmuşlardır. Fen-Teknoloji-Toplum dersine kayıtlı 33 fen bilgisi öğretmen adayı çalışmaya katılmıştır. Çalışmanın veri kaynağını ön-son görüşmeler, açık uçlu sorular, bireysel dokümanlar ve derslerin video kayıtları oluşturmaktadır.

İlk yapılan analizler sosyobilimsel konularda muhakeme yeteneklerinin değerlendirilmesinde kullanılan rubrikin gelişmesine katkıda bulunmuş ve bu yeteneklerin daha detaylı değerlendirilmesine olanak sağlayan ikinci bir rubrik geliştirilmesine olanak sağlamıştır. Sonuçta fen bilgisi öğretmen adaylarının muhakeme yeteneklerinin ön ve son görüşmelere göre anlamlı bir şekilde geliştiği bulunmuştur. Ayrıca derste uygulanan birinci ve ikinci aşamadan sonra yapılan analizlerde de, öğretmen adaylarının sosyobilimsel muhakemelerinin bir dönem boyunca aşamalı olarak geliştiği bulunmuştur. Ders içerisinde uygulanan aktivitelerin fen bilgisi öğretmen adaylarının sosyobilimsel muhakeme yeteneklerine katkısı tartışılmıştır. Program geliştiriciler ve öğretmenler için önerilerde bulunulmuştur.

Anahtar Kelimeler: Sosyobilimsel Konular, Muhakeme, Karmaşıklık, Sorgulama, Çoklu Perspektif

To my family

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LIST OF ABBREVIATIONS

NPP	Nuclear Power Plant
PST	Preservice Science Teachers
SSI	Socioscientific Issues
SSR	Socioscientific Reasoning

CHAPTER 1

INTRODUCTION

1.1 Socioscientific Issues and Science Education

Stem cell, cloning, genetically modified foods, global warming, and nuclear power plant are examples of issues which individuals may face in their daily lives. Individuals make judgments and decisions about whether nuclear power plants should be constructed, or genetically modified foods should be banned or allowed. These issues usually results in debate including opposing ideas because there is no consensus about them among individuals. Having different and opposing ideas makes them controversial, dilemmatic, and open to multiple solutions. Such issues are called as socioscientific issues (Sadler, 2004). Sadler (2004) defined socioscientific issues (SSI) as "complex, open-ended, often contentious dilemmas, with no definitive answers. In response to socioscientific dilemmas, valid, yet opposing, arguments can be constructed from multiple perspectives" (p. 514). These issues can be negotiated and resolved through informal reasoning which "involves the generation and evaluation of positions in response to complex issues that lack clear-cut solutions" (Sadler, 2004, p.514). Individuals should critically

evaluate these issues and make sound and informed decisions on them. They should develop necessary skills such as analytical and evaluative reasoning skills which enable them to analyze the impact of these issues on different stakeholders.

The number of studies focusing on decision making regarding socioscientific issues is increasing gradually (Sadler, 2003). Students, as future citizens of a society, should learn how to negotiate and make reasonable decisions on these issues. Scholarly papers emphasize the teaching of science related societal issues as one of the goals of science education for educating scientifically literate citizens (Hofstein, Eilks, & Bybee, 2011; Lee, Chang, Choi, Kim, & Zeidler, 2012; Sadler, Barab, & Scott, 2007; Zeidler, Sadler, Simmons, & Howes, 2005).

The recent reforms in science education underline the need for citizenship education, so the science related societal issues which are socioscientific issues should be addressed in science classrooms (Barrue & Albe, 2013). It means that socioscientific issues should be considered pedagogically in science education curricula.

The relation between science, technology and society (STS) education has gained emphasis among science education researchers since 1970s (Zeidleret al., 2005). Zeidler et al. (2005) argued that although theoretical and pedagogical aspects of SSI were based on the STS education, they are different and have unique approaches. They are conceptually related and both relate science to societal issues. However SSI is differentiated from STS by emphasizing moral and ethical

development and development of character and virtue (Zeidler et al., 2005). Zeidler et al. (2005) stated that SSI is not only a context for learning science but also a pedagogical strategy having clear instructional goals. From theoretical and pedagogical perspectives socioscientific issues have been studied by science education researchers to explore students' reasoning when making decisions about them. As a new approach, SSI has been accepted as having more holistic approach to teach controversial issues than STS approach.

In light of this, this study describes an investigation of preservice science teachers' (PSTs) reasoning on aspects of practice for decision-making in the context of SSI. The detailed information about SSI, informal reasoning and socioscientific reasoning were given in the following sections.

1.2 Theoretical Framework

In the context of science, reasoning historically referred to formal reasoning characterized by rules of logic and mathematics (Sadler, 2004). Formal reasoning was generally associated with well-defined problems for which individuals are provided some premises and required to evaluate whether a given conclusion is right or wrong (Evans & Thompson, 2004). Means and Voss (1996) argues that when the problem is well-defined as in formal reasoning, informal reasoning processes are not aroused since "informal reasoning assumes importance when information is less accessible, or when the problems are more open-ended, debatable, complex, or ill-structured, and especially when the issue requires that the individual build an argument to support a claim" (p. 140). Formal reasoning is not

well-suited with ill-structured problems since these problems do not have clear premises and conclusions (Shaw, 1996). Shaw (1996) emphasized that the ill-structured problems are the ones individuals mostly face in their daily life on which they have to make choices and decisions. Sadler (2004) stated that "just as scientists employ informal reasoning to gain insights on the natural world, ordinary citizens rely on informal reasoning to bring clarity to the controversial decisions they face" (p.515). That is individuals exhibit informal reasoning when they are asked to take positions on controversial issues.

Within SSI research, findings on students' informal reasoning patterns are mixed based on their considerations such as emotive, social, scientific, economic, ecological or human-based (Patronis, Potari, & Spiliotopoulou, 1999; Sadler & Zeidler, 2005; Wu & Tsai, 2007; Yang & Anderson, 2003). In other words, individuals may exhibit different patterns of informal reasoning in the negotiation and resolution of socioscientific issues. For example, Patronis et al. (1999) described four different reasoning patterns as social, ecological, economic and practical based on the nature of students' arguments developed for or against to the issue which was the design of a road in their local area. Yang and Anderson (2003) determined two different reasoning modes as scientifically-oriented and socially-oriented based on the kind of information students used during decision-making on nuclear power. Sadler and Zeidler (2005) stated that informal reasoning includes the cognitive and affective processes of negotiating and resolving SSI and individuals rely on cognitive, affective, or both cognitive and affective processes to

formulate and support their positions. Based on this, Sadler and Zeidler (2005) suggested three reasoning patterns as rationalistic (cognitive informal reasoning), emotive (cognitive and affective informal reasoning), and intuitive (affective informal reasoning) based on the students' considerations in response to the different genetic dilemmas. Wu's study (2013) revealed 6 different reasoning modes based on the nature of arguments in the context of genetically modified food. Figure 1.1 outlines the informal reasoning patterns in the context of SSI.

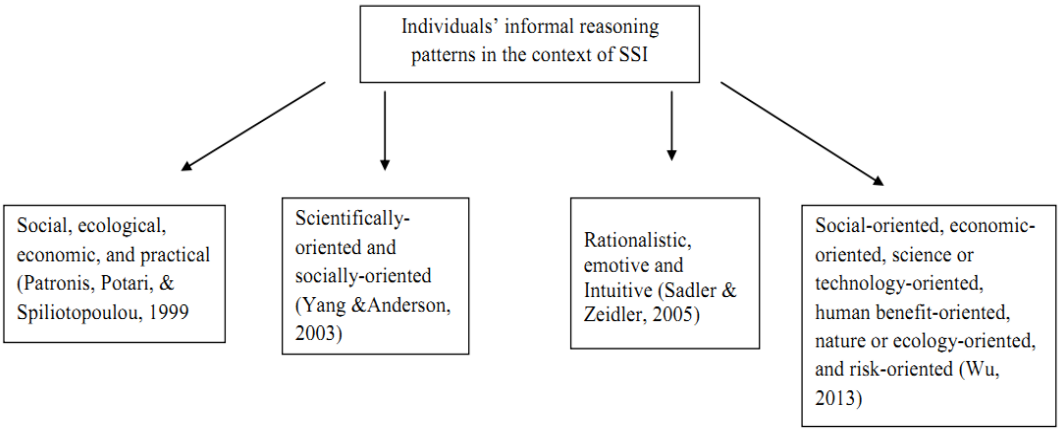

Figure 1.1 Different Informal Reasoning Patterns Revealed in SSI Research

Most recently another research line focus on the on the nature of SSI (i.e. being complex, multifaceted and uncertain, lacking clear-cut solutions, requiring ongoing research) and students' understanding and abilities (i.e. recognizing the complexities associated with SSI, examining SSI from multiple perspectives and, appreciating the need for ongoing inquiry, exhibiting skepticism when presented potentially biased information). Students are expected to use these understanding and skills to negotiate and resolve SSI. Sadler, et al. (2007) conceptualized the understanding and abilities about nature of SSI as "socioscientific reasoning"

(SSR) and defined it as "a theoretical construct which subsumes aspects of practice associated with the negotiation of SSI and addresses the citizenship goal" (p. 374). Individuals should have an adequate understanding of nature of SSI to be able to make informed and sound decisions. Figure 1.2 presents the framework related to the negotiation and resolution of SSI.

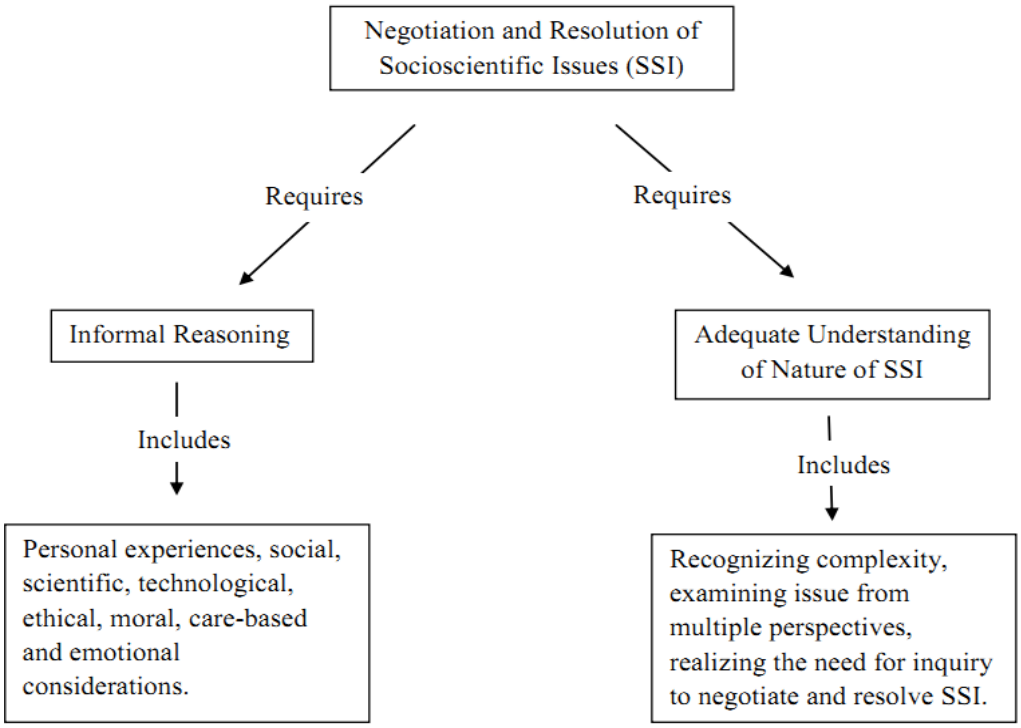

Figure 1.2 Framework Associated with the Negotiation and Resolution of SSI

Four aspects were suggested for socioscientific reasoning (Sadler et al., 2007, p. 374.). These are:

1. Recognizing the inherent *complexity* of SSI.
2. Examining issues from multiple *perspectives*.
3. Appreciating that SSI are subject to ongoing *inquiry*.

4. Exhibiting *skepticism* when presented potentially biased information.

In a further study Sadler, Klosterman, and Topcu, (2011) reconceptualized perspectives and skepticism aspects and treated them as one aspect under the dimension of perspectives. In this study, socioscientific reasoning was studied including three aspects which are complexity, inquiry, and perspectives.

"Complexity" is associated with the nature of SSI. Zeidler and Sadler (2011) stated that SSI is complex by definition. Socioscientific issues are ill-structured problems and have no clear-cut single solutions (Sadler, 2004). They are open to multiple solutions based on different ideas and views about them. It was emphasized that individuals recognizing the complexity associated with the SSI can demonstrate sophisticated practice with respect to complexity and they are able to make more informed, sound, and evidence-based decisions when compared to the individuals who cannot realize the complexity and suggest single and simple solutions.

"Perspectives" as an aspect of socioscientific reasoning refers to the negotiation of socioscientific issues from different perspectives (Zeidler & Sadler, 2011). Zeidler and Sadler (2011) expressed that socioscientific issues include dilemmas in which conflicting ideas, views, and values compete to be prioritized. Individuals hold different interests, ideas, priorities and biases (Sadler et al., 2007). People having different perspectives were expected to discuss SSI differently and to reach different solutions. Individuals who can examine SSI from different perspectives

can display more sophisticated reasoning on SSI and make informed decisions as compared to the individuals who concentrate on single perspective in resolving SSI.

"Inquiry" aspect of SSR was conceptualized based on the uncertain nature of SSI (Sadler et al., 2007). Sadler et al. (2007) emphasized that SSI are ill-structured problems subject to ongoing investigation. These issues include undetermined information which is explored through further research during their negotiation. The information at hand may not be sufficient or may be biased. Therefore thoughtful negotiation of SSI requires ongoing inquiry to make evidence-based decisions. Individuals who appreciate that SSI is subject to ongoing inquiry may present more sophisticated reasoning in SSI discussions by requiring additional information to answer the possible questions related to SSI.

It is important for individuals to develop sophisticated socioscientific reasoning, understanding and skills with respect to complexity, inquiry, and perspectives. Reasoning skills represent mental processes such as classifying, predicting, comparing, analyzing, evaluating, drawing conclusions and inferences (Stiggins, Arter, Chappuis, & Chappuis, 2004) to be able to evaluate knowledge, information and opposing positions on social and scientific issues. Stiggins et al. (2004) identified six different reasoning patterns which students should master. These are analytical reasoning, synthesis, comparative reasoning, classifying, inductive reasoning, deductive reasoning and evaluative reasoning. Analytical and evaluative reasoning are used for making judgments and decisions on controversial issues.

Individuals use analytical reasoning when they focus on components or parts and investigate the relationship between them. Stiggins et al. (2004) stated that for students to be successful in using analytical reasoning, "they must be able to identify parts of something and then have practice at describing relationships among those parts, or between the part and the whole" (p. 65). Evaluative reasoning involves expressing and defending an opinion, a point of view, a judgment, or a decision (Stiggins et al., 2004). They identified three components of evaluative reasoning as assertion, criteria the assertion is based on, and evidence that supports the assertion. In the case of socioscientific reasoning, both analytical and evaluative reasoning are required for students to understand complex (complexity aspect of SSR), multifaceted nature of SSI (multiple perspectives aspect of SSR) and to realize the need for additional information (inquiry aspect of SSR) to resolve those issues. When students encounter a socioscientific issue, they should be able to determine confronting arguments for and against a specific solution and investigate them carefully. After investigating different ideas, they should be able to express their own assertions and provide plausible evidences. Students should be able to examine the SSI from different perspectives, as components of SSI, to reach an informed decision. Through analytical and evaluative thinking processes, students may develop an adequate understanding of the complexities and dynamics of SSI. In this study, it was expected that students use analytical and evaluative thinking processes when they make judgments about nuclear power plant construction. Table 1.1 summarizes the aspects of SSR and

how evaluative and analytical thinking processes were used in the context of nuclear power plant for this study.

Table 1.1 A Summary of Socioscientific Reasoning Aspects

Aspects of Socioscientific Reasoning	Explanation	Evaluative and Analytic Thinking Process
Complexity	To be able to judge the complex nature of the issue, identify sources for complexity, provide evidence to support their judgment	*Assertion*: Judging whether nuclear power crisis is easy or difficult to solve. *Criteria*: Identifying different sources that make the issue complex or straightforward. *Evidence*: Providing evidence to support their point of view.
Inquiry	To be able to evaluate given information, recognize lack of information and the need for ongoing research to solve the issue.	*Assertion*: Evaluating whether the given information is enough to solve the nuclear power crisis *Criteria*: Recognizing different lines of information that is not given but required for the solution. *Evidence*: Supporting why that information is necessary to solve the problem.
Multiple Perspectives	To be able to judge different perspectives in terms of their point of view, provide reasonable claims and opinions in parallel with the given perspective.	*Assertion*: Judging how given perspectives will react to the use of renewable energy sources instead if nuclear energy. *Criteria*: Providing reasonable claims for and against nuclear power plant construction in terms of given perspectives *Evidence*: Supporting different perspectives' claims

1.3 Research Questions and Rationales

This study investigates the PSTs' socioscientific reasoning before, during and after a SSI-focused course. It was expected that PSTs improve their socioscientific reasoning when they were engaged in the classroom practices about negotiation and resolution of SSI. Two main research questions guided this study were given below.

1.3.1 Research Question 1

Research Question 1: How does PSTs' socioscientific reasoning change in response to participation in a SSI-focused course?

a. How do PSTs recognize the inherent complexity of socioscientific issues before and after a SSI-focused course?
b. How do PSTs realize that SSI is subject to ongoing inquiry before and after a SSI-focused course?
c. How do PSTs examine socioscientific issues from multiple perspectives before and after a SSI-focused course?

Rationale for Research Question 1. As stated earlier SSR is a construct focusing on individuals' understanding and abilities important to negotiation and resolution of SSI. There are few studies on SSR (Sadler, et al 2011; Sadler, Barab, & Scott, 2007; Simonneaux & Simonneaux, 2009). Sadler et al. (2007) developed SSR as a theoretical construct and provided an assessment rubric for it. In the following study, Sadler et al. (2011) modified SSR based on previous study and created a new

assessment strategy which was discussed in great detail in next chapter. They aimed to explore how students improve their SSR through a 3-week intervention on global warming. This study also aimed to improve SSR by designing an intervention which covers a full semester. It also advanced the assessment of SSR. It is expected that classroom practices and experiences in a SSI-focused course may support improvement in PSTs' socioscientific reasoning.

1.3.2 Research Question 2

Research Question 2: How does PSTs' socioscientific reasoning change during the SSI-focused course?

a. How do PSTs recognize the inherent complexity of socioscientific issues after phase 1 and 2 during a SSI-focused course?
b. How do PSTs realize that SSI is subject to ongoing inquiry after phase 1 and 2 during a SSI-focused course?
c. How do PSTs examine socioscientific issues from multiple perspectives after phase 1 and 2 during a SSI-focused course?

Rationale for Research Question 2. The second research question intends to explore PSTs' development of SSR during the SSI-focused course. The classroom applications of SSI were important because the research exploring classroom practices in the context of SSI is not sufficient (Sadler et al., 2011). PSTs' participation in classroom activities could account for the advances in their socioscientific reasoning.

1.4 Definition of Terms

Socioscientific Issues (SSI): SSI is defined as open-ended, often contentious dilemmas, with no definitive answers and informal reasoning processes were used to solve these issues.

Socioscientific Reasoning (SSR): It is defined as aspects of practice associated with the negotiation and resolution of SSI. It includes understanding and abilities such as recognition of complex nature of SSI, examining SSI from multiple perspectives and appreciating that SSI is subject to ongoing inquiry (Sadler et al., 2007).

1.5 Significance of the Study

SSI has provided a new image for science education focusing on the students' involvement in real-life social problems based on science (Sadler & Fowler, 2006). They stated that the science classrooms in schools should reflect the dynamics of interaction between science and society focusing on both science aspects related to the issues and the social aspects including, economical, political, ethical and moral dimensions. When the science is isolated from socioscientific issues, students do not develop necessary skills and practices and gain necessary knowledge to use in response to the real life problems including social dilemmas (Sadler & Zeidler, 2005). As being a member of a society, they will ultimately encounter with such conflict issues at a point in time. Therefore SSI movement in school science is an opportunity to practice skills and knowledge to resolve real life problems. The integration of socioscientific issues into science education was discussed by researchers because it is vital in terms of the development of good citizens who are

aware of scientific knowledge (Driver, Newton, & Osborne, 2000; Kolstø, 2001a). It is clear from recent international research in science education that the progression of scientific literacy with moral and ethical dimensions is important to make science more relevant to the students' everyday life (Zeidler et al., 2005). Scientific literacy is defined as a multidimensional construct including "being able to use scientific knowledge and ways of thinking for personal and social purposes" (Rutherford & Ahlgren, 1990, pp. xviii). Scientifically literate individual is the one who "use appropriate scientific processes and principles in making personal decisions" and "engage intelligently in public discourse and debate about matters of scientific and technological concern" (NRC, 1996, p. 13). With the international reforms in science education, Turkey also acknowledged recent reform movements in the new science and technology curriculum and has published it in 2005. The vision of science and technology curriculum was stated as to educate all students as scientifically literate individuals without considering the individual differences (MoNE, 2005). The new curriculum proposed that scientific literacy has seven aspects one of which emphasizes the relation between science, technology, society, and environment. One of the characteristics of scientifically literate individuals was stated as being able to relate science, technology, and society and to use the knowledge, understanding, and skills gained in solving problems and making decisions (see Appendix A for the goals of Turkish science and technology curriculum in 2005). In 2013, the national science and technology curriculum has undergone several revisions to integrate socioscientific issues into the science education. One of the goals of science education was stated as "to develop habits of

mind through the use of socioscientific issues" (MoNE, 2013) (see Appendix B for the goals of Turkish science and technology curriculum in 2013). With this goal in mind, the 5th grade science and technology textbook was refined. Some socioscientific issues such as the use of food additives or the use of naphthalene as a moth repellent at home were presented for students' discussions. In order to develop habits of mind such as acquiring skepticism, maintaining open-mindedness, evoking critical thinking, recognizing multiple forms of inquiry, searching for data-driven knowledge (Zeidler et al., 2005), students should participate in socioscientific reasoning and decision making process. Therefore the classroom activities should be designed to achieve this goal. In order to use SSI in parallel with the goals of science education, science teachers should also have the necessary pedagogical knowledge and skills.

They should be able to implement classroom activities about SSI to reach the goals of science education. Their training in teacher education programs should also include how to teach SSI. In light of this, this study was conducted with preservice science teachers to develop their SSI understanding and socioscientific reasoning. PSTs' negotiation of SSI is not only important for their personal decisions but also for their profession as a teacher since they will teach such topics in their future classrooms. They can assist their students to develop scientific literacy and to be a scientifically literate individual. Their students may be the future politicians, businessman, engineers who have to make decisions. PSTs engagement with SSI during their teacher education programs may provide them with necessary

knowledge and skills to integrate SSI into science education. Therefore, they may help their students to gain necessary knowledge and skills to make informed decisions on science related societal issues.

This study is also significant in providing empirical evidence for the improvement of SSR through participating in classroom discussions and activities. Most literature focuses on different SSIs as a context and informal reasoning as a way to negotiate it (e.g. Means & Voss, 1996; Sadler & Zeidler, 2005; Shaw 1996). On the contrary, little literature emphasizes the nature of SSI. Sadler et al. (2007) introduced the construct "socioscientific reasoning". It includes four dimensions which are directly related to the nature of SSI. However there is not sufficient evidence to claim that SSR can be improved through classroom practices.

Zeidler, Sadler, Applebaum, and Callahan (2009) also stated that there is a gap in the literature in terms of extended SSI treatments and its effects on learning outcomes. It was emphasized that classroom practices about SSI can enable the development of socioscientific reasoning (Zeidler & Sadler, 2011). There is a number of studies in the field of socioscientific inquiry in classrooms (e.g. Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Dolan, Nichols, & Zeidler, 2009; Pedretti, 1999; Sadler et al., 2007; Sadler et al., 2011; Sadler, Romine, Stuart, Merle-Johnson, 2013). These studies utilized different learning environments (including game-based curriculum, web-based inquiry environments, and issues-based environments) to permit students to develop an understanding of socioscientific inquiry and reasoning. This work also contributes to the research in the field of

socioscientific inquiry in classrooms. In this study we also utilized an issue-based approach through which preservice science teachers learned about how to negotiate and resolve SSI. A semester-long SSI-focused course was designed for PSTs to engage with socioscientific reasoning. The classroom practices PSTs experience in the SSI-focused course may help them develop their socioscientific reasoning to improve their understanding and abilities to negotiate and resolve SSI. Socioscientific reasoning help individuals conceptualize complexities and dynamics of socioscientific issues. Therefore, this investigation was conducted with the intent of exploring participants' socioscientific reasoning before, during and after an SSI-focused course.

CHAPTER 2

LITERATURE REVIEW

2.1 Scientific Literacy, Socioscientific Issue and Science Education

Many science educators were concerned about the decline in number of students attending science classes in high schools and pursuing a career in science or science-related professions (Hofstein et al., 2011; Tomas, Ritchie, & Tones, 2011; Zeidler et al., 2005). Students do not find science as relevant to their daily lives (Osborne, Simon, & Collins, 2003) because school science does not address the usefulness of science in daily life (Feinstein, 2011; Jenkins & Nelson, 2005). Feinstein stated that science in schools is not aligned with the things students deal in their daily lives. As a result, students gradually stop being involved in science and disenchantment with science makes them not to choose it for their future life.

Feinstein (2011) emphasized the usefulness of science primarily due to its relevance to daily decisions. These decisions may include either individual issues such as planning heating budget (Layton, Jenkins, MacGill, & Davey, 1993), medication or diet (Jenkins, 1999) or societal and political issues such as global

warming (Sadler & Klosterman, 2009), nuclear energy (Ryder, 2002), DNA and its applications (Jenkins, 1999). By using usefulness of science education, Feinstein (2011) is referring "to the very specific notion that science education can help people solve personally meaningful problems in their lives, directly affect their material and social circumstances, shape their behavior, and inform their most significant practical and political decisions" (p.169). Therefore how useful science is highly correlated how often you use it throughout your life. Feinstein (2011) complains about not having enough evidence to support the argument that science content that we learn in schools may guide us throughout our lives to be more successful, happier, healthier, better decision makers, and better citizens. Paul Hurd's suggestion in 1958 supported that schools are responsible to advance science but also they are responsible to make science useful. Hurd (1998) argued that a large amount of students do not understand completely what is taught in science classes and, as a result, they forget what they learn in a short time and cannot recognize the usefulness of science.

Science education should contribute to public life and common good (Hurd, 1998). It should aim to educate scientifically literate individuals for the society. There is not a consensus on the definition of scientific literacy (Roberts, 2007) but it can be concluded that there is a shift toward science for citizenship to educate scientifically literate citizens who are aware of science, technology and their impact on society (Aikenhead, 2002; Barrue & Albe, 2013; Davies, 2004; DeBoer, 2011; Dimopoulos & Koulaidis, 2003; Hofstein et al., 2011; Jenkins, 1999; Levinson,

2010; Roth & Désautels, 2004). Aikenhead (2006) proposed possible characteristics of school science one of which is the citizenship preparation for the everyday world. He emphasized that "this alternative everyday-life approach that animates students' self-identities, their future contributions to society as citizens, and their interest in making personal utilitarian meaning of scientific and technological knowledge" (p. 2).

Scientific literacy is a commonly stated goal for science curricula in most countries (Aikenhead, 2002; Barrue & Albe, 2013). In 1958, Paul Hurd published his work, "Science Literacy: Its Meaning for American Schools" which aims to emphasize science for the curriculum including primary and secondary education. On October 4, 1957, the Soviet Union successfully launched Sputnik I, which is the world's first artificial satellite. Sputnik caused the paranoia and concern that the Soviets had beaten Americans into space (Abramson, 2007). Sputnik started a new age not only in technology but also in science education. Hurd (1958) stated that after Sputnik, American families were concerned about whether their children were having the education which would make them capable of dealing effectively with the developments in science and technology. Hurd (1958) emphasized that curriculum developers should be able to design educational programs to meet the needs and the challenges for the future world which is highly dynamic in science and technology. In 1958, Hurd was curious about whether the educational programs could be designed to maintain "the delicate balance of scientific, social and economic forces" in the future (p. 14). Why Hurd was so interested in

educational programs is that he believed that schools are the places to advance science and its features. Science is a keystone in solving problems related to society, economy, and politics. “Scientific literacy is seen as a civic competency required for rational thinking about science in relation to personal, social, political, economic problems, and issues that one is likely to meet throughout life. The science–technology–society movement provides a framework for inventing school science curricula relevant to the life of every student” (Hurd, 1998, p. 410). The reason why science policy makers are so concerned about science related societal dilemmas is vastly connected to the fact that “students need to realize that science is changing rapidly, not only in its research techniques and organizational structures but also in its relationships with society at large” (Ziman, 2001, p.165). Ziman (2001) further emphasized that “students need to learn about the practices, institutions, career choices, and societal responsibilities of research scientists, and to rehearse in advance some of the moral dilemmas that they are likely to meet” (p.165). Therefore socioscientific issues empowering students to realize the relation between science, technology and society including ethical and moral issues should be placed in science education.

Hurd (1998) mentions how technology shaped science and guided projects in astronomy, biology. Even technology is used with science like “sci-tech” and “technoscience” (Hurd, 1998, p. 409). Therefore it is inevitable that technology will continue to develop by means of science and, in turn, technology will lead to new projects in science. Society is not a monolith and it can derive benefits from

these developments in science and technology. The science-technology-society movement explains the dynamic interaction between these agents. This dynamic interaction may cause some debates between them. Developments in technology and science may not always be accepted all individuals in a society and different perspectives are inevitable within it. Such developments result in socioscientific issues such as stem cell, cloning, or genetically modified food for which individuals hold different views. The term "socioscientific issue" refers to the social controversial issues consisting of opposing opinions neither of which are exactly acceptable. SSI was considered as a pedagogical strategy to equip students with knowledge and ability for decision-making process on these issues through social interaction and discourse (Zeidler et al., 2005). The required knowledge to make informed decisions is the understanding of the relation between science, technology and society including moral and ethical awareness (Zeidler et al., 2005). Moreover the abilities such as reasoning, evaluating, analyzing and drawing conclusions are required to make rational and informed decisions about SSIs. SSIs are usually ill-structured in nature, debatable, and argumentative and require a degree of moral reasoning and reflection of multiple perspectives and diverse values in the process of decision-making (Lee et al., 2012). Socioscientific issues indicates complex, ill-structured problems including a degree of uncertainty in scientific evidence and multiplicity of point of views (Colucci-Gray, Camino, Barbiero, & Gray, 2006). Colucci-Gray et al. (2006) emphasized that "complexity and multiplicity of points of views are putting communities in the condition of

having to undertake complex decisional processes, where "experts" have conflicting views" (p. 232).

Ratcliffe and Grace (2003) described the nature of socioscientific issues as

- Have a basis in science, frequently that at the frontiers of scientific knowledge;
- Involve forming opinions, making choices at personal and societal level;
- Are frequently media-reported, with attendant issues of presentation based on the purposes of the communicator;
- Deal with incomplete information because of conflicting/incomplete scientific evidence, and inevitably incomplete reporting;
- Address local, national and global dimensions with attendant political and societal frameworks;
- Involves some cost-benefit analysis in which risk interacts with values;
- May involve consideration of sustainable development;
- Involves values and ethical reasoning;
- May require some understanding of probability and risk;
- Are frequently topical with a transient life (p.2)

The attempts to integrate the socioscientific issues into science curriculum aim to make science classrooms more representative of the society. Yager (1996) stated that science, technology and society relations have appeared since early 1980's. Current conceptualizations of socioscientific curriculum put forward the difference

between socioscientific approach and other approaches such as the science–technology–society (STS) approach (Sadler, 2004). "The science–technology–society (STS) movement provides a framework for inventing school science curricula relevant to the life of every student" (Hurd, 1998, p. 410). STS education and socioscientific issues are different in nature. STS covers science-technology and society as separate or non-related issues independent of each other (Pedretti & Hodson, 1995) while SSI approach tries to encourage students to deal with scientific but dilemmatic issues which influence the societies (Kolstø, 2001a). Moreover, Zeidler et al. (2005) emphasized that STS primarily emphasizes the influence of science and technology on society. However it does not consider the moral and ethical dimensions of the issues which may affect the way individuals take a position toward the issue. On the other hand socioscientific issue approach based on a conceptual framework that combines the socioscientific issues with the individuals' moral development and epistemological tendencies. Moreover the importance of emotions and character in science education are considered within the socioscientific issue approach. (Sadler, 2004; Zeidler & Keefer, 2003).

Millar and Osborne (1998) underlined that science education should prepare individuals for "a full and satisfying life in the world of the 21st century" (p.2012). They stated that science education should:

- sustain and develop the curiosity of young people about the natural world around them, and build up their confidence in their ability to inquire into its behaviour. It should seek to foster a sense of wonder, enthusiasm and

interest in science so that young people feel confident and competent to engage with scientific and technical matters.

- help young people acquire a broad, general understanding of the important ideas and explanatory frameworks of science, and of the procedures of scientific inquiry, which have had a major impact on our material environment and on our culture in general, so that they can:
    - appreciate why these ideas are valued;
    - appreciate the underlying rationale for decisions (for example about diet, or medical treatment, or energy use) which they may wish, or be advised, to take in everyday contexts, both now and in later life;
    - be able to understand, and respond critically to, media reports of issues with a science component;
    - feel empowered to hold and express a personal point of view on issues with a science component which enter the arena of public debate, and perhaps to become actively involved in some of these;
    - acquire further knowledge when required, either for interest or for vocational purposes. (p.2012)

Due to the fact that scientifically literate citizens are necessary in such a world that is continually improving in technology and scientific knowledge (Kolstø, 2001a), science curriculums should focus on SSI more than before. Students should practice such classroom activities including socioscientific issues to be prepared for the future life. They should engage with in-class activities which forces them to

think critically, form arguments and find logical and reasonable solutions to the problems that are similar to the ones in real life. Since teachers will guide them during those activities, teachers also should be aware of socioscientific issues. Science teachers should be equipped with necessary knowledge and skills to be able to incorporate these issues into their science curricula (Tomas et al., 2011) since there is a widespread concern that these issues are not included in science classrooms due to lack of pedagogical knowledge and skills (Hofstein et al., 2011; Saunders & Rennie, 2013).

The related literature shows that most of the studies in socioscientific issues focused on informal reasoning to negotiate and resolve these issues.

2.2 Informal Reasoning in the Context of Socioscientific Issues

Kuhn (1993) emphasizes that socioscientific issues requires the use of informal reasoning rather than formal reasoning since they are complex, open ended, and often embrace debatable problems which do not have fixed solutions. Informal reasoning is well-suited with the kinds of dilemmas which students encounter in real life.

Informal reasoning has an important role in scientific inquiry. Kuhn (1970) stated that science does not depend entirely on formal modes of reasoning. Tweney (1991) states that formal reasoning is considered the canons of scientific inquiry however Means & Voss (1996) argued that it is not appropriate for resolving issues which are ill-defined, complex and do not have single solution. Perkins, Farady,

and Bushey (1991) emphasized that informal reasoning are flexible compared to formal reasoning. When further information is obtained, individuals may change their premises in parallel with the new information and whatever they conclude is not obvious that is it may change depending on the premises, in turn, on the new information. It can be concluded that individuals create and assess their own viewpoints to resolve socioscientific issues. Means and Voss (1996) described informal reasoning as "Informal reasoning assumes importance when information is less accessible, or when the problems are more open-ended, debatable, complex, or ill-structured, and especially when the issue requires that the individual build an argument to support a claim" (p.140). Sadler (2003) also defined informal reasoning as cognitive and affective processes involved in the negotiation of complex issues and formation or adoption of a position. There exist different representations of informal reasoning in the SSI literature. Individuals' interpretation of data and evaluation of information results in different informal reasoning representations. Patronis et al. (1999) examined the nature of students' arguments about construction of a road close to their school. Students' thinking processes displayed during interviews or in-class activities revealed that there are arguments differing in nature. The concerns or factors which shaped students' decisions for the road construction resulted in different type of arguments. Patronis et al. (1999) identified and categorized these arguments as social, ecological, economic and practical. They stated that these arguments were an expression of either students' personal values or most widely accepted social values. Another representation of informal reasoning was proposed by Yang and Anderson (2003)

investigated secondary school students' reasoning modes as associated with their preferred type of information in the context of nuclear energy usage. The analysis of students' verbal reasoning yielded two types of reasoning modes which are scientifically-oriented and socially-oriented. The authors stated that scientifically-oriented students rely on scientific information more than personal ideas while socially-oriented students consider personal opinions, beliefs and values more than scientific information during their thinking process. Sadler and Zeidler (2005) described informal reasoning patterns in a different way. Their classification was based on the cognitive and affective processes. Sadler and Zeidler (2005) stated that individuals have tendencies such as dependence upon personal experiences, emotions, social considerations or moral issues and these tendencies contribute to the individuals' reasoning and thinking patterns. They studied with college students in the context of genetics related dilemmas. Sadler and Zeidler (2005) explored three informal reasoning patterns as rationalistic, intuitive and emotive. Individuals who back up their positions with reason and logic show rationalistic informal reasoning while individuals who rely on immediate feelings display intuitive informal reasoning pattern. Individuals exhibiting emotive informal reasoning rationalize their positions based on a sense of care, emotions and empathy. Wu and Tsai (2007) examined the grade ten students' informal reasoning in the context of nuclear energy. They represented students' informal reasoning based on the research of Means and Voss (1996), Patronis et al. (1999), Sadler and Zeidler (2005) and Yang and Anderson (2003). They identified students' decision-making modes as intuitive and evidence-based. Then they explored students' reasoning

modes as an indicator of their perspectives on the issue. They classified reasoning modes based on the considerations which students rely on. These modes were social-oriented, ecological-oriented, economic-oriented, science-oriented, and technology-oriented.

2.3 Socioscientific Reasoning

2.3.1 The Invariant Features of SSI

As briefly mentioned in Introduction, SSR serves as a tool for researchers to practically measure and to evaluate the practices in which students participate in learning environments where they focus on SSI. SSR involves understanding and abilities about the invariant features of SSI. These features were complexity, inquiry, and perspectives. These features are implicitly or explicitly pointed out in studies of SSI (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Bingle & Gaskell, 1994; Chinn & Brewer, 1993; Erduran, Simon, & Osborne, 2004; Gallagher & Appenzeller, 1999; Gardner & Jones, 2011; Hogan, 2002; Kolstø, 2001a; Kolstø, 2001b; Kortland, 1996; Pedretti, 1999; Sadler & Donnelly, 2006; Sadler & Zeidler, 2005; Zeidler, 1997; Zeidler et al., 2005; Zeidler, Walker, Ackett, & Simmons, 2002; Zohar & Nemet, 2002). The literature related to them was provided below.

2.3.1.1 The complexity of SSI

Sadler et al. (2007) emphasized that SSI practices should be oriented in a way that advances individuals' conceptualization of SSI in terms of its nature of complexity and their understanding that solving SSI includes investigating multiple ideas, perspectives and interest. Furthermore, they bring attention to the concern that SSI

should not be simplified to be solved on a single aspect, on the contrary, "more sophisticated socioscientific reasoning would involve recognizing multiple, dynamic interactions within SSI which preclude simple, linear solutions" (p. 375).

How individuals reason about ill-structured problems constitutes the main idea supposed by Reflective judgment Model (Hofer & Pintrich, 1997; King & Kitchener, 1994). The reflective stages refers to a stage of epistemological beliefs in which people acknowledge that evidence and knowledge derive from different and various sources and they are able to analyze probable claims of debatable evidence (Zeidler et al., 2009). Reflective Judgment Model is in congruence with socioscientific reasoning apart from the fact that it has a developmental perspective while socioscientific reasoning does not (Zeidler et al., 2009). People are engaged in different sources of knowledge and evidence during the negotiation of SSI and they assess their possibility and plausibility. It is possible that they may not recognize the complex nature of SSI. It is also possible that they may provide different sources for complexity and defend them.

The scholarly papers focusing on SSI has either stated the complex nature of SSI or found it as a component of reasoning about SSI (Barab et al., 2007; Bingle & Gaskell, 1994; Gallagher & Appenzeller, 1999; Hogan, 2002; Kolstø, 2001a; Lee et al., 2012; Pedretti, 1999; Sadler & Zeidler, 2005; Sadler & Donnelly, 2006; Yang & Anderson, 2003; Zeidler, 1997). Latour (1987) proposed two forms of scientific knowledge as "ready-made science" and "science-in-the-making". First one refers that scientific knowledge is considered as the facts about nature which are not

controversial and independent of context that leads to its development while the second one is the science that is constructed in social context; includes scientific claims not facts which are open to negotiation and can be revised. “Ready-made-science” describes the science in textbook and considered as the content of the school science (Kolstø, 2001a). This implies the consensus between textbook science and frontier science which refers to the smooth harmony between them. However “science-in-the-making” is the science in which the end product is not the end of the process and consensus is not reached about it, thus, it is open to challenges and revisions. “Science-in-the-making” is the science that is presented and negotiated in conferences, journals or in debates between the researchers (Kolstø, 2001a). It was informed that there is no clear cut border between “science-in-the-making” and “ready-made-science”. Kolstø (2001a) discusses a region between them in which there is competition, collaboration, review, debate or temporary consensus among scientists which results in knowledge claims that gain or lose confidence. Kolstø (2001a) stated that “science-in-the-making” is associated with the socioscientific issues which citizens face in their daily lives. These issues do not have consensus among scientists concerning factual aspects and this may answer the reasons why they continue to be an issue (Kolstø, 2001a).

Kardash and Scholes (1996) studied the influence of people’s beliefs about certainty of knowledge and about a controversial issue, which is AIDS, on their interpretation of debatable information. The participants were seventy-eight female and 18 male undergraduates enrolled in introductory educational psychology

course. They found that believing uncertain nature of knowledge and having less strong prior beliefs about AIDS lead to writing more tentative, inconclusive and mixed evidence used conclusions. Kardash and Scholes (1996) suggested that the researchers should aim "to help students develop an appreciation that not all problems have a single right answer, although some do; that as science progresses, some of what we once held as true also changes; and that what on the surface appears to be dialectically opposing viewpoints may, in some cases, be synthesized into a new framework" (p. 270). Students reported tentative conclusions about HIV and AIDS which leaded to interpretation of the complex nature of social and scientific issues.

Bingle and Gaskell (1999) explored two ways of examining scientific knowledge as positivist and social-constructivist position in the context of sterilizing Galileo spacecraft in order to prevent contamination of Jupiter's natural environment. There published articles which protested NASA's Galileo project and suggested to sterilize Galileo's atmospheric probe and parachute to avoid microorganisms enter the atmosphere of Jupiter and change its natural environment (Strand, 1984a, 1984b). They stressed the complex nature of issues in real world and the necessity of multiple perspectives while dealing with them.

Gallagher and Appenzeller (1999) mentioned about oversimplification of the systems in universe among the different disciplines of science and Hogan (2002) argued the deterministic view of the universe which resulted in simple and linear cause-and-effect relationships which should be shifted to a more complex view of

disciplines. Ecologists were considered as the first scientists that acknowledge the complexity of their disciplines and this resulted in how the complex view of disciplines has brought different subject areas together such as mathematics, engineering, computer science (Gallagher & Appenzeller, 1999). The results of this complex view can be seen in making computer simulations of complex systems to be able to study their components.

Hogan's (2002) idea for her study was to investigate the nature and content of students' dialogue about an invasive aquatic species based on the aim that is to prepare students as informed citizens who can actively participate in decision making process about issues which directly affects their lives. She pursued the interest for the Science-Technology-Society education to achieve the goal of science education to educate students as scientifically literate citizens. Hogan believed that the societal aspect of science education can be made more noticeable by convening students and public in science related projects such as environmental ones. Through gathering in these projects, different minds meet to collect and analyze data, negotiate on findings and prepare a report or message to be relayed to the decision makers. Gathering different views results in a more comprehensive and integrative discussions to solve the issues. Citizens tackle many socioscientific issues throughout their whole lives, however they do not have the chance to be involved in discussions about them physically and mentally (Hogan, 2002). Science education integrated with environmental education can be a solution for students to gain and practice knowledge and skills about environmental decision making.

Hodson (1994) claimed that science education should encounter concerns related to economical, educational, socio-political and environmental and give emphasis to "personalization of learning and politicization of science education. Personalization is considered essential because the transformation of society, on which the solution of current environmental crises depends, can only be achieved by individuals who are critically literate, politicized, confident and assertive. Acquiring the range and depth of knowledge, skills and values necessarily requires that the curriculum focuses very directly on the understanding and experiences of individual learners" (p.75). Hodson considered three elements for environmental education which is education *about* the environment, education *in* and *through* the environment, and education *for* the environment. Education *about* the environment refers to the attainment of necessary knowledge and skills, education *in* and *through* environment refers to studying in the environment as a field work, education *for* environment means developing value and attitude for environmental awareness and protection (Hodson, 1994). Hogan believes that education in and through environment is the only one approach to environmental education whereas the others are acting as complement to it. That is studying environment requires not only knowledge and skills to be able to collect, analyze and interpret data related to problems based on personal values and opinions but also field work to gain experience.

Hogan reported key features of ecological system which emphasize the complex connection between the elements of it and dynamic nature of systems. Direct-

indirect and hidden-observable connections can take place within ecosystems and ecosystems are subject to change and evolution to reach a static equilibrium which is the ideal one but never achieved. It was emphasized that the nature of ecosystems should not be neglected by decision makers, environmental policy managers which somehow determine the change within ecosystem. The relation between complexity and uncertainty was described as the more complex is a system; the less certain it is to be able to predict the results. Therefore Hogan strongly emphasizes that decision makers and citizens should know about ecosystems to be able to make informed decisions on science and society related environmental issues. Since ecosystems are complex and uncertain, they should be able predict possible outcomes of their decisions and step in to make necessary changes. The result of Hogan's study was crucial in terms of SSR and its aspects. The key features (mentioned before) that she used was in congruence with SSR aspects. She does not refer to specifically complexity, inquiry, and perspectives however what she found and how she interpreted the findings were in alignment with them. The group of students in her study showed differences across groups, although there was consistency within groups. The most notable reasoning patterns across groups were associated with focusing on only ecological dimension, integrated reasoning about the complexity of systems, focusing on values and including uncertainty into reasoning. This study revealed that four groups out of 8 used more information than they are given to produce their own interpretations, conclusions and recommendations about the ecological issue. One group mostly supported their discussions from different factors including engineering and

economy with a variety of management strategies. One group focused on biocentric and anthropocentric values. The group focusing on uncertainty in their reasoning concluded that they do not know enough about the results of the invasive species on already existing species and they need more research before a decision. This supports that inquiry (i.e. requiring more information) is a part of reasoning about SSI. Students reflected on their group discussions and these reflections were useful in their appreciation of complex nature of involving in socioscientific issues decision making process in social environment.

Barab et al. (2007) used a virtual environment (that is Quest Atlantis) which included both real-world and simulated, socially and academically meaningful activities around a socio-scientific issue which is related to aquatic habitat. Students did not only learn some scientific concepts such as erosion, eutrophication, water quality; they also developed some skills such as graphing, hypothesis generation, water quality analysis, socio-scientific reasoning, and scientific inquiry. This study also aimed to raise students' environmental awareness. Authors added that "students were expected to develop an appreciation for the complexities involved in scientific decision making, having to balance ethical, economic, political, and scientific factors" (p.62).

2.3.1.2 Multiple Perspectives

Latour's (1987) argument about the two forms of scientific knowledge showed that the transition between "science-in-the making" and "ready-made-science" results in arguments, debates, controversies, and competing claims to be the winner. Facts

are not facts yet considered as claims and do not exist longer with the addition of new claims (Bingle & Gaskell, 1999). Bingle and Gaskell (1999) stated that "When uncertain knowledge associated with science-in-the-making is a part of a social issue, a socioscientific dispute results because there is no consensus as to the scientific facts" (p.187). Different ideas, interests, perspectives, personal experiences among scientists play a significant role in "science-in-the-making". And since this is associated with SSI, those differences among stakeholders, referring to multiple perspectives, take also part in negotiation of SSI. “Perspectives” is related to the people’s interests, ideas, priorities and biases (Sadler et al., 2007). People having different perspectives were expected to discuss SSI differently and to reach different decisions. Sadler et al. (2007) suggest that “no single perspective is necessarily privileged but it should not be assumed that all perspectives are equally defensible” (p. 376). SSI discussions should include diverse perspectives such as economical, societal, environmental and political. Some of these perspectives might be prioritized in SSI discussions based on the nature of the issue. The important point here is that individuals should be aware of other perspectives rather than their own perspectives and these perspectives may not be consistent with their views.

When Kardash and Scholes (1996) examined the relation between beliefs about nature of knowledge and writing conclusions about AIDS, they found that mixed evidence from different perspectives were used in students’ writings leading to

inconclusive conclusions. They emphasized the role of multiple perspectives in such issues.

It was emphasized before that Reflective Judgment Model and SSI has some common points. Zeidler et al. (2009) outlined that they both include ill-structured problems and issues, necessitates a variety of opinions or positions and ability to interpret them. They both do not require only opinions and positions but also evidence to buttress them. Therein, reflective judgment model is in parallel with SSR not only for the appreciation of complexity of SSI but also recognizing multiple perspectives when negotiating SSI. Dealing with ethical, economic, political, and scientific aspects of SSI and balancing them in solving the problems is an important part of SSR. The participants in this study had some difficult times during the discussions of NPP. For example, some participants refused NPP since it has negative results on ecological system and aquatic habitat. However when they were presented the positive sides of NPP in terms of economy and job opportunities for the local people, they were struggled and recognized that the better solution from one perspective cannot be better from other perspective and the issue, then, becomes more difficult to make a decision, as supported by the study of Barab et al. (2007).

Zeidler et al. (2002) also reported some implications on behalf of the multiple perspectives aspect of SSR. They investigated the relationships between students' views of the nature of science and their reactions to evidence for socioscientific issues. Zeidler et al. (2002) suggested that students may be better at making

decisions which are both reasonable and scientific on SSI when multiple perspectives are integrated with their own mental processes. The teaching strategies that include multiple perspectives should take a part in discussing SSI for achieving the goal of science education.

2.3.1.3 Inquiry

Sadler et al. (2007) stated that "the inquiry dimension of socioscientific reasoning references the fact that SSI are ill-structured problems subject to ongoing investigation. SSI are situated in the real world, and their underlying premises, conditions and other potentially significant information may not always be determined or known" (p. 376).

Hogan (2002) claimed that students' reasoning in making decision about an environmental issue differed from the one of experts in such a way that the former was less integrative to reflect on the complex environmental issues because students are, like most people in society, not experts in environmental issues. This fact challenges them to analyze, interpret, and reflect on the given information to make a decision of recommendation. Hogan's study, which is making environmental decision for control of an invasive aquatic species with given ecological and environmental information, showed that decision making in such environmental issues which are related to society and science requires examining and thinking about scientific or other pertinent information. Careful analysis of information at hand and the necessity of further information in resolving the issue is a basis of SSI. Hogan recommended that "students should be taught to approach

environmental problems through asking a set of key questions that require integrating a number of concepts and reasoning skills to answer" (p. 364). It was stated that students like most citizens may not have the answer to all questions related to the problems so they should be encouraged to ask scientists, experts to gather the information they need to form reasoned opinions. This specifies the need for additional information to be able to present informed arguments and solutions as inquiry dimension of SSR implies.

2.3.2 Establishing Socio-scientific Reasoning

This section provides information how SSR was conceptualized and established as a result of the study conducted by Sadler et al. in 2007.

Socio-scientific reasoning (SSR) aims to describe the practices which individuals experience when they negotiate SSI. “That is, socio-scientific reasoning was developed as a means of understanding student practices relative to the invariant features of SSI” (Sadler et al., 2011). Informal reasoning “involves reasoning about causes and consequences and about advantages and disadvantages, or pros and cons, of particular propositions or decision alternatives. It underlies attitudes and opinions, involves ill-structured problems that have no definite solution, and often involves inductive (rather than deductive) reasoning problems” (Zohar & Nemet, 2002, p. 38). Socioscientific reasoning (SSR) also involves individuals’ reasoning on SSI with a focus on its nature of complexity, requiring ongoing inquiry (inquiry referring to doing research and gathering more information), and evaluating different views, ideas, thoughts. Individuals engage in a reasoning process through

which they think on causes, costs, different claims, justifications and reactions, advantages and disadvantages, different kind of information to solve complex, ill-structured time and effort requiring issues. SSR is developed as a construct that based on previous studies focusing on decision making on socioscientific issue. Sadler et al. (2007) operationalized SSR and constructed a framework to analyze it. They interviewed with twenty-four middle school students who participated in a ten day unit focused on SSI, water quality dilemma and its factors, in a virtual world. Two scenarios were used; one was related to water quality and pollution (Branville scenario) that was a close context to students' experiences in classroom and the other one was related to energy production and pollution (Triveca scenario). All students were interviewed using these scenarios and the interview data was investigated to develop the rubric which included four aspects of SSR (i.e., complexity, perspectives, inquiry, and skepticism) with four levels for each aspect. The developed rubric was used to score the interview data and yielded a high inter-rater consistency. Different rubric was developed for skepticism aspect of SSR for two scenarios due to the differences in context which were warranted by the data. The rubric for rubric complexity, perspectives, inquiry was given in Table 2.1 and the rubric for skepticism was given in Table 2.2.

Table 2.1 Rubric for the Complexity, Perspectives, and Inquiry Aspects of Socioscientific Reasoning

Levels	Complexity	Perspectives	Inquiry
1	Offers a very simplistic or illogical solution without considering multiple factors	Fails to carefully examine the issue.	Fails to recognize the need for inquiry.
2	Considers pros and cons but ultimately frames the issue as being relatively simple with a single solution	Assesses the issue from a single perspective.	Presents vague suggestions for inquiry.
3	Construes the issue as relatively complex primarily because of a lack of information. Potential solution tends to be tentative or inquiry-based.	Can examine a unique perspective when asked to do so.	Suggests a plan for inquiry focused on the collection of scientific OR social data.
4	Perceives general complexity of the issue based on different stakeholder, interests, & opinions. Potential solutions are tentative or inquiry-based.	Assesses the issue from multiple perspectives.	Suggests a plan for inquiry focused on the collection of scientific AND social data.

Table 2.2 Rubric for the Skepticism Aspect of Socioscientific Reasoning

Levels	Branville Scenario	Triveca Scenario
1	Denies differences among stakeholder positions.	Declares no differences among stakeholders.
2	Ascribes differences in stakeholder positions to differences in information.	Suggests that differences likely exist among stakeholders.
3	Ascribes differences in stakeholder positions to a desire to avoid blame.	Describes differences among stakeholders.
4	Recognizes conflicting interests and purposes among various stakeholders.	Describe differences and discusses the significance of conflicting interests.

The levels for complexity aspect ranged from Level 1 which assesses students' perceptions of the issue as very straightforward and unproblematic to Level 4 which assesses students' perception of the complexity in relation to the contending ideas of the different stakeholders. The levels for inquiry aspect ranged from Level 1 which assesses students' failure the recognition of the need for additional information to Level 4 which assesses students' recognition of additional data referring to scientific and social. Perspectives aspect of SSR has also 4 levels. The lowest level assesses that the students cannot examine the issue from multiple perspectives whereas the highest one assesses that students can examine from multiple perspectives. The skepticism aspect was measured with two different rubrics as mentioned before (see Table 2.2).

The reliability analyses were conducted to find out the relationships among the SSR aspects within each scenario and between scenarios. As a result of this, it was found that complexity and inquiry aspects are reliable with reliability coefficients as .76 and .73 respectively. On the other hand perspectives and skepticism aspects did not show so high reliability with reliability coefficients as .42 and .37 respectively. Although the perspectives aspect has low reliability, Sadler et al. (2007) believed that it is theoretically significant and requires further research on it. The low reliability for skepticism was interpreted in terms of the contextual differences and it was claimed that skepticism may be irrelevant to the other aspects of SSR. Sadler et al. (2007) suggested that further studies were also

required for skepticism to be included as an aspect of SSR and to analyze it effectively.

2.3.3 Exploring Further SSR and its Aspects

This section provides information about study conducted by Sadler et al. (2011) to explore further SSR and its aspects.

In a second study conducted by Sadler et al. (2011), skepticism aspect was found to be interrelated to perspectives aspect. Thus skepticism and perspectives aspects were unified and treated as one aspect. In this study SSR was also investigated in terms of three aspects (i.e., complexity, perspectives, inquiry). Therefore two rubrics (breadth and depth rubrics) used and developed in this study do not include skepticism aspect. They will be explained in detail in next chapter.

Sadler et al. (2011) underlined that early research on SSI explores students' informal and moral reasoning, argumentation skills, nature of science understandings, science content knowledge but does not specifically explore students' experiences and practices related to how they discuss and make decision about SSI in learning environments in or out of school classroom environment. Therefore they felt the need of research in this way and focused classroom based research about SSI. Through technology based learning environment, students were enabled to engage in activities for different educational goals including enhancing science learning, conceptualization of SSI, and practices related to features of SSI

(i.e. SSR). They intended to explore SSR more to make it a more useful and measurable construct.

This study was also critical in terms of curriculum material development for SSI and the implementation of these materials since lack of material can be a barrier for teachers to integrate SSI into their science curricula. Moreover the observation of how teachers implement these materials provided the researchers to see the differences between "the intended curriculum" and "the enacted curriculum" (Sadler et al., 2011, p. 47). This enables researchers to interpret those differences and to make the necessary changes so that the intended curriculum becomes more implementable.

The classroom materials were developed on global warming through collaborations with teachers. It was a 3-week unit, 15 classrooms hours in total, including assessment. The target population was high school students. The science classrooms in two high schools were involved in the study. The teacher involved in this study in one of high schools taught environmental science, anatomy, and physiology whereas the other teacher taught regular chemistry. The aim of the curriculum was to make students aware of science content underlying global warming, to understand global warming with its causes and consequences, to develop scientific practices and science process skills, to develop personal opinion and values based on scientific content and practices and students' own perspectives, to improve students' SSR so that they are able to use SSR in other contexts. Students first engaged in global warming as reported in media and then

they focused on the related science content. Students were pre and post-tested on science content knowledge and SSR.

When Sadler et al. (2007) first introduced SSR as a construct and its assessment rubric, there were some problems related to the perspectives and skepticism aspects. Although complexity and inquiry were proven as a reliable and stable measure across contexts and related to a common latent variable (SSR), perspectives and skepticism were not in the same alignment. Therefore, in the second study the latter two aspects were further investigated to establish them as reliable and stable measures. Perspectives and skepticism aspects were reconceptualized and treated as a single aspect including premises from both aspects that were originally developed. The results with new three aspects yielded that there is not relationship between aspects so they were investigated as single variables. The interview protocol in previous study (Sadler et al., 2007) were redesigned to meet the changes in aspects and developed as an open-ended questionnaire, the Socio-scientific Issues Questionnaire (SSIQ), to be able to apply to large group of students to explore its reliability and validity. Although underlying idea and thought were the same as the original version, this version of protocol included forced-choice and open-ended questions for students to comprehend and to respond. In conclusion, SSIQ included description of a socio-scientific issue, its diagram and related questions. Based on the new version of SSR and SSIQ, new rubrics developed for three aspects (i.e. complexity, inquiry, and

perspectives). The one for inquiry aspect was given as an example in Table 2.3. The others are developed in the same manner.

Table 2.31 Scoring Rubric for the Inquiry Aspect of Socioscientific Reasoning

Level	Description
0	Suggests that additional inquiry is not necessary.
1	Suggests that additional inquiry is necessary but does not identify a specific line of inquiry.
2	Suggests that additional inquiry is necessary and identifies one specific line of inquiry.
3	Suggests that additional inquiry is necessary and identifies two specific lines of inquiry.
4	Suggests that additional inquiry is necessary and identifies three or more specific lines of inquiry.

One of the rubrics to evaluate complexity, inquiry, and perspectives aspects of SSR used for this study was adapted from Sadler et al. (2011). The data analysis with this rubric led to the development of a second rubric. The two rubrics used in this study for each aspect were given and explained more in the next chapter.

2.4 Research on SSI Interventions in Classrooms

This section will provide a review of the studies focused on the of socioscientific curricular interventions.

Unlike the literature reporting the necessity of science related social issues to improve scientific literacy, the design, implementation and effects of the SSI interventions in classrooms were not advanced sufficiently (Sadler et al., 2007).

The literature review showed that SSI-based classroom implementations mostly focused on learning outcomes such as students' science content knowledge gains (Barab et al., 2007; Klosterman & Sadler, 2010; Venville & Dawson, 2010), nature of science conceptions (Eastwood, Sadler, Zeidler, Lewis, Amiri, & Applebaum, 2012; Khishfe, 2012; Khishfe, 2013; Khishfe & Lederman, 2006), argumentation skills (Foong & Daniel, 2013; Khishfe, 2013; Lin & Mintzes, 2010; Osborne, Erduran, & Simon, 2004; Patronis, et al., 1999; Venville & Dawson, 2010; Zohar & Nemet, 2002). The studies cited utilized an intervention and investigated its effects on specified outcomes. There are few studies investigating the effect of SSI interventions on students' socioscientific reasoning during negotiation of socioscientific issues (Barab et al., 2007, Sadler et al., 2007, Sadler et al., 2011).

The literature documenting the effect of SSI interventions on student content knowledge gains emerged as a response to the concern that is whether SSI has an important role in science education. Although it was emphasized that SSI has science dimensions and should be integrated into science curricula (Sadler & Zeidler, 2005), educators argued whether students advance science learning through SSI applications in classrooms (Sadler et al., 2007). As a result, researchers focused on classroom interventions that aimed to improve students' science learning in the context of SSI. The work of Barab et al. (2007) designed a game-based learning environment called as *Quest Atlantis* to engage students both in real and simulated socioscientific issues. A virtual world facing a problem (a decline in fish numbers) was created. There were three groups (an indigenous population, a

logging company, and a fishing company) that blamed each other for the decline in fish numbers. Students navigated the environment in the role of expert helper. Their duties included interviewing with people having different perspectives on the problem, collecting and analyzing data, and proposing informed solutions. Twenty eighth fourth grade students participated in the study. Of them, 16 were girls and 12 were males. One of the goals of this study was to support students in learning science concepts. Multi-level assessments of learning (proximal and distal-level evidence of individual science learning) were performed to assess students' learning science concepts. As a result, the authors found that students learned about the science content. Venville and Dawson (2010) also studied the effect of intervention including argumentation about a genetics-based socioscientific issue on grade ten students' conceptual understanding of genetics. They utilized an intervention which included one lesson on argumentation skills and two more lessons on the use of those skills in the context of genetics related SSI. Authors studied with four classes with 92 students. Two classes received explicit argumentation lessons during genetics course and the other two classes did not receive any treatment. Pre and posttests including multiple choice items and short answer items to measure students' understanding of genetics were administered. The results revealed that students' understanding of genetic concepts changed significantly from pre to post-instruction. The study of Klosterman and Sadler (2010) also explored the impact of a SSI-based intervention on improving science content knowledge. They developed a three week unit including 15 lesson hours on global warming including concepts such as atmospheric composition, the

measurement and absorption of radiation by CO2 and other gases, the process of combustion and explanations for and causes of climate change. Data were collected prior to and after the intervention from 108 students who enrolled in environmental science and chemistry courses. These courses were included in the curriculum of 9 to 12 grade students. Science content knowledge was measured through a standards-aligned test and a curriculum-aligned test. The mixed results from both tests supported the authors' hypothesis that SSI can be used as a context for developing students' science content learning.

The influence of SSI-based interventions on students' nature of science conceptualizations has gained emphasis since nature of science was advocated as a goal of science education. Khishfe (2013) studied the influence of a SSI unit in which explicit NOS and argumentation instruction were integrated on argumentation skills and nature of science understandings of seventh grade students. A total of 121 students from two different schools (61 students from one school, 60 students from other) participated in the study. The seventh grade classes were randomly assigned to two different treatment groups. One treatment group included the explicit NOS and argumentation instruction while the other received only explicit NOS instruction. The author and two teachers worked collaboratively on the unit of *Water Usage and Safety.* They prepared lesson plans including explicit NOS and argumentation instruction. The treatments continued for eight weeks. At the beginning of the unit, both groups received explicit NOS instruction for two weeks and the remaining six weeks they received the same content

instruction embedded with tentative, empirical and subjective aspects of NOS. As an exception, one of the groups also received argumentation instruction at the beginning of the unit. Data was collected through open-ended questionnaires and interviews about two socioscientific issues before and after treatments. The results revealed that the group receiving explicit NOS and argumentation instruction showed more informed NOS understandings and more developed argumentation skills. Similarly Eastwood et al. (2012) studied the effect of two curricula (SSI-driven and content-driven) on high school students' NOS understandings. Four 11^{th} and 12^{th} grade Anatomy and Physiology classes participated in the study. Two classes were taught by SSI-driven curriculum while the other two received instruction through content-driven curriculum. Both curricula were embedded with explicit-reflective NOS instruction. SSI classes learned course content through focusing on a variety of SSI such as stem cell research, fast food and health, water quality, and euthanasia. Several activities were developed to engage students with both science content and the social aspects of the issues. The classroom activities mostly included discussion, argumentation, role-play, small group work and specific research on some of the issues. The subjective, theory-laden, empirical, creative, and culturally embedded NOS aspects were emphasized. The classes receiving content-driven curriculum participated in more traditional and textbook oriented classroom activities. The content group studied anatomy and physiology topics such as cells, tissues, organs, and organ systems through lectures, laboratory activities, and discussion of topics. NOS aspects covered in SSI group were also highlighted in the content group embedded with the anatomy and physiology

content. Students' pre and post NOS understandings were investigated to reveal the effect of two curricula. Quantitative analysis yielded that the students in both groups displayed significant gains in each NOS aspect except social and cultural NOS aspect. However the qualitative analysis showed that students used accurate and relevant examples in supporting their perspectives on the social and cultural NOS aspect. The authors' suggestion was that SSI contexts can serve to improve NOS understandings including nuanced conceptions. The study of Khishfe and Lederman (2006) investigated the effect of integrated and nonintegrated NOS instruction within global warming unit which lasted for 6 weeks. Two intact classes including 42 ninth graders taught by the same teacher participated in the study. The classes were randomly assigned to the two different NOS instruction approaches. Both were instructed about NOS and global warming for four 45 minute class during 6 week. Tentative, empirical, human imagination and creativity, distinction between observation and inference, and subjective aspects of NOS were emphasized during both instructions. They differed in terms of the NOS instruction approach. The integrated group received NOS instruction embedded within the global warming while the nonintegrated group received separate NOS instruction in which the teacher did not connect NOS and the global warming. For example the differences in two scientists' inferences for the same observation about global warming were emphasized to point out to the subjective nature of science in the integrated group while generic activities were conducted in nonintegrated group. Nonintegrated group first received NOS instruction followed by content instruction around global warming. Data were collected through open-ended questionnaires

and interviews before and after treatments. Data analysis showed that the explicit NOS instruction resulted in the developed NOS understandings without considering whether it was embedded in a controversial science topic. The integrated and nonintegrated groups hold more informed NOS views for five aspects after the instructions. The authors argued that this does not necessarily mean that nature of science should be taught separately from the science content. It is only an indicator for the effectiveness of both instructional strategies on NOS views.

Several researchers designed SSI instruction including argumentation and investigated the influence of it on students' argumentation skills. The work of Patronis et al. (1999) was an experimental study carried out with 14 years old students. Students focused on a real problem which was the planning of a road near the school. The intervention included different steps. First the teacher stated the problem and asked students to write their personal opinions about it. Two weeks later, the teacher commented on students' opinions and asked them to form groups in which they represented residents and specialists working for the construction of the new road. In the next step the groups presented their group suggestions and justified their decisions. In this step, students benefitted of a variety of arguments to support their decisions. Finally they rated one of the groups' suggestions as the best to be sent to the City Council for further evaluation. The authors examined the quality of arguments used by students and explored how students' arrived at a decision. Their findings revealed that the students were able to develop different

kind of arguments as qualitative, semi-quantitative or quantitative. Students mostly developed qualitative arguments which were identified as the ideas based on the different aspects of the situation such as social, ecological, economic or practical. These arguments included personal beliefs, opinions, and values about the situation. Patronis et al. (1999) also stated that the decision- making was mostly performed individually in the classroom. They explored that personal experience and analogies affected the decisions reached in the classroom. Zohar and Nemet (2002) carried out an experimental study to investigate the effectiveness of the implementation of the Genetic Revolution Unit on students' argumentation skills. A total of 186 ninth grade students from two schools participated in the study. There were five experimental group classes who learned advanced genetic concepts through Genetic Revolution unit and four comparison group classes who learned those concepts through lecturing and solving standard genetic problems for approximately 12 lessons. Experimental group classes received explicit argumentation instruction. Argumentation skills were assessed through written worksheets before and after treatment and audiotaped discussions of small groups on two bioethical dilemmas. The results revealed that approximately 90% of the students formulated simple arguments including a conclusion and one justification initially. After implementation experimental group students formulated more complex arguments including more than one justification. The study conducted by Venville and Dawson (2010) (mentioned before in this section) also investigated tenth graders' argumentation quality. A quasi-experimental design research with two classes (one as argumentation group and the other as comparison group)

revealed that the argumentation group showed significant improvement in the complexity and quality of arguments they formed after participating in argumentation classes about cystic fibrosis and genetically modified tomatoes.

In addition to the research focusing on the effect of SSI implementations on science content knowledge, NOS understandings, and argumentation skills, the recent research addresses the influence of SSI implementations in classrooms on students' socioscientific reasoning. The work of Barab et al. (2007), Sadler et al. (2007), and Sadler et al. (2011) investigated the influence of classroom implementations in SSI context on students' socioscientific reasoning. These studies were discussed before in detailed, therefore I will briefly mention about them. Through a gaming learning environment, Barab et al. (2007) facilitated students to built socioscientific reasoning skills. The students in this study showed high quality socioscientific reasoning pattern. They appreciated the complexity associated with SSI, tried to balance ecological and economical concerns, considered scientific data and multiple lines of evidence. Sadler et al.'s study (2007) was an extension of Barab et al.'s (2007) to provide a valid assessment of socioscientific reasoning. Sadler et al. (2007) developed rubrics for each aspect of socioscientific reasoning through quantitative and qualitative analysis of interviews conducted with middle school students about two different issues. The last study, Sadler et al. (2011), investigated the effect of a classroom implementation of global warming on students' socioscientific reasoning. They also revised the assessment of socioscientific

reasoning. This study found no significant difference in students' socioscientific reasoning before and after implementation.

CHAPTER 3

METHODOLOGY

The purpose of this study was to investigate the change in the preservice science teachers' socioscientific reasoning as they participated in the teaching and learning activities during SSI-focused course. In this chapter, research questions, research method, data collection procedures, data analysis and trustworthiness of the study were included.

3.1 Research Questions

This study aimed to investigate the following main and sub-research questions:

1. How does PSTs' socioscientific reasoning change in response to participation in a SSI-focused course?

    a. How do PSTs recognize the inherent complexity of socioscientific issues before and after a SSI-focused course?
    b. How do PSTs realize that SSI is subject to ongoing inquiry before and after a SSI-focused course?

c. How do PSTs examine socioscientific issues from multiple perspectives before and after a SSI-focused course?

2. How does PSTs' socioscientific reasoning change during the SSI-focused course?

d. How do PSTs recognize the inherent complexity of socioscientific issues after phase 1 and 2 during a SSI-focused course?
e. How do PSTs realize that SSI is subject to ongoing inquiry after phase 1 and 2 during a SSI-focused course?
f. How do PSTs examine socioscientific issues from multiple perspectives after phase 1 and 2 during a SSI-focused course?

3.2 Research Design

Based on the research questions mentioned in previous section, a design based research approach was used. Design based research is "an emerging paradigm for the study of learning in context through the systematic design and the study of instructional strategies and tools" (The Design-Based Research Collective, 2003, p.5). That is, researchers design and change the learning environment to study learning. Tabak (2004) stated that "design-based research methods incorporate both design and empirical research with the goal of developing models and understanding of learning in naturalistic intentional learning environments (p. 226). Cobb, Confrey, diSessa, Lehrer and Schauble (2003) expressed that "this designed context is subject to test and revision, and the successive iterations that result play a

role similar to that of systematic variation in experiment" (p. 9). Design based research is also known as design experiments (Brown, 1992; Collins, 1992). Design experiments "ideally results in greater understanding of a learning ecology- a complex, interacting system involving multiple elements of different types and levels- by designing its elements and by anticipating how these elements functions together to support learning" (Cobb, et al., 2003). In this study, it was also aimed to create a learning ecology through design experiments including a series of teaching sessions with a single set of students to understand teaching and learning processes in depth.

More specifically, this study matches with design based research in aiming to design, implement, analyze and redesign of a SSI-focused course to improve socioscientific reasoning among preservice science teachers. For this purpose, three main steps as suggested by Cobb et al. (2003) were followed. These steps were explained in the following sections.

3.2.1 Preparing for the Design Experiment

Cobb et al. (2003) suggested that before conducting a design experiment the first issue to be clarified is to identify the theoretical intent. Design experiments are conducted in a varied range of settings such as classroom design experiments in which a research team works with a teacher or another research team member to assume the responsibility for the instruction (Cobb et al., 2003). Cobb et al. (2003) identified crucial issues that should be addressed in conducting any type of design experiment. The first one is to identify the theoretical intent of the design

experiment. The second issue to be considered is specifying goals or endpoints for student learning. Third one is documenting students' initial understandings. These issues were addressed in describing the classroom design experiment in the current study later in this chapter.

3.2.2 Conducting a Design Experiment

In conducting a design experiment, the aim is to improve the initial design by evaluating it through analysis of students' learning and the learning environment (Cobb et al., 2003). Depending on the needs of the experiment, a research team or single researcher can collaborate in conducting the design experiment. Four important functions were identified in conducting a design experiment (Cobb et al., 2003). Firstly, in conducting design experiments, learning pathways and the potential means to support learning should be clearly determined. Secondly an ongoing relationship between researchers and the teachers should be cultivated. Third one is developing a deep understanding of learning pathways and means supporting learning while the experiment is in progress. This is essential for improving the initial design. Final function is the meetings with researchers and teachers to discuss previous learning pathways and to plan for the future ones to achieve the goals for student learning. Developing deep understanding of learning pathways and means requires collecting data on both students' learning and the means that were used to support learning. A variety of data sources can be collected such as students' work, classroom discussions, interviews, or different forms of assessment.

3.2.3 Conducting Retrospective Analysis

In testing and revising the initial design, historical or retrospective analysis is performed on students' learning and means to support that learning. After a teaching session, the research team collects data and analyzes to see if the previous teaching session achieved its goal or it requires revision.

3.2.4 Classroom Design Experiment: SSI-Focused Course

A semester-long SSI-focused course was designed to improve PSTs' socioscientific reasoning. Total instruction time was 36 hours, 3 hours per week. The course included readings, socioscientific issue introduction, and negotiating and resolving socioscientific issues. Different teaching and learning activities took place throughout the course. The next three sections describe the preparation for SSI-focused course, conducting it and performing retrospective analysis about it.

3.2.4.1 Preparing the SSI-Focused Course

The theoretical intent of this classroom design experiment was to focus on the relationship between different classroom practices and improvement in socioscientific reasoning. The course was designed in a manner in which PSTs can strengthen their ideas and decisions about science based social issues. This is part of scientific literacy since educators want individuals to understand issues that they face in their daily lives through different media channels and appreciate how scientific and technological developments influence their life and also how social needs shape science and technology. Moreover, individuals gain perspectives on issues of a rapidly developing science and technologies and their effects. They can

recognize that these issues dominate the national discourse and understanding these issues is necessary for citizenship. After clarifying the theoretical intent, specific goals and endpoints were identified for the design experiment. In the syllabus the initial aim of the course was stated as

> Science, technology and society (STS) is an interdisciplinary field aims to investigate and understand how science and technology influence societies' culture, values, and its institutions and how societal issues influence science and technology. As we all know our life is shaped by scientific and technological understanding and their productions. Thus, it is imperative to know that how scientific and technological understanding and knowledge influence our life through their manipulation of our societal dynamics. By the same token societal dynamics also change scientific and technological understanding, knowledge, and their applications.

This statement suggested that the course mainly intends to help students gain an understanding of science, technology, and society and the dynamic relationship between them. To achieve this aim, the main objectives stated in the syllabus were

1. Explain the characteristics of science established by positivist paradigm.
2. Describe the characteristics of science established by post positivist paradigm.
3. State alternative views of science and technology.
4. Demonstrate knowledge about philosophy, history, and nature of science.
5. Conduct a literature search on computers and at library.
6. Describe different types of societal impact on science and technology.

7. Describe different types of scientific and technological impact on society.
8. See the importance of the issues related to science, technology, and society.

These objectives have a parallel orientation with the general course goal. They also refer to science, technology, society and the interaction among them. In addition to the objectives related to the STS which were existed in the course syllabus previously, the objectives about socioscientific issues were also added. These objectives were

1. To identify characteristics of socioscientific issues
2. To explain the differences between STS and SSI
3. To relate SSI with scientific literacy and citizenship
4. To identify different types of reasoning in SSI
5. To relate science content with SSI.
6. To identify different views related to nuclear power
7. To argue on different views related to nuclear power
8. To defend their own ideas about nuclear power
9. To assess opposing ideas and to refute if possible
10. To develop decision- making skills in the nuclear power plant context
11. To look for more information in negotiation of nuclear power.
12. To transfer their learning in negotiation of nuclear power to other science-related issues.

13. To discuss science behind the nuclear energy.
14. To recognize the challenge associated with nuclear power and in solving similar issues.

The discussions and activities are designed so that PSTs gain those objectives at the end of the SSI-focused course. There were teacher-led discussions, teacher-guided group activities and independent group activities within the course. Teacher-led discussions engaged PSTs in different views related to nuclear power and follow-up discussions challenged them with justifying their ideas and assessing others'. The teacher-guided group activities help them develop decision making skills through collaboration with others. The group activities let PSTs be informed about the complex nature of decision-making and ill-structured problem solving process. They were faced with ill-structured problem from daily life, applied their own knowledge and mental processes in addition to the provided by the instructor, control and regulate their own learning and develop reasoning skills. The independent group activities provided opportunities for PSTs to negotiate and resolve a different SSI on their own so that they transfer their learning to other contexts.

The objectives stated above are in congruence with the nature of socioscientific issues and socioscientific reasoning. SSI is multifaceted, challenging, and open to tentative solution. It requires that individuals focus on different views, evaluate each idea and claim carefully, collaborate with others (including experts, public, government, environmentalists, scientists, etc.) and make informed decisions

through assessing all ideas, thoughts, information, and positive and negative sides. The next section and its sub-sections explain the SSI-focused course in detailed.

3.2.4.2 Conducting the SSI-Focused Course

There were three phases in the course. After each phase, PSTs' socioscientific reasoning was assessed and the next phase was revised. The phases in the SSI-focused course were summarized in Table 3.1.

Table 3.1 The SSI-Focused Course

Pre-assessment: Exploring initial socioscientific reasoning	
Phase 1: Teacher-led discussions	
---Content---	*---Teaching and Learning Activities---*
• STS and STS teaching • SSI and informal reasoning • Nuclear power plant	• Whole classroom discussions • Use of probing questions • Presenting Information • Debriefing sessions • Second-order discussions
Assessment 1: Exploring socioscientific reasoning based on phase 1	
Phase 2: Teacher-guided group activities	
---Content---	*---Teaching and Learning Activities---*
• Decision making on Nuclear power plant	• Group discussions • Argumentation • Debriefing sessions • Second-order discussions
Assessment 2: Exploring socioscientific reasoning based on phase 2	
Phase 3: Independent group activities	
---Content---	*---Teaching and Learning Activities---*
• Negotiating and resolving different socioscientific issues	• Group discussions • Classroom presentations • Argumentation
Post-assessment: Exploring final socioscientific reasoning	

3.2.4.2.1 Phase 1

3.2.4.2.1.1 The Content of the Phase 1

The content of the first phase included science-technology-society, socioscientific issues, informal reasoning, and nuclear power plant as a specific SSI. It began with the readings about STS which are “Science, Technology and Society”, “Meaning of STS for Science Teachers” (Yager, 1996); “The Congruency of the STS Approach and Constructivism” (Lutz, 1996); “What is STS Science Teaching?” Whole class discussions took place based on these readings. Instructor encouraged PSTs to elicit their ideas and thoughts on STS, STS and science education. The importance of social issues with science connection was stated due to their interrelatedness. Since the participants were senior PSTs and they will teach STS topics in future, the instructor mentioned about STS approach to science education. She underlined that students must be given many opportunities to discuss their beliefs and value judgments and to propose solutions to real world problems so that they will be able to engage in meaningful discourse about science and technology related societal issues and go on to make informed decisions about them. As a whole class, the necessity of studying science and technology in society was discussed. The Bhopal gas tragedy and the ENIAC, the first computer, were introduced to the PSTs. Through these stories, PSTs had a view on how science, technology and society influence each other.

In this phase, STS approach to science education was introduced. The view of science as the accumulation of facts and the teachers as the source of information

were deemphasized. Instead, it emphasized that knowledge is constructed, teachers are facilitators, and textbooks are not source of knowledge. Moreover, it was discussed whether science should be only in classrooms or science should be linked to real life situations outside of the classrooms and whether society should be a part of science classrooms. All of these positioned to help PSTs to have a view of STS and its implications in science classrooms. The intimate intermingling of STS and constructivism was explained. PSTs were asked to reflect on their ideas about constructivism since they learned about constructivism in method courses. Then they are asked to build a relationship between STS and constructivism.

After introducing STS, SSI and informal reasoning were introduced. The habits of mind like acquiring skepticism, maintaining open-mindedness, evoking critical thinking, recognizing multiple forms of inquiry, accepting ambiguity, searching for data-driven knowledge were emphasized to be able to make informed decisions (Zeidler et al., 2005). The uniqueness of SSI and the distinction between STS and SSI were negotiated. The problems with STS were determined and SSI was introduced as a big umbrella covering all aspects of STS besides ethical aspect of science, moral reasoning and intellectual development of individuals (Zeidler et al., 2005). Functional scientific literacy, as a conceptual framework having four areas important for pedagogical purposes, was investigated and analyzed through the discussions between instructor and PSTs. The four areas which are nature of science issues, classroom discourse issues, cultural issues, and case-based issues were detailed separately. PSTs were already knowledgeable about nature of science

since they had two methods courses which focused on nature of science. Discussions on functional scientific literacy underlined the need for more argumentation and classroom discussions in science education. Cultural differences within the classroom were foregrounded in order to make clear that science educators should pay attention to the individual differences in moral reasoning and emotions within the classroom. Having deciphered STS, SSI and the distinction between them, the informal reasoning and informal reasoning patterns were explained as rationalistic, emotive, and intuitive (Sadler & Zeidler, 2005). The Readings "Patterns of Informal Reasoning in the Context of Socioscientific Decision Making" (Sadler & Zeidler, 2005), and "Preservice Science Teachers' Informal Reasoning about Socioscientific Issues: The influence of issue context" (Topcu, Sadler, & Yilmaz-Tuzun, 2010) were discussed. PSTs were given some episodes for different SSI and asked which pattern they fall into. After introducing SSI theoretically, the reading "Toward a Global Understanding of Nuclear Energy and Radioactive Waste Management" (Powell, Robinson, & Pankratius, 1994) was introduced. Then PSTs read some readings from media and journals about the positive and negative impacts of nuclear power plants on economy, environment, politics, and society. Whole classroom discussions took place on these readings. The classroom discussions based on pros and cons of NPP were triggered by instructor through asking some guiding questions. These questions (will be explained in the next chapter) referred to different perspectives related to NPP. PSTs discussed each of them through whole class discussions guided by instructor. They presented some claims and counter claims for each from media, news or

articles and expected to provide evidence for them. The dialogue events between instructor and PSTs or between PSTs resulted in different opinions and justifications for them.

3.2.4.2.1.1 The Teaching and Learning Activities of Phase 1

The teaching and learning activities in the phase 1 included teacher-led whole classroom discussions. The classroom discussions about STS, SSI, and informal reasoning were based on the readings. The instructor delivered the instruction and PSTs shared their ideas. On the other hand, the classroom discussions about nuclear power plant were more varied in terms of teaching and learning activities. Instructor utilized probing questions, presented information and carried out debriefing sessions and the second-order discussions. PSTs were more active during these discussions.

Probing Questions

During the first phase of SSI-focused course, instructor asked probing questions to initiate the discussions on nuclear power plant. These questions emphasized different perspectives associated with the nuclear power plant. Mainly economical, environmental, political, and societal aspects of nuclear power plant were discussed through these questions. These questions framed the issue in terms of multiple perspectives. The probing questions aimed to make PSTs more noticeable about different aspects of nuclear power plant including both advantageous and disadvantageous. As a result, PSTs could have a chance to negotiate nuclear power plant with respect to multiple perspectives including both pros and cons and PSTs

were expected to realize multiple perspectives and develop their socioscientific reasoning in terms of multiple perspectives.

The main question during the negotiation of nuclear power plant was whether nuclear power plant should be constructed or not. Then the instructor asked the probing question “Is NPP a cheap energy source?” to emphasize the economical perspective and initiated whole classroom discussion. After receiving PSTs’ responses, instructor asked another probing question “What is the relation between a unit of energy source and produced energy for NPP and other energy sources like coal or natural gas?” to foster PSTs think about NPP and compare it with other energy sources. Based on PSTs’ responses, instructor asked the following probing question “Do we have enough uranium sources?” and talked about Turkey’s uranium source. The teacher-led classroom discussions about nuclear power plant included the same pattern in terms of other perspectives. All probing questions asked in the SSI-focused were provided in Table 3.2. These questions were investigated by two researchers and the perspectives emphasized in each question were determined.

Table 3.2 Questions and Associated Perspectives in Framing NPP

	Perspectives			
	Environmental	Societal	Economical	Political
Framing Questions	Is NPP a solution to global warming? Is it a clean energy source?	Does NPP provide job opportunities?	Is NPP cheap energy source?	Does having a NPP make Turkey an energy independent country?
	How does an earthquake affect NPP's functioning and, in turn, how does this affect ecosystem and livings?	How do the local people feel about living with a NPP?	What is the relation between a unit of energy source (uranium) and produced energy for NPP and other energy sources (coal, natural gas)?	Is the construction of NPP decided by only government or a group of people having different ideas?
	How is a NPP cooled down? And what are the results of this process in terms of ecosystem?	Does NPP influence tourism in Akkuyu?	How does a NPP produce that much energy?	Is NPP really necessary now or is it a long term solution for energy?
	Is nuclear waste dangerous? How?	How does a nuclear accident affect the physical and psychological health of people?	Do we have enough uranium sources?	How does NPP affect our relations with foreign countries, especially the ones that we import energy?
	Should we check nuclear waste stored under ground periodically? Why?	Is society really informed about NPP or they are only blind protesters?	How much does it cost to build and maintain a NPP? What about the cost for deconstruction?	Is energy a pretext for NPP? Are there other reasons like a nuclear bomb?
	How does radiation affect living organisms?		Does Turkey have enough scientists, experts, and technicians to function a NPP?	Can nuclear waste be controlled for any leakage for years without being dependent on the change of government party?
	Why is Akkuyu selected for NPP?		What about the storage of nuclear waste and control of it for long years?	

Presenting Information

During teacher-led classroom discussions on nuclear power plant, instructor provided a variety of information including historical, research results, expert views and scientific information about nuclear power plant for PSTs. PSTs learned history of nuclear power plant in Turkey, major nuclear accidents all over the world, the research results about the effect of nuclear power plant on ecosystem and living organisms, expert views about the impact of nuclear power plant on economy and politics, scientific information about nuclear power plant.

Debriefing Sessions

During the SSI-focused course, instructor carried out debriefing sessions about nuclear power plant. The timing of these sessions was important since they were carried out after PSTs experienced practices about negotiation and resolution of nuclear power plant. In these sessions, instructor reviewed main points discussed, reverted to previous utterances, and summarized the information presented through interacting with PSTs. In these sessions, there was a focus on review and critical examination of topic by engaging PSTs with a series of questions. These questions challenged PSTs and forced them to think critically.

Second-Order Discussions

After discussions about nuclear power plant, instructor carried out second-order discussions. First-order discussions refer to the object-level discussions in which PSTs discuss nuclear power plant. The classroom activities such as asking probing questions about nuclear power and debriefing sessions all refer to first-order

discussions. In the first-order discussions, PSTs and instructor focus on the nuclear energy. This is object-level, meaning that a particular topic is negotiated; PSTs' ideas about it were explored. Second order-discussions refer to a more abstract-level of understanding and take them away from particular concepts being discussed about and assist them in realizing SSI, its relation to scientific literacy, and its invariant features in general. Second-order discussions about SSI help PSTs realize the general features and relationships among SSIs and to reflect on similar issues which share the same features and relationships. For example, in first-order discussions PSTs can discuss about nuclear power, and its aspects however in second-order discussions they can think about SSI in general, reflect on its features and what makes an issue as SSI, and how different reasoning exists in dealing with these issues. Most of the time, first order-discussions about nuclear energy and second-order discussions about SSI were integrated to help PSTs apply their understanding of SSI in specific contexts. They learned about SSI, nuclear power, and nuclear power as an SSI. And then they applied this understanding, knowledge and skills they learned in their reasoning, problem solving, and decision making processes in the context of other SSIs.

This phase served as a base for STS, SSI, and science education. It was developed to facilitate PSTs to comprehend STS, SSI, the differences between them and informal reasoning and nuclear power plant as a specific SSI.

3.2.4.2.2 Phase 2

3.2.4.2.2.1 The Content of the Phase 2

During the first phase, PSTs did not have a chance to make a decision about socioscientific issues by themselves rather they learned basic information and concepts. With this in mind, second phase aimed to provide an experiential learning environment for PSTs to participate in a decision making process about a specific socioscientific issues under the guidance of instructor. The second phase included a decision making activity about nuclear power plant emphasizing economical, environmental, political and societal aspects of nuclear power plant.

3.2.4.2.2.2 The Teaching and Learning Activities of Phase 2

During the second phase, group activities, argumentation, debriefing sessions and second-order discussions were carried out. The decision making activity included four small groups as business man, environmentalists, scientists and politicians. The three groups (business man, environmentalists and scientists) documented their arguments and their suggestions about nuclear power plant construction and the politicians as representative of ministry of energy and natural resources who listened to these groups' arguments about nuclear power plants and made a decision for its construction. The three small groups made a decision based on their arguments and informed the politicians about their decisions and arguments. The politicians made a final decision but some disagreements between groups caused whole class discussion at the end. After the group activity, debriefing sessions and second-order discussions took place.

3.2.4.2.3 Phase 3

3.2.4.2.3.1 The Content of the Phase 3

During the second phase, PSTs had a chance to negotiate and resolve nuclear power plant by the assistance of the instructor. They were assigned to the groups by the instructor and asked for assistance when they needed. Since they discussed the pros and cons of nuclear power in terms of different perspectives, they were already knowledgeable about nuclear power. Based on this idea, the third phase was designed in a way that PSTs negotiate and resolve socioscientific issues independently. The third phase included the negotiation and resolution of four different socioscientific issues. This was an independent group activity in which a group of PSTs negotiated different SSIs and tried to come to informed decision. The SSIs discussed were stem cell, genetically modified organisms, genetic screening and experiment with animals independently.

3.2.4.2.3.2 The Teaching and Learning Activities of Phase 3

In this phase, group activities, argumentation and classroom presentations were carried out. Each group was asked to select a SSI different than NPP and negotiate and resolve it by themselves and tried to make informed decisions. The last group activity was important in terms of how they formed their groups in terms of different perspectives and how they presented their arguments, justifications, counter claims and rebuttals to resolve a socioscientific issue. The independent group activities were purposefully formed to help PSTs learn how to negotiate and resolve different SSIs and to catch their attention to the nature of SSI. That is they

were allowed to design their own group activities and were thus able to be involved in the process of decision making process. This allowed for an implementation of socioscientific decision making and reasoning which they learned about in class to their independent group decision making activity. As a result, the groups of PSTs organized the activity, found relevant information, and made decision through negotiating only with their peers and did not receive any assistance from the instructor.

3.3 Participants

The participants of this study were PSTs enrolled in Science-Technology-Society course in the fall semester of 2010-2011 at a large, research-oriented university located in the capital city of Turkey. The Science-Technology-Society course was a required course for senior PSTs during their final year of science teacher education program. The number of PSTs enrolled in the course was not the same with the number of participants participated in the interviews. Therefore, I will first present the information about all PSTs who were enrolled in the course and involved in all data collection procedures except interviews. After, I will give information about PSTs who were interviewed.

In total 33 PSTs enrolled in the course and all of them were involved in all data collection procedures except interviews. Among them 26 PSTs were female and seven were male. Their age ranged from 22 to 26. They were all senior PSTs and will be able to teach elementary and middle school science classes after they graduated. All of them completed the same basic science courses such as physics,

biology and chemistry and teacher education courses such as educational psychology, measurement and assessment, laboratory application in science, methods of teaching science, and classroom management offered in previous semesters. Almost all PSTs (except one PST) completed environment related course such as environmental sciences or sustainability. Three PSTs were the members of World Wildlife Fund organization. Especially the chemistry courses included science content about nuclear power plant such as atoms, molecules, isotopes, radioactivity, and neutron bombardment which are related to the nuclear chemistry. Among 33 PSTs enrolled in the course, I interviewed with 24 PSTs based on their voluntary participation. Five of them were male and 19 of them were female. During their post-interviews they were asked whether they heard about socioscientific issues. All PSTs heard about these issues such as nuclear power and global warming. However they stated that they never participated in such classroom activities and decision making process which took place in this course. Therefore the participants were selected purposefully because they enrolled in the science-technology-society course and participated in teaching and learning activities related to the negotiation and resolution of socioscientific issues.

3.5 Data Collection

All of the data were collected during the semester-long SSI-focused course. In order to investigate the change in PSTs' socioscientific reasoning a wide range of data collection procedures were utilized. Pre and post interviews and open-ended questions, reflection papers, reports, video-recordings of whole class discussions,

video and audio-recordings of group discussions provided the data source for this study. Each data collection technique was detailed below.

3.5.1 Interviews

Interviews were conducted at the beginning and at the end of the course to investigate PSTs' socioscientific reasoning in the context of nuclear power plant (NPP). The interview protocol developed by Sadler et al. (2011) used in this study with some changes based on the context. Originally the interview protocol was about global warming. The researcher and her advisor redesigned the interview questions according to the nuclear power plant. Finally the protocol consists of one written socioscientific scenario with a series of questions (Appendix C). The issue given in this scenario is a real one for the PSTs since it is the current situation in Akkuyu, Mersin, Turkey. The interviews began with the PSTs reading the Akkuyu Nuclear Power Plant scenario and then they summarized the scenario. After they seemed to have clear understanding of the scenario, they were interviewed. The researcher asked different set of questions aimed to explore PSTs' understanding about complexity, inquiry and perspectives aspects of SSR. In the first part of the interview, PSTs' understanding about complex nature of SSI was investigated. They were asked to reason on complexity associated with the nuclear power plant. In the second part of the interview, the focus was to reveal PSTs' understanding about the need of ongoing research (i.e. inquiry) in negotiation of SSI. They were asked to reason on the information about NPP given in the scenario and to discuss more information if they need. Final part of the interview aimed to explore PSTs'

understanding about multiple perspectives in negotiating and resolving SSI. They were asked to discuss on different perspectives associated with NPP. All of the interviews were recorded and then transcribed by the researcher. PSTs' answers were scored according to the assessment rubrics by two independent researchers. The rubrics for each aspect of SSR were given in Data Analysis section.

3.5.2 Open-Ended Questions

All PSTs enrolled in the course responded to a set of questions about nuclear energy and the associated challenge (Appendix D). They were asked about nuclear energy, radioactivity, nuclear waste, and the challenge with NPP. PSTs answered these questions at the beginning and at the end of the semester.

3.5.3 Reflection Papers

All PSTs wrote down two reflection papers. PSTs wrote the first reflection paper (Appendix E) after Phase 1. In the first reflection paper, PSTs responded to a series of questions about NPP and their individual decisions on nuclear power plant construction in Akkuyu. The second reflection paper (Appendix F) was requested after the second phase to evaluate how this activity helped them improve their socioscientific reasoning. These reflection papers provided evidence for the contribution of activities to the PSTs' understanding of complexity, inquiry, and multiple perspectives of SSR.

3.5.4 Video and Audio Recordings

All class sessions from mid-semester till the end of the semester were video-recorded. Moreover the group discussions during the decision making activity were audio-recorded. These recordings revealed information about the teaching and learning activities conducted in the SSI-focused course. They were also helpful to revise the teaching and learning activities.

3.5.5 Reports

PSTs prepared reports for the decision making activity as a group. In this report, they stated claims and justifications for a specific perspective of NPP, and recommendations for the construction of NPP. These reports were utilized in the data analysis through providing support for their understanding of complexity, inquiry, and multiple perspectives of SSR.

3.6 Data Analysis

This section provides how data were analyzed to answer the research questions of this study. The data were analyzed both in a qualitative and quantitative way to investigate whether SSI-focused course support the development of socioscientific reasoning among learners.

The main research question and its sub-questions examined to what extent PSTs' socioscientific reasoning change during SSI-focused course. To investigate this, PSTs' socioscientific reasoning was assessed before the SSI-focused course, after phase 1, after phase 2 and at the end of the SSI-focused course.

In data analysis of a qualitative study, the researchers' role is to make sense of data gathered through interviews, videos, observations and documents. Moreover, they interpret the data and the interpretation of the data is reported in terms of categories, themes, theory or models (Merriam, 1998). In this study constant comparative method of data analysis was performed to analyze the data set to answer the research questions. The constant comparative method of data analysis was developed by Glaser and Strauss (1967). Glaser and Strauss (1967) stated that "the analyst starts by coding each incident in his data into many categories of analysis as much as possible, as categories emerge or as the data emerge that fit an existing category" (p. 105). Two independent researchers analyzed the multiple data sources (audio recordings, reflection papers, written reports). Both researchers analyzed all data sources to catch the instances that PSTs either implicitly or explicitly elicit their ideas for the aspects of SSR.

3.6.1 Data analysis of Pre and Post Interviews

Participants' responses to interview questions were examined with two rubrics. The researcher studied with a SSI expert during the analysis of the pre and post interviews. An initial analysis of interview data was conducted with this expert. Since his native language was English, a sub-set of five pre and post interview transcriptions was translated into English to analyze the data with the rubric developed by Sadler et al. (2011) according to a level-based approach. This rubric was called as "breadth rubric". Breadth rubric assesses whether participants

- are aware of complexity of SSI and provide sources for the complexity,

- demand more information and provide lines of inquiry,
- recognize and state differences in opinions and interests.

Because of the nature of the data obtained in this study, breadth rubric was not enough to assess PSTs' SSR. Thus for this study a second rubric called as "depth rubric" was developed to assess PSTs' SSR. Table 3.3, 3.4, and 3.5 give the levels, their descriptions, and example quotes from the data of this study for each level for SSR aspects: inquiry, complexity, and perspectives respectively.

Table 3.3 The Breadth Rubric for Inquiry Aspect of Socioscientific Reasoning

Questions: If you were responsible for deciding how to resolve the Akkuyu Bay situation, would you need additional information regarding the situation before making your decision? What kinds of additional information would be necessary for you to make a decision regarding the Akkuyu Bay situation?		
Level	Description	Exemplars
0	Suggests that additional inquiry is not necessary	No. That information is satisfactory to resolve the situation in Akkuyu.
1	Suggests that additional inquiry is necessary but does not identify a specific line of inquiry.	Yes but I do not know what kind? I should do research for it.
2	Suggests that additional inquiry is necessary and identifies a specific line of inquiry.	Yes. I wonder when the license for Akkuyu was obtained.
3	Suggests that additional inquiry is necessary and identifies two specific lines of inquiry.	Yes. Exactly when the license for Akkuyu to construct NPP was obtained? And also I look for whether Akkuyu is an earthquake region or not.
4	Suggests that additional inquiry is necessary and identifies at least three specific lines of inquiry.	I need a serious research. I want to learn how much energy we need, how NPP affects surrounding environment and livings. I want to know what people living in Akkuyu think about NPP. Is Akkuyu stable in terms of earthquakes?

Table 3.4 The Breadth Rubric for the Complexity Aspect of Socioscientific Reasoning

Questions: Can Akkuyu Bay situation be solved easily? Explain why you think so?		
Level	Description	Exemplars
0	States no complexity.	It can be solved easily because there are many people dealing with it.
1	Refers to the complexity with no source for it.	Not easy. It should not be constructed, I think.
2	Refers to the complexity and states one source for it.	It cannot be solved easily. Some people may prefer NPP but the people living there do not want it due to the risk of radiation.
3	Refers to the complexity and states two sources for it.	It cannot be solved easily since it has impact on ecosystem, economy, human, animals. We cannot only focus on economy and ignore other dimensions. We also cannot focus on only ecosystem and livings and ignore others.
4	Refers to the complexity and states at least three sources for it.	According to me, it is not easy to solve. We should think ecosystem. We should think energy need. We should think how radioactive waste will be stored. We should consult with people living there.

Table 3.5 The Breadth Rubric for Perspectives Aspect of Socioscientific Reasoning

Questions: A group of concerned Akkuyu citizens gathered to discuss a solution for the Akkuyu Bay situation. The group suggested that nuclear power plant should not be constructed for the health of the citizens in Akkuyu and for the surrounding ecosystem and living species. The energy demand should be met from sun and wind. For example; the wind turbines can be constructed out at sea and abundant sunlight in Mediterranean region should be utilized. How do you think the Turkish government, nuclear energy proponents, and environmentalists would respond to this suggestion? Please explain your response.

Level	Description	Exemplars
0	Cannot recognize that different groups will have different opinions.	I do not think NPP will be constructed. The government will do whatever it wants. Others will just protest it.
1	Recognize potential differences in opinions but offer no real analysis.	Government, nuclear energy proponents and environmentalists will react differently to the wind and solar use because they think differently.
2	Analyze/explain 1 given perspective.	Nuclear energy proponents may claim that NPP can be more efficient than wind and solar so they may want it.
3	Analyze/explain 2 given perspective.	Government focus on economy and financial issues and NPP can be more beneficial so it does not support wind and solar. Environmentalists claim that solar and wind are environmentally friendly and so they support citizens.
4	Analyze/explain at least 3 given perspective.	Government claim that NPP is more economical and efficient when compared to sun and wind. Proponents also mention about efficiency of NPP in terms of energy and its necessity for Turkey to be an independent country. Environmentalists support wind and solar because they are clean energy, renewable and do not produce dangerous waste.

The primary researcher and the expert independently examined a sub-set of pre and post interviews for five participants using the breadth rubric to explore their references to the complexity, inquiry, and perspectives and the degree of it. The first turn of analysis resulted in nine inconsistencies out of thirty scores. After negotiation, it was come out to be one inconsistency. The remaining was due to personal error during the scoring. The initial analysis revealed that the rubric was not sufficient enough to capture participants' reasoning. The data was telling more in terms of aspect of SSR but the rubric could not grasp it. The following quote exemplifies this. Participant 1 needs more information to solve the nuclear power plant crisis in Akkuyu and states three different lines of information underlined in the excerpt. Participant 2 also needs information and requires three different specific information. Using the original rubric, both participants are assigned to level 4.

> Participant 1: This information is not enough. I need more information about seismic stability of Akkuyu. … The rate of decay of radioactive materials is necessary. I should know how ecosystem is affected from NPP and radiation…
>
> Participant 2: These are not enough to make a decision. For example detailed information was not given about seismic stability. This is important for NPP to function safely and also for nuclear waste to be stored in safe since leakage can occur and soil and underground water become radiated. Then how radiation affects people and other livings? What levels of radiation are risky for them? Up to a level it is not dangerous. We all get radiation through roentgen but that is minimum and do not affect. I also want to know how nuclear waste will be stored if NPP is constructed. That is highly radioactive and needs long years to decay. Half life of uranium to decay is really long and emits radiation until initial amount is decayed. Turkey is not so careful about such danger. Due to nuclear waste tragedy in Istanbul and Izmir, we are in the list of countries having nuclear accident even without a NPP.

Participant 1 stated that more information was needed to solve the nuclear power plant crisis in Akkuyu and cited three different lines of information underlined in the excerpt. Participant 2 also referred to the need of more information including three specific lines. Using the original rubric, both participants were assessed at level 4. While the first participant listed the different lines of information to make a decision, the second participant not only stated specific information but also discussed why that information was required. However, the original rubric was not capable of reflecting this difference. With this underlying idea, we refer to this rubric as the "breadth rubric" which investigates whether individuals cite various lines of information rather than the extent to which they discuss them in-depth and provide rationales for them.

As it was stated the breadth rubric did not satisfactorily assess students' reasoning on SSI based on the data; therefore, a second rubric was developed to account the depth of student responses. We referred to this second rubric as the "depth rubric."

Depth rubric assesses whether participants

- are aware of complexity of SSI, provide sources for complexity and further explanations, justification or reasoning for them.
- demand more information, provide lines of inquiry and further explanations, justification or reasoning for them.
- recognize and state differences in opinions and interests and further explanations, justification or reasoning for them.

The depth rubric for each aspect of SSR is given in Tables 3.6, 3.7, and 3.8.

Table 3.6 The Depth Rubric for Inquiry Aspect of Socioscientific Reasoning

Questions: If you were responsible for deciding how to resolve the Akkuyu Bay situation, would you need additional information regarding the situation before making your decision? What kinds of additional information would be necessary for you to make a decision regarding the Akkuyu Bay situation?		
Level	Description	Exemplars
0	Does not require any additional information to make a decision.	No. That information is satisfactory to resolve the situation in Akkuyu.
1	Requires additional information to make a decision without giving a specific line.	Yes, I need detailed information. This is so superficial like a newspaper article. It does not further inform about NPP.
2	Requires additional information to make a decision, identifies specific lines of inquiry without further explanations for them.	Yes, I need lots of information about seismic stability of Akkuyu, how nuclear waste will be stored, whether we have experts in nuclear energy, what local people think, how ecosystem will be affected…
3	Requires additional information to make a decision, identifies specific lines of inquiry with further explanations for them.	Yes, I want to learn about seismic situation in Akkuyu. I need the statistical records about it since earthquakes are the big enemies of NPP. They may destroy the power plant and cause radiation leakages. This is also true for stored nuclear waste. If we bury it in an earthquake zone, it may give damage to the container which is full of waste and radioactive materials can leak to underground water and soil. This may affect agriculture, drinking water and all related organisms eating and drinking them.

Table 3.7 The Depth Rubric for Complexity Aspect of Socioscientific Reasoning

Questions: Can Akkuyu Bay situation be solved easily? Explain why you think so?		
Level	Description	Exemplars
0	Cannot recognize the complex nature of the issue.	It can be solved easily if as a society we do not behave emotionally.
1	Can recognize the complex nature of the issue without any reasonable sources for complexity.	Not easy to solve and reach a consensus. Some people want some people protests.
2	Can recognize the complex nature of the issue, identify reasonable sources for complexity but cannot give further explanations and details for them.	This issue is really difficult and takes long time to reach a decision because there are different dimensions related to NPP. We should consider economy, environment, society, and political issues.
3	Can recognize the complex nature of the issue, identify reasonable sources for complexity and can give further explanations and details for them.	To be able to reach a decision about NPP seems really impossible. It requires a good balance between economy, environments, and society. NPP is economical since a unit of uranium produces really substantial amount of energy when compared to other energy sources and this energy is continuous not like wind and solar. It also constructed on a small area but produce more. It is also important for international relations and for Turkey to be independent on energy. However, environment and society can be affected due to radiation and nuclear waste. Sea water will be used for cooling purposes in NPP and it will be returned to the sea carrying some radioactive materials. Sea life can be affected. Soil can be radiated and so agricultural products. So, energy need, economy are important but environment, people, health are also important.

Table 3.8 The Depth Rubric for Perspectives Aspect of Socioscientific Reasoning

Questions: A group of concerned Akkuyu citizens gathered to discuss a solution for the Akkuyu Bay situation. The group suggested that nuclear power plant should not be constructed for the health of the citizens in Akkuyu and for the surrounding ecosystem and living species. The energy demand should be met from sun and wind. For example; the wind turbines can be constructed out at sea and abundant sunlight in Mediterranean region should be utilized. How do you think the Turkish government, nuclear energy proponents, and environmentalists would respond to this suggestion? Please explain your response.		
Level	Description	Exemplars
0	Cannot recognize that different groups will have different opinions.	I think all of us should support wind and solar, they are so harmless.
1	Can recognize potential differences in opinions but cannot suggest reasonable claims/opinions in parallel with a given perspective.	Government, nuclear energy proponents and environmentalists will react differently to the wind and solar use because they think differently.
2	Can recognize potential differences in opinions and can suggest reasonable claims/opinions in parallel with a given perspective without further explanation, evidence or justification.	Government, nuclear energy proponents and environmentalist think differently and react to wind and solar in different ways. Government and proponents may be in the same line. They think about economy and development, while environmentalists focus on environment and society.
3	Can recognize potential differences in opinions and can suggest reasonable claims/opinions in parallel with a given perspective with further explanation, evidence or justification.	All react in different ways. Government think about budget and does not prefer wind and solar since they are costly and do not produce much energy. They are not efficient and need a minimum level of wind or daytime for sun. They require huge areas and maintenance is challenging. NPP is more efficient producing more energy in a small area. It can function safely for years if precautions were taken and it can be a good solution for global warming. We have uranium sources….

To establish validity and reliability of depth rubric, the primary researcher and the expert analyzed the sub-set of pre and post interviews for breadth and depth of SSR. In this analysis, there were five inconsistencies out of thirty scores. However, they were resulted due to personal error and agreed upon. To further establish validity and reliability, a second sub-set of pre and post interviews were translated into English and both investigators analyzed it with breadth and depth rubric. For breadth rubric, there were two inconsistencies out of thirty scorings for only inquiry aspect. As a result, the inter-rater reliability for breadth rubric was found to be 93%. In addition to this, the significance of the inter-rater reliability was tested using Cohen's Kappa (Cohen, 1960). The results of the inter-rater analysis are given as Kappa = 0.90 with $p < 0.001$. This measure of agreement is statistically significant and is outstandingly convincing as Kappa values from 0.40 to 0.59 are considered moderate, 0.60 to 0.79 substantial, and 0.80 outstanding (Landis & Koch, 1977). For a convincing agreement, Kappa values should be at least 0.6 and most often higher than 0.7.

The analysis with depth rubric yielded 3 different scores out of thirty scorings, two for inquiry aspect and one for perspectives aspect. As a result, the inter-rater reliability for depth rubric was found to be %90. The results of the inter-rater analysis are Kappa = 0.84 with $p < 0.001$. This measure of agreement is also statistically significant and is outstandingly convincing (Landis & Koch, 1977).

An inter-rater reliability analysis using the Kappa statistic was performed to determine consistency among raters for both breadth and depth rubric. The results

were satisfactory enough to conclude that both rubrics are yielding valid and reliable scoring for complexity, inquiry, and perspectives aspects of SSR.

3.6.1.1 Scoring of Breadth and Depth Rubrics

The analysis of data according to the breadth and depth rubrics results in a range of score pairs. The breadth rubric had five levels (0 to 4) and the depth rubric had four levels (0 to 3). Based on how some performance levels were defined, there were some necessary linkages between an individual's scores on the two rubrics. For example, individuals earning 0 or 1 on the breath rubric could only score 0 and 1 on the depth rubric. Individuals earning two or more in breadth will have at least a two in depth. In considering ways to combine scores in order to create a composite score, we prioritize the depth score because the depth rubric evaluates participants' deep reasoning in each aspect through exploring whether participants discuss the ideas in their responses. For example, in case of inquiry, students' discussions on various lines of information are more important than how many lines of information they stated. This is also consistent with Bloom's taxonomy of cognitive levels (Krathwohl, 2002). The depth of students' responses requires a higher cognitive level than breadth. The ultimate score pairs and their descriptions are provided in Tables 3.9, 3.10, and 3.11 for each aspect.

Table 3.9 The Score Pairs and Descriptions for Complexity

Score pairs	Descriptions
0-0	Cannot recognize complexity of the issue.
1-1	Can recognize complex nature of issue without sources for complexity.
2-2	Can recognize complex nature of the issue; provide one source for complexity without further explanation, justification, or reasoning for it.
2-3	Can recognize complex nature of the issue; provide two sources for complexity without further explanation, justification, or reasoning for them.
2-4	Can recognize complex nature of the issue; provide at least three sources for complexity without further explanation, justification, or reasoning for them.
3-2	Can recognize complex nature of the issue; provide one source for complexity with further explanation, justification, or reasoning for it.
3-3	Can recognize complex nature of the issue; provide two sources for complexity with further explanation, justification, or reasoning for each.
3-4	Can recognize complex nature of the issue; provide at least three sources for complexity with further explanation, justification, or reasoning for each.

Table 3.102 The Score Pairs and Descriptions for Inquiry

Score pairs	Descriptions
0-0	Does not require additional information.
1-1	Requires additional information without specifying lines of inquiry.
2-2	Requires additional information, suggests one specific line of inquiry without further explanation, justification, or reasoning for it.
2-3	Requires additional information, suggests two specific lines of inquiry without further explanation, justification, or reasoning for them.
2-4	Requires additional information, suggests at least three specific lines of inquiry without further explanation, justification, or reasoning for them.
3-2	Requires additional information, suggests one specific line of inquiry with further explanation, justification, or reasoning for it.
3-3	Requires additional information, suggests two specific lines of inquiry with further explanation, justification, or reasoning for each.
3-4	Requires additional information, suggests at least three specific lines of inquiry with further explanation, justification, or reasoning for each.

Table 3.11 The Score Pairs and Descriptions for Perspectives

Score pairs	Descriptions
0-0	Cannot recognize potential differences in opinions.
1-1	Can recognize that different groups will have different opinions but cannot provide reasonable claims/ideas for them.
2-2	Can recognize that different groups will have different opinions, provide reasonable claims/ideas for one given perspective without further explanation, justification, or reasoning for it.
2-3	Can recognize that different groups will have different opinions, provide reasonable claims/ideas for two given perspectives without further explanation, justification, or reasoning for them.
2-4	Can recognize that different groups will have different opinions, provide reasonable claims/ideas for at least three given perspectives without further explanation, justification, or reasoning for them.
3-2	Can recognize that different groups will have different opinions, provide reasonable claims/ideas for one given perspective with further explanation, justification, or reasoning for it.
3-3	Can recognize that different groups will have different opinions, provide reasonable claims/ideas for two given perspectives with further explanation, justification, or reasoning for them.
3-4	Can recognize that different groups will have different opinions, provide reasonable claims/ideas for at least three given perspectives with further explanation, justification, or reasoning for them.

3.6.1.2 Transforming Score Pairs into an Ordinal Scale

The score pairs introduced in the previous section were transformed into a composite ordinal scale with the prioritization of the depth score. The score pairs were 0-0, 1-1, 2-2, 2-3, 2-4, 3-2, 3-3, 3-4. The listing in Table 3.12 presents the hierarchical arrangement of composite scores. The 0-0 is the lowest level in terms of both breadth and depth SSR while the 3-4 is the highest level in terms of both. The ordered version of the score pairs was transformed into eight-point scale. The

lowest reasoning level refers to 1 and the highest one refers to 8. Combining breadth and depth SSR in this way can make the interpretation of rubrics easier. The improvement in aspects of SSR among learners can be revealed more reasonably.

Table 3.123 Depth and Breadth Score Pairs and Eight-Point Scale

Depth-Breadth Scores	0-0	1-1	2-2	2-3	2-4	3-2	3-3	3-4
Eight-Point System	1	2	3	4	5	6	7	8

The scores for breadth and depth rubrics are combined according to this system for three aspects for each participant. Each participant has a point for each aspect and that point has a description. For example, if a participant has 5 in this system for complexity, this means he has a depth score of 2 and a breadth score as 4. This further refers to the explanation which is this participant can recognize complex nature of the issue and provide at least three roots for complexity. However he can only mention about them without being able to provide explanation, justification or reasoning. Table 3.13 provides an example for scoring of a participant breadth and depth rubric for three aspects and a mean SSR score.

Table 3.134 An Example for Combining Depth and Breadth Scores

	Complexity		Inquiry		Perspectives	
	Depth	Breadth	Depth	Breadth	Depth	Breadth
D-B Scores	1	1	2	2	2	3
Point	2		3		4	

Note that D refers to Depth and B refers to Breadth.

After analyzing the pre and post interviews with both breadth and depth rubrics and combining them, each participant had a pre-interview and post-interview score for SSR. The magnitude of difference between PSTs' SSR before and after SSI-focused course was determined using Wilcoxon Signed Rank.

3.6.2 Data Analysis after Phase 1 and Phase 2

The intent of this study was to explore the change in the PSTs' socioscientific reasoning during SSI-focused course. Therefore in addition to the assessment of the participants' socioscientific reasoning before and after the course, their reasoning was assessed after first and second phases. These assessments were also based on the level performances of the rubrics mentioned in the previous section. The reflection papers were mainly used to assess PSTs' SSR after both phases. Additionally, after the second phase, the written reports were utilized.

3.7 Trustworthiness

Validity and reliability are two important concepts that should be taken into consideration in judging the quality of the study (Patton , 2002). Merriam (1998) reports that "validity and reliability issues are concerns that can be approached through careful attention to a study's conceptualization and the way in which data was collected, analyzed and interpreted and the way in which findings are presented" (p.199-200). In quantitative research, Fraenkel and Wallen (2006) identified validity as "the appropriateness, correctness, meaningfulness, and usefulness of the specific inferences researchers make based on the data they collect" (p.151) and reliability as "the consistency of the scores obtained and how

consistent they are for each individual from one administration of an instrument to another and from one set of items to another" (p.157). However it was argued that "the language of the positivistic research is not congruent with or adequate to qualitative work" (Ely, Anzul, Friedman, Garner, & Steinmetz, 1991, p.95). Therefore different perspectives existed on validation and reliability in qualitative research (Creswell, 2007). One of the dominant perspectives was suggested by Lincoln and Guba (1985). Lincoln and Guba (1985) talked about the trustworthiness of a study and they used specific terms "credibility", "transferability", dependability" and "confirmability" as equivalents of "internal validity", "external validity", "reliability", and " objectivity".

Credibility refers to the internal validity of a study. Lincoln and Guba (1985) suggested some techniques to produce credible findings and interpretations such as prolonged engagement, persistent observation, triangulation, and peer debriefing. To increase the credibility of this study, I spent a great deal of time with the participants to learn the classroom culture, participants and to build trust. Different modes of triangulation were also used to increase credibility such as data triangulation, investigator triangulation, theory triangulation and methodological triangulation (Denzin, 1970). Patton (1987) describes triangulation as "building checks and balances into a design through multiple data collection strategies" (p.60). "Triangulation strengthens a study by combining methods. This can mean using several kinds of methods or data, including using both quantitative and qualitative approaches" (Patton, 2002, p. 247). Using more than one data collection

procedures decreases the insufficiencies in one data collection method and increases the strength of the qualitative study. Data triangulation, investigator triangulation, and methodological triangulation are the ones that were benefitted in this study. I compared data from videos, reflection paper, interviews, and written reports. I interviewed with only voluntary PSTs. I utilized both quantitative and qualitative methods of research. Peer debriefing is another technique in establishing credibility. I finally conducted debriefing sessions with an expert to discuss my findings and interpretations.

The second issue in trustworthiness is transferability which refers to the external validity. It deals with the generalizability of the results of a study (Merriam, 1998). This is an issue that some researchers do not consider in qualitative studies since the both the participants and the study design change depending on the context. Bogdan and Biklen (1998) define generalizability as "referring to whether the findings of a particular study hold up beyond the specific research subjects and the setting involved" (p.32). In qualitative research, generalizability is not a prior issue because researchers aim to get in-depth understanding of the situation not to find a formula to generalize the findings. This is valid especially when the researcher studies with single case. There may be some ways to increase this phenomenon, such as a detailed description of characteristics of the participants, context of the study and the study design. I tried to give a detailed- description of the context and the classroom practices to allow other researchers to share the findings of the study.

Dependability is another issue that should be considered in establishing trustworthiness in a qualitative research. Merriam (1998) stated that "reliability refers to the extent to which research findings can be replicated" (p.205). It is the replication of the study and getting the similar results. Merriam (1998) emphasized that reliability in qualitative research is different than the reliability in traditional research because the latter focus on single reality while the former includes many interpretations of the phenomena. Therefore it is difficult to repeat a qualitative study and expect the same results. Rather it was expected that "the results are consistent with the data collected" (Merriam, 1998, p. 207). There are several techniques to increase dependability such as triangulation and audit trail. Like in credibility using multiple data sources and different methods of data collection can strengthen dependability. Through audit trail, researchers can explain how they collected data, how categories emerged and how they made decisions and arrived at their results (Merriam, 1998). In this study, as I mentioned before, I did data and method triangulation. Moreover I described my case in detail and data collection procedures clearly. I tried to explain how I analyzed the data sources and arrived at the results. During data analysis of both research questions, I studied with a second researcher to reach consensus on categories and interpretations. We compared our individual results and then negotiated on inconsistencies.

Confirmability is the final issue to be discussed. It refers to the objectivity. Lincoln and Guba (1985) proposed that intersubjective agreement is an approach to establish objectivity. "If multiple observers can agree on phenomenon their

collective judgment can be said to be objective". In this study, two researchers agreed on the findings and interpretations to be objective. Moreover, peer debriefing was performed to ensure that the results were not biased. Furthermore, I made the whole research process accessible by giving detailed, clear, and meaningful explanations.

3.8 Ethics for Research

The participants were informed about the purpose of the study, the volunteer nature of participation, promised confidentiality, and provided contact information for the researcher and advisor. Participants were not coerced in any way and had the option to leave the study at any time.

All data were collected by the researcher and investigated by the researcher. No individual results will be reported. Data collected will not be used for other purposes. Access to the data continues to be restricted to the researcher and will be kept in a secure for a while following the completion of the study.

CHAPTER 4

RESULTS

The results of the study were presented in two sections. First section reported the PSTs' socioscientific reasoning through comparing pre and post assessments during the SSI-focused course. In the second section, PSTs' socioscientific reasoning after phase 1 and phase 2 was presented.

4.1 Section One: PSTs' Socioscientific Reasoning during Pre and Post Assessments

This section reveals the results for PSTs' socioscientific reasoning through comparing pre and post assessments which were performed before and after the SSI-focused course. Quantitative results were followed by the qualitative data. All quotations presented for this section are preceded with participants' number ranging from 1-24 and interview number ranging from 1 (pre) to 2 (post). For example for the third participant's post interview results were given as 3-2.

The intent of this study was to investigate whether PSTs gain knowledge and reasoning skills in negotiating a SSI when they participate in discussions and interactions with other PSTs in a semester-long SSI-focused course. The course

involved nuclear energy as the main SSI. It is the hot topic in Turkey recently and studied mainly during the course as a whole class. Later, different SSIs were discussed by PSTs as a group. The aim was to help PSTs improve their reasoning for complexity, inquiry, and perspectives aspects of SSR. To remind, these are inherent features of SSI and essentially focused on during socioscientific discussions and argumentation.

4.1.1 Recognizing the Inherent Complexity of SSR during Pre and Post Assessments

It was emphasized throughout the study that SSI is complex in nature. Individuals should recognize the complex nature of SSI in order to make informed decisions to prevent simple, illogical, and single solutions which are based on only one dimension and shade the complexity of SSI. Breadth and depth rubrics assess the complexity in different ways. In the case of breadth of complexity, the rubric documents whether individuals site various sources of complexity for the issue. On the other hand, the depth rubric assesses how well detailed the individuals can discuss sources of complexity. The least sophisticated reasoning (Level 0) in breadth of complexity occurs when individuals cannot recognize complexity, mentions about how easy and straightforward to solve the issue without considering any sources for complexity. Individuals assigned to Level 1 can recognize the complex nature of the issue due to different stakeholders but cannot provide sources for complexity. Individuals at level 2 in breadth can recognize the complex nature of the issue and state one source for it. Level 3 and 4 refer to providing two and three or more sources for complexity respectively.

The lowest level (level 0) in the depth of complexity refers to a lack of recognition of complexity, while the level 1 corresponds to the recognition of complexity. Level 2 was associated with locating sources for complexity. The highest level in depth of complexity (level 3) addresses the recognition of complexity with sources including in-depth reasoning for them. Unlike breadth, depth rubric does not assess how many sources individuals presented rather it investigates whether those sources were discussed in detailed.

4.1.1.1 Comparison of PSTs' Reasoning for Complexity According to Breadth Rubric during Pre and Post Assessments

The relative frequencies of PSTs in each level for complexity aspect regarding breadth rubric before and after SSI-focused course were given in Figure 4.1. The bar graph in Figure 4.1 showed that while the number of PSTs in lower levels (0, 1, 2) according to the breadth rubric decreased, the number of PSTs in higher levels (3 and 4) increased after the course. Before the course 6 (25%) PSTs could not recognize complexity and provided very simplistic and illogical solutions for nuclear power problem. They mostly emphasized that the nuclear crisis could be solved easily and their solution was to construct it in another place if the current place was not suitable. Six (25%) PSTs only recognized complexity but could not identify any sources or reasons for why it is difficult to solve the problem. Five (21%) PSTs recognized complex nature of the issue and figured out only one source for complexity. Six (25%) PSTs presented two sources for complexity. Only one PST (4%) could give three or more sources for complexity so this PST was assigned the highest level in complexity.

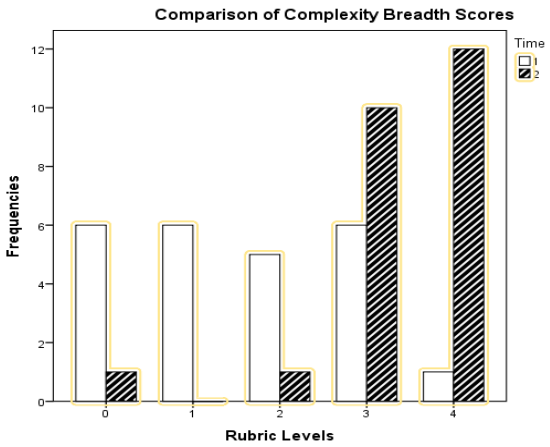

Figure 4.1 Frequency of PSTs in Each Level Regarding Complexity-Breadth before and after the SSI-Focused Course

An examination of Figure 4.1 revealed a clear trend toward improvement in the breadth of complexity following PSTs' participation in the SSI-focused course. After the course the number of PSTs in low levels decreased while high levels covered more PSTs. Only one PST (4%) still could not recognize complexity. There were no PSTs (in level one) who recognized complexity without sources. Almost all (23 PSTs, 96%) PSTs recognized complexity and site the sources of complexity. One of them presented one source, 10 (42%) PSTs talked about two sources and 12 (50%) PSTs provided level 4 responses including at least three sources for complexity.

In addition to the quantitative results, qualitative data was provided below to demonstrate the change in the PSTs' reasoning for complexity according to the breadth rubric. The following quotes exemplified how a participant reasoned on complexity before and after the SSI-focused course. The qualitative data were

presented as quote pairs for each participant to enable readers to see the change. For exploring PSTs' understanding on complexity, they were given a case (see Appendix C) and were asked whether the nuclear energy debate in Akkuyu can be solved easily. During the interview, they were required to elaborate their answers. During the pre and post interviews one of the PSTs responded to this question as follows

> 4-1: Not easy. This is nuclear. We had bad experience in the past. I think it should not be constructed. It can be very dangerous.
>
> 4-2: Of course not easy. NPP has advantageous and disadvantageous. That's why it is difficult to decide. Everyone treats according to their own benefits. Ok it will provide more energy since bombarding uranium with neutron that's fission and huge energy comes out. And also we have rich uranium source and this will decrease the cost for the source. On the other hand, as a result of NPP, environment and people can get damaged. Nuclear waste is radioactive and its radioactivity does not stop in a short time. It keeps releasing radiation for long. It should get cold first which requires time and then should be kept underground which results in other problems. Checking them in underground is required. The type of container is really important to prevent leakage of radioactive material. I mean lots of issues should be considered before making a decision. The health of people and other living things in that area also gets threatened. NPP probably will use the sea water in Akkuyu for cooling and it will be also sent back to the sea. So the marine life will be affected by radioactive materials too. People may swim in the sea and can be affected. This requires good evaluation of all these issues and it is difficult.

This PST provided a level 1 response according to the breadth rubric during the pre-interview. It means that he recognized the complexity but cannot explain the underlying reason for complexity. He just referred to bad experiences in the past and proposed a very simplistic solution. During post-interview, he provided a rich

and detailed answer for the same question and he was assigned to level 4 for it. He really could talk about the complex nature of the nuclear problem in Akkuyu and situated sources for it.

The following quote pair also exemplified how another participant improved their reasoning in terms of complexity.

> 23-1: It cannot be solved easily. Some people may support the construction of NPP but the people living there do not want it due to the risk of radiation. Therefore environmentalists and local people protest too much and resist so the situation become more difficult.
>
> 23-2: Cannot be solved easily…This is so controversial. Yes it has good points but it has also bad ones. Therefore it is difficult to deal with. We all know how dangerous NPP is and experienced it in Chernobyl even it is not in our country. But how will we supply energy. This is also important issue to consider because energy is very important for Turkey and its development. But it has also some drawbacks. Environment and society can be affected due to nuclear waste, radiation. Sea water will probably used to cool down in NPP and it will be returned to the sea which can carry some radioactive materials to the sea. Soil can be influenced from radiation and agricultural production can be also under risk. So energy need, economy are on one side, environment, people, health, etc. are on the other side. Difficult to decide.

This participant was assigned to level 2 for its answer during pre-interviews because he mentioned about difficulty to solve the problem and then referred to protests due to risk of radiation to explain why it is difficult to solve it. It was evident that he recognized the complex nature of the issue but could not reason for it sufficiently. Therefore level 2 represented his answer for pre-interview. When his post response was investigated, he actually performed a better reasoning in terms of

complexity and assigned to level 4. He mentioned that the crisis in Akkuyu cannot be solved easily and referred to energy, economical, environmental, societal, and health concerns about it.

4.1.1.2 Comparison of PSTs' Reasoning for Complexity According to Depth Rubric

The analysis of data with depth rubric offered how deep PSTs' reasoning in terms of complexity. Figure 4.2 compared the relative frequencies of PSTs in each level for complexity aspect regarding depth rubric before and after the SSI-focused course.

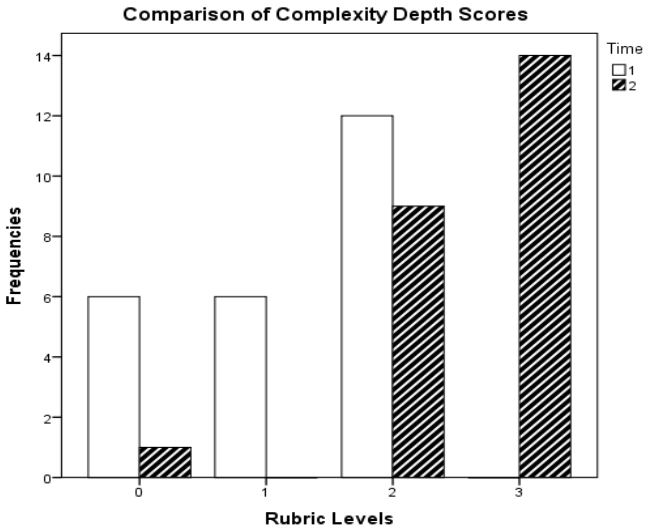

Figure 4.2 Frequency of PSTs in Each Level Regarding Complexity-Depth before and after the SSI-Focused Course

The bar graph in Figure 4.2 revealed that all PSTs offered responses in level 2 and below based on complexity depth rubric. Six (25%) of them could not recognize complexity and 6 (25%) PSTs acknowledged complexity without sources. Twelve (50%) PSTs were at a higher level which refers to the recognition of complexity

and presence of sources (level 2). At this time how many sources provided was not important since the emphasis was not on the number but on the rich explanation and reasoning. Level 3 responses were not presented before the course. This level refers to not only recognition of complexity with probable sources but also underlines the reasoning between sources and complexity (see chapter 3 for rubrics and level explanations). After the course PSTs' deep reasoning showed improvement and 14 (58%) of them offered level 3 responses. These PSTs stated that nuclear crisis cannot be solved easily and provided economical, political, environmental or societal reasons with in depth explanations and justifications. For example one of them referred to radiation problem as an environmental and societal reason for making nuclear energy complex and discussed the effects of radiation on human, agriculture, organisms with providing scientific information for radiation. Nine (38%) PSTs were at level 2 providing only sources for complexity without tying them to any reason, evidence or justification. Only one PST offered a response at level 0 after the course.

Qualitative data also showed the improvement in PSTs' reasoning for complexity according to the depth rubric. The following quote showed how a PST improved his reasoning and assigned to level 2 after instruction while he was at level 0 before SSI-focused course.

> 12-1: It can be solved easily because there are many people dealing with it. Of course it requires research and planning but at the end, after weighing negative and positive aspects, can be decided accordingly.

> 12-2: It is rational not to decide easily. I mean we should not decide quickly. Because it has impact on both human, animals, and environment but it also affects economy, our dependency on foreign sources. We cannot think just ecosystem there and decide accordingly ignoring other dimensions. But we cannot only consider economy and ignore ecosystem, environment, people, and health. NPP is efficient in terms of energy production, we get more energy, and we use uranium that we have.

Before the course participant 12 provided a very simplistic solution for the situation in Akkuyu and could not recognize its complexity. Although he referred to the need for research and planning, he thought that the problem is easy to solve by only considering its advantageous and disadvantageous. After the course, this participant considered the impact of nuclear power plant on specific issues such as health, economy, environment, and society. Correspondingly, his reasoning for complexity changed. He did not think any more that the problem can be solved without having troubles. He even emphasized that it should not be decided quickly because of its impacts on different agents. However he could not discuss them in detailed. Therefore this participant was assigned to level 0 for his pre answer and a level 2 for his post answer on depth rubric.

Another participant stated that

> 15-1: Two sides have strong supports. I mean there are people who want the construction of NPP and who are against it. For NPP, instead of Akkuyu, we may find another place which does not have a lot of livings. I mean a rural place far from people, livings etc.
>
> 15-2: Well I think difficult. It has many disadvantages compared to advantages. It will meet the energy need to a large amount. This is its positive side. However we should think the harm given to environment.

> There are radioactive materials released from NPP. Their effects last for long years because of the life time of radioactive elements. They continually release radiation. This is so bad. People can get radiation directly. They also can get radiation through their foods because the food also keeps radiation and this gives double harm to the people. Nuclear waste is really dangerous. We should keep them underground but how? We do not have necessary equipments and these also cost too much and then we should keep them under control for years. I am not sure that Turkey can do this. In this problem, everyone is right actually. Government wants to get bigger and bigger and so just focus on economy and ignores other issues. This is what developing countries do. The energy is required to develop. But on the other hand, there is a group of people trying to protect natural life, the health of society, the ecological system.

This participant offered a level 1-response during pre assessment and a level 3-response during post assessment. Before the course he seemed to recognize complexity but could not state and discuss the reasons for it and provided a simple and illogical solution. After the course, however, he showed understanding of complexity, presented various sources, and argued on them for complexity. He not only referred to these sources but also provided rich, valuable information including complex relationships among them. For example he talked about radioactive materials and further commented on why they are so dangerous. At this point he referred to half-life of radioactive materials and emission of radiation during this period. His post answer to the question was really reasonable and satisfactory for reasoning on complexity. Therefore he was assigned to level 3 by providing not only source for complexity but also further explanations, evidence and justification for it.

4.1.1.3 Comparison of PSTs' Reasoning for Complexity According to Breadth and Depth rubric

At this point it is important to compare bread and depth rubric scores before and after course. Before course 12 (50%) PSTs had a view about complex nature of the issue and provided at least one source for why solving nuclear power problem is difficult (at level 2, 3 or 4) according to the breadth rubric. When PSTs' pre-interviews were analyzed according to depth rubric, it was found that none of those PSTs could achieve reasoning for the relation between the sources they presented and the complex nature of nuclear energy. After the course, 22 (92%) PSTs provided at least one source for complexity according to the breadth rubric (at level 2, 3 or 4). Depth rubric analysis showed that 14 (58%) of them presented not only sources for complexity but also offered reasoning for the relation between the sources and complex nature of the issue. As a result, depth rubric allowed us to differentiate the individuals who can connect the sources and complexity through rich, in-depth and justified reasoning from the individuals who can only list the sources for complexity. In a general sense, the result showed that almost all PSTs' participating in the SSI-focused course comprehended the complex nature of the issue and provided sources about it. Moreover more than half of PSTs did not only site reasons but also argued on them with detailed explanations. This is a substantial change if it is considered that none of the PSTs could achieve it before course.

The following quotes from interviews show how PSTs' reasoning for complexity differs according to the breadth and depth rubric. I will compare the post responses

of participants 4 and 12 (4-2 and 12-2) which were given above. Two participants were assigned to level 4 according to breadth rubric. That is they both recognized the complexity and provided reasonable sources for it. However participant 4 evidently shows a deeper reasoning for complexity and its sources. This was captured by depth rubric and participant 4 was assigned to level 3 while participant 12 was assigned to level 2 according to the depth rubric. Although both participants emphasized the impact of nuclear power plant on similar issues like environment, people, health, energy need, economy, participant 4 provided a good analysis and evaluation of them and further related concepts. For example they both discussed that nuclear power is beneficial for economy and energy need. The difference between two answers was that participant 4 stated why it provides more energy and how the cost will decrease by constructing a nuclear power plant. He provided scientific knowledge to explain how nuclear power plant produces more energy. Therefore participant 4 provided higher level of reasoning than participant 12. This difference was also observed among other participants and other dimensions which were given in following sections. To remind, this was the reason for the researcher to develop a second rubric (i.e. depth rubric) that represents the data better.

4.1.1.4 Interpreting the Composite Scores of PSTs' Breadth and Depth Reasoning for Complexity

In this study, the combination of PSTs' breadth and depth scores were converted into an eight point ordinal scale for interpreting breadth and depth scores together. Since breadth and depth rubrics were related to each other, it was reasonable to combine them. The depth rubric was prioritized in composite scores (see chapter 3

for details). The investigation of composite scores for complexity aspect suggests that PSTs performed better for breadth and depth rubric after the course. The descriptive statistics for combined depth and breadth rubric scores before and after course were displayed in Figure 4.3.

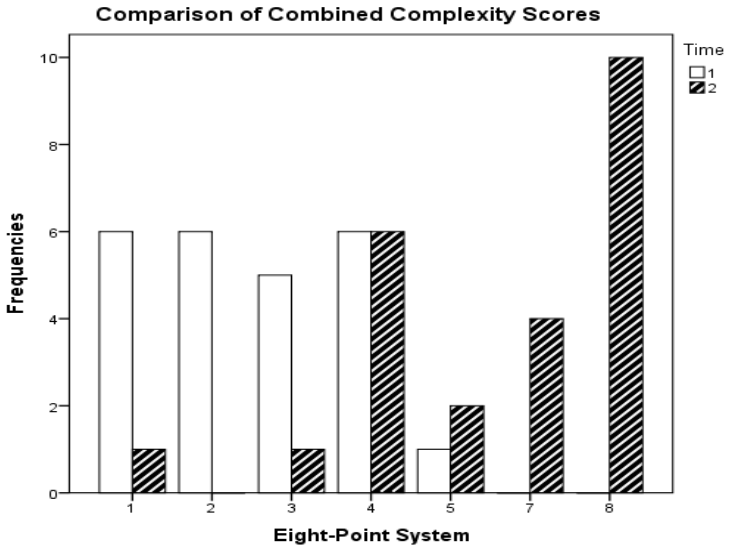

Figure 4.3 Frequency of PSTs in Each Level for Complexity Composite Scores before and after the SSI-Focused Course

In Chapter 3, the eight-point scale was explained in detail. To remind briefly, each point in the scale has a corresponding depth and breadth score. For example the point one refers to the level zero in both breadth and depth rubric. Point 1 means that individuals cannot recognize the complex nature of the issue and offer simplistic, illogical solutions for the issue at hand. The lower points in eight-point scale refer to low level reasoning while higher points refer to more complex and sophisticated reasoning. At the outset of the study, a majority of PSTs presented low level reasoning according to the composite scores (see Figure 4.3). The number

of PSTs in low levels decreased after implementation and PSTs provided more complex and sophisticated reasoning. In order to investigate the magnitude of this difference, Wilcoxon signed rank test was performed on composite scores (see Table 4.1).

Table 4.1 The Change in the PSTs' Composite Scores for the Complexity

	Change for Complexity
Z-Value	-4.029

A Wilcoxon Signed Rank Test revealed a large effect size in the composite complexity scores of participants after the course when compared with the scores before the course, $z = –4.03$, r= .58. The median score on the complexity increased from pre assessment (Md= 2.5) to post assessment (Md= 7.0). This result enables researcher to conclude that PSTs recognized the complex nature of the socioscientific issues and their reasoning is more sophisticated after they participated in the SSI-focused course.

4.1.2 Understanding that SSI is Subject to Ongoing Inquiry during Pre and Post Assessments

Inquiry is essential feature of SSI. Discussion of SSI requires ongoing inquiry since a part of information about SSI is always lacking and need to be searched. The ill-structure nature of SSI makes it complex and open to gathering additional information from a variety of sources in every step of decision-making process.

This part of the chapter gives quantitative and qualitative results for inquiry aspect. It is organized according to the breadth, depth and composite scores on inquiry.

4.1.2.1 Comparison of PSTs' Reasoning for Inquiry According to Breadth Rubric

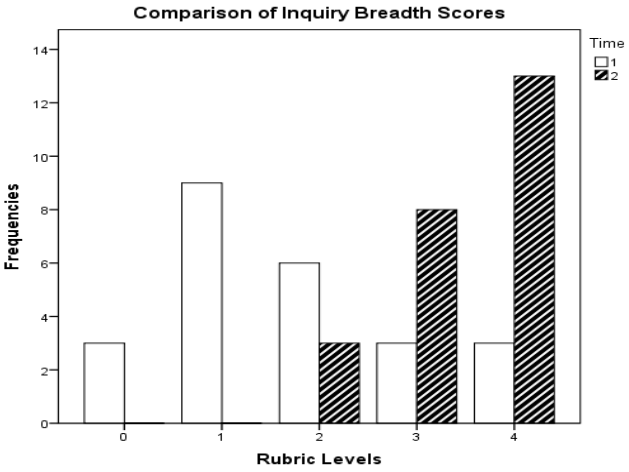

Figure 4.4 Frequency of PSTs in Each Level Regarding Inquiry-Breadth before and after the SSI-Focused Course

The bar graph in Figure 4.4 showed that the number of PSTs in low levels reduced while the number of PSTs in high levels increased after the course based on the breadth rubric. Before the course 3 (13%) PSTs did not state the need for additional information and 9 (38%) PSTs only recognized the need for more information without identifying any specific lines of information. Six (25%) PSTs provided only one specific line of information and 3 (13%) presented two lines of information. Three (13%) PSTs could give three or more specific lines of information and assigned a level 4 which is the highest level in inquiry. After the course, there were no PSTs in level 0 and 1 which means that each PST recognized

the need for more information and asked for at least one specific line of inquiry. Three (13%) PSTs asked for more information including one specific line of information. Eight (33%) PSTs required two specific lines of information and 13 (54%) PSTs talked about three or more lines of information in solving the nuclear power problem and they were assigned the highest reasoning level. They all talked about the inadequacy of the information given in the case to solve the problem and stated what information they need before making a decision.

PSTs' were asked following question in order to evaluate their reasoning for inquiry "If you were the one deciding how to resolve the Akkuyu Bay situation, would you need additional information before making your decision? What kinds of additional information would be necessary for you to make a decision regarding the Akkuyu Bay situation?" PSTs' responses to the questions were assessed based on whether they make decision on according to the information given in the case, or they were able to evaluate that information and recognize the need for other information. To exemplify, the 17th participant's answer for the question during pre and post interviews were given below.

> 17-1: Some alternative places for NPP can be mentioned. Public should be informed about NPP. Some people protest it without knowing nothing but some knows about NPP and do not want it. The ideas of these people can be mentioned.
>
> 17-2: Detailed information is required. Geological background should be mentioned, for example. Earthquake is biggest enemy of NPPs. I need more information about NPP. This is like newspaper article. For example what disadvantageous NPP has? What about the rate of decay of radioactive materials and how long is required for them to be stable

without releasing radiation. How ecosystem is affected? It will be better if these are considered.

This participant provided a level 2 response during pre interview. He requires information about alternative places for nuclear power plant construction. He was assigned to level 4 based on his post interview responses. In the post interview this participant explicitly stated the need for more information and several specific lines of information. He asked about geological background of Akkuyu, radioactive materials, and the effects on ecosystem. The difference in his pre and post responses showed the improvement in his reasoning. Although he also specified one specific line of information during pre interview, his post answer reveals that he was more informed about Akkuyu and requires more reasonable information.

The following participant exemplified level 0 and level 4 responses for pre and post interviews respectively. This change was substantial since he could not realize the need for more information before the course but he could perform better after the course. He both realized the need for ongoing research and required specific lines of information before making a decision. This shows that he was able to analyze and evaluate the information given in the case and identified the necessary but lacking information.

2-1: It seems enough. If I were, I will not construct it.

2-2: I need extra information of course. These are so superficial. I want to learn earthquake risk of Akkuyu. I want to learn how much radioactive material will be released and how the level of radiation affects people and livings. What people think about NPP? They want it

> or not. How will it affect environment and species? Lots of things I need. I want to learn the amount of money to construct it, to deal with nuclear waste, to maintain it, to deconstruct it when it is shut down because we learned that it has a life time and cannot work forever. So these are needed to be investigated in detail to construct or not to construct it. We should know whether it is worth doing or not. And also I want to compare the energy produced with NPP and other power plants. Actually I want to compare NPP and other power plants in terms of all their advantages and disadvantages.

It was clearly evident in the post interview response that this participant was able to admit that the given information was not enough to make a decision and identify necessary information for the solution of nuclear power crisis. He particularly referred to earthquake risk in Akkuyu, radiation problem, the effects of environment and livings, the cost for construction and deconstruction, the amount of energy and comparison with other energy sources. These were all logical and realistic views.

The participant below was assigned to level 3 and level 4 for his answers before and after the course respectively.

> 4-1: Of course I need more information. How is it constructed? What happens in case of an accident? I need detailed information. What happens to the regions after constructing NPP? These should be investigated.
>
> 4-2: I need a serious research. Well, it says we have insufficient energy. First I will investigate how much energy we need and can we meet it through other energy sources. We can really have energy need because our population increases and we develop in industry and technology. Then I search for NPP worldwide. What happened in countries where NPP was constructed? What happened to environment? Species may become extinct. Plants, foods may get radiation. I read that after Chernobyl, tea and nuts were radiated in Black Sea region. I will also

> search Akkuyu. I do not know if it is in earthquake zone. If so, this may cause accidents and leakages. I also want to know the thoughts of people living there about NPP. It directly affects people. They may want since you know it creates jobs opportunities. Or they may not want since bad experience in the past. What else? I think that's all. I communicate with economists, environmentalists, citizens. This is so important to make a decision which could be doing it or not.

He was already able to recognize the need for ongoing research and provided several lines of information during pre interview. He added more lines of information to his answer during post interview and performed a better analysis in terms of the kind of information. In his prior answer, participant 4 was seeking for more general information about nuclear power when compared to the post answer such as the results of an accident in nuclear power plant. His answer after the course refers to more specific information about nuclear power such as the impact of nuclear power plant on species, plants, and food.

4.1.2.2 Comparison of PSTs' Reasoning for the Inquiry According to Depth Rubric

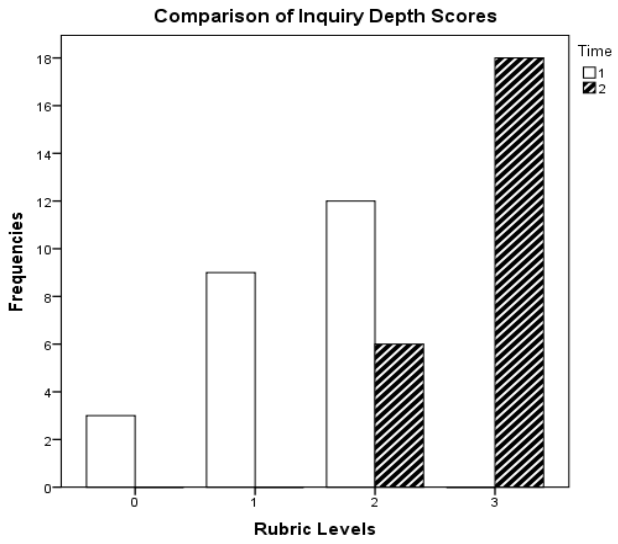

Figure 4.5 Frequency of PSTs in Each Level Regarding Inquiry-Depth before and after the SSI-Focused Course

Figure 4.5 compared the number of PSTs in each level before and after the SSI-focused course for inquiry aspect based on depth rubric. It suggested that PSTs' were more likely in low level for inquiry before the course. Three (13%) PSTs stated that the given information is enough and there is no need to get additional information in solving the problem. Nine (38%) PSTs realized that the information is not sufficient to solve the problem but could not mention about what information is necessary more. Half of PSTs offered level 2 responses which include the recognition of inquiry and presence of specific lines of information. Level 3 responses were not observed before the course like in complexity dimension. This level refers not only understanding the need for ongoing research in solving such

problems but also underlines the reasoning for why more research and information is necessary (see chapter 3 for rubrics and level explanations).

After PSTs participated in the SSI-focused course, their reasoning for inquiry aspect showed improvement and 18 (75%) of them offered level 3 responses. They not only stated the need for more information including specific lines but also examined them for its relation to nuclear power plant. For example one PST asked about whether Akkuyu is in earthquake zone and then referred to some consequences due to earthquakes in nuclear power plant region. Remaining 6 (25%) PSTs offered level 2 responses which include the recognition of inquiry and presence of specific lines of information without tying them to any reason, evidence or justification.

The qualitative data were also provided below to display the improvement in participants' reasoning for inquiry aspect according to the depth rubric before and after the course. Following quote pair provides an example for the development of PSTs reasoning for inquiry from level 2 to level 3 after the course.

> 23-1: Yes. Why Akkuyu? Is there a special reason for it? It can be another place, more rural. There are many areas, not productive or touristic. I need justification for Akkuyu so that I become convinced otherwise I do not want it.
>
> 23-2: No, these are not enough to make a good decision. For example, detailed information was not given about seismic stability. It is so important for NPP to function safely and also for nuclear waste to be stored in safe and not to be polluted with radioactive materials. How radiation affects people and other livings. What levels of radiation are risky for them? Up to a level it is not dangerous. We all get radiation through roentgen but that is minimum and do not affect much. I also

> want to know how nuclear waste will be stored If NPP is constructed. That is also highly radioactive and needs long years to decay. Half life of uranium to decay is very long. I do not know the exact number but it is really long. Turkey is not so careful about such dangerous things. You know the nuclear waste tragedy in Istanbul and Izmir. Without NPP, we have nuclear accident.

Participant 23 stated the necessity of extra information before making a decision and specified one line of information during the pre interview. In post interview, he was also aware of the lack of knowledge in the given scenario and refers to the further information about seismic stability, radiation risk, and nuclear waste problem. However he does not only refer to these specific lines of information but also refers to further explanations and justification for them. For example, he discussed seismic stability in Akkuyu including its importance for nuclear power plant itself and nuclear waste to be stored safely. Moreover he was curious about how nuclear waste will be stored because it is radioactive and remains as radioactive for years. He was able to relate nuclear waste, radioactivity, decay and half-life concepts. Therefore he was assigned to the highest level in depth rubric.

Recognizing the need for ongoing research was also evident in the following participants' quote. This participant was not able to comprehend it before course but he was able to refer it with detailed analysis of information which was needed for making decision.

> 9-1: According to me it is enough. It gives advantageous and disadvantageous and then asks for what to do. That's enough for me.

> 9-2: Of course I need. For example it says there will be energy need but we do not know how much? It is said that nuclear energy will be cheaper than other energy sources but how much? Because some nuclear energy opponents claim that nuclear energy is more expensive since its construction was expensive and it should be deconstructed which requires another costs. Moreover nuclear waste should be stored and checked which means another cost. The information about how nuclear waste will be stored is not given. This is a really serious problem. They need to be stored in safe containers otherwise they can mix with water which can be used in agriculture. Then people may also get it. It mentions about seismic stability briefly. I really need the seismic status of Akkuyu. In case of an earthquake nuclear power plant can be damaged.

Before SSI-focused course participant 9 did not recognize the need for ongoing research for solving such issues. He stated that he could make decision with the given information in the case. After he participated in classroom discussions and activities he provided a totally different answer. He was able to acknowledge the importance of research in making decisions about SSI and presented specific lines of information. He even displayed deep reasoning for them. For example he discussed that nuclear power produces cheap energy but he underlines the cost for construction and deconstruction of nuclear power plant, and also the storage and control of nuclear waste. He performed same reasoning for nuclear waste and its possible effects on agriculture and people. That is he evaluated the given information well and the complex relations between causes and consequences.

4.1.2.3 Comparison of PSTs' Reasoning for the Inquiry According to Breadth and Depth rubric

When we compare breadth and depth rubrics scores before and after the course, it was found that all PSTs understand the necessity for more information and provided at least one specific line of information after course. Before course, 12

(50%) PSTs were aware of the inquiry and discussed about at least one reasonable line of information necessary to solve the issue. The depth rubric analysis revealed that all of these 12 PSTs could only refer to that information rather than explaining why they are needed. After the course all PSTs acknowledged that the information presented to them to solve nuclear power problem is not sufficient and asked for at least one specific line of information according to breadth rubric. However depth rubric illustrated that only 18 of them presented further explanation, evidence or justification to relate the need for information to the solution of nuclear power problem; remaining 6 could not. As a result, depth rubric allowed us to differentiate the individuals who can ask for more information including rich, in-depth and justified reasoning (18 out of 24) from the individuals who can refer only to the information (6 out of 24).

It will be better to exemplify the differences among PSTs' reasoning for inquiry according to breadth and depth rubric. The following quotes shows how PSTs' reasoning was interpreted based on breadth and depth rubric.

> 6-2: It is not enough and I need more information. I want to learn more about ecology in Akkuyu, seismic background of it. We learned that seismic stability is required to construct a NPP otherwise it may be dangerous. I also investigate if we really need energy. It is also important to know our uranium resources. If they are not sufficient then we may import it and this also requires a different budget. This may not be beneficial because we want to construct NPP since it produces cheap energy but if we do not have enough uranium then it does not produce cheap energy. I also look for what we will do with nuclear waste. It is another problem. Where will they be kept? They emit radiation for years. We should bury them underground but we should also check them regularly. If there is any leakage to underground water or the place we bury is an earthquake zone then serious results occur. Ok we

> want to construct a NPP but we do not consider its waste. It is not like domestic waste. So I should do research about nuclear waste and how to deal with it. Of course I do not mean I will decide to construct it but I will consider its advantages and disadvantages in terms of different aspects and then I will think. I mean I will not decide quickly.
>
> 10-2: There is. Information should be collected on how much energy need Turkey has. Then I need the data for how much harm coal plant gives. The comparison of different energy sources in terms of their efficiency should also be given. If NPP is constructed, what advantageous and what disadvantageous it will have. I need detailed information.

Participant 6 and 10 were assigned to level 4 based on breadth rubric because they were both aware of the need for ongoing research and provided three or more specific lines of information to decide on nuclear power plant issue. The information they provided was reasonable and useful. However, at the first glance, it was obvious that participant 6 made deeper explanation and evaluated the information critically because he did not only identify specific lines of information but also provided why those information were needed for deciding a decision about nuclear power. Therefore he was assigned to level 3 according to depth rubric while participant 10 was assigned to level 2 according to same rubric. Participant 10 also acknowledged the need for inquiry and stated some of the specific information but his answer lacked further explanations, justification or evidence for it.

4.1.2.4 Interpreting the Combination of PSTs' Reasoning for the Inquiry

PSTs' breadth and depth scores for inquiry were paired and assigned a point from 1 to 8 in the same way it was done for complexity. Figure 4.6 presents the

frequencies for each point in the scale. It is clearly evident that PSTs could not show sophisticated reasoning for inquiry before they participated in the course and they were all gathered in lower points (below 5). The composite scores after the course revealed that PSTs were mostly assigned level 4 and above. Their reasoning for inquiry showed improvement after the participation in the classroom discussions and activities.

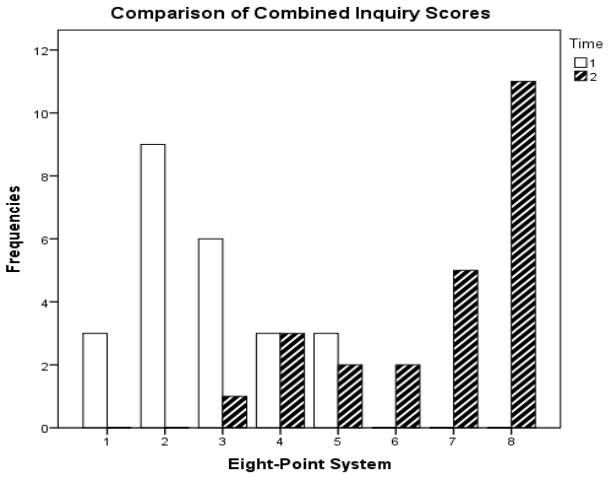

Figure 4.6 Frequency of PSTs in Each Level Regarding the Inquiry Composite Scores before and after the SSI-Focused Course

To investigate the magnitude of the change in PSTs' inquiry, Wilcoxon signed rank test was conducted. The results were given in Table 4.2.

Table 4.2 The Change in the PSTs' Composite Scores for the Inquiry

	Change for Inquiry
Z-Value	-4.308

A Wilcoxon Signed Rank Test revealed a large magnitude of difference in the composite inquiry scores from pre to post assessments, $z = -4.31$, $r = .62$. The median score on the inquiry increased from pre assessment (Md= 2.5) to post assessment (Md= 7.0). This result enables researcher to conclude that PSTs understood that SSI is subject to ongoing research their reasoning regarding inquiry aspect of SSR was more sophisticated after they participated in the SSI-focused course.

4.1.3 Examining SSI from Multiple Perspectives during Pre and Post Assessments

People have different opinions, ideas, biases, background and experience in different areas. This variety results in people looking socioscientific issues from different perspectives. Therefore a variety of solutions is inevitable when a group of people try to solve it. Perspectives should be considered carefully in socioscientific argumentation and individuals should be aware of different perspectives and biases of people. This section portrays both the quantitative and qualitative results for perspectives aspects according to the breadth, depth, and combined scores as well as PSTs' responses from interviews.

4.1.3.1 Comparison of PSTs' Reasoning for the Perspectives According to Breadth Rubric

The analysis of PSTs' pre-interviews based on breadth rubric for their reasoning on multiple perspectives revealed that 1 (4%) PST could not recognize that different groups may have different views and interpret the issue based on their views (see Figure 4.7). Three (13%) PSTs realized that there can be differences in views of

different groups but could not offer real analysis for them. The real analysis means that PSTs can provide some claims or opinions in consistent with a given perspective. Six (25%) PSTs had a view that multiple perspectives exist among groups and could provide real analysis for one perspective given them. More than half of PSTs (14 PSTs, 58%) also appreciated the differences in individuals' ideas, thoughts, and views. Half of them analyzed and explained two given perspectives plausibly and the rest could perform real analysis for three given perspectives. The analysis of post-interviews for breadth rubric displayed that all PSTs recognized the varieties in opinions and views and presented ideas for at least one given perspective. One PST could do this explanation for one perspective, 4 (17%) PSTs for two perspectives, and 19 (79%) PSTs for three perspectives. The analysis of breadth rubric provided us valuable information about PSTs' examination of the nuclear power from different views and their understanding of the nature of SSI as multiple perspective-taking.

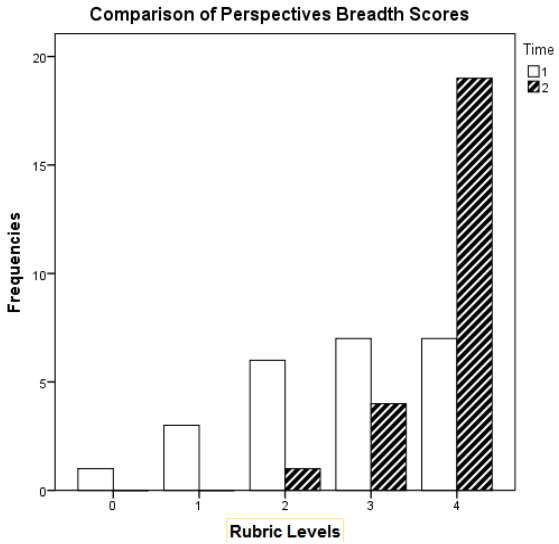

Figure 4.7 Frequency of PSTs in Each Level Regarding Perspectives-Breadth before and after the SSI-Focused Course

To exemplify PSTs' reasoning for multiple perspectives, the following qualitative data was presented. For this aim, participants were provided with a scenario which was about the Akkuyu citizens' suggestion of the use of wind and solar energy instead of nuclear power and they were asked about the reactions of government, nuclear energy proponents and environmentalists to this suggestion.

> 2-1: Government, nuclear energy proponents and environmentalists will react in a different way but government and nuclear energy proponents can share some common views. Government does not probably support the Akkuyu citizens. Environmentalists support the Akkuyu citizens. As far as I know wind and solar energy are not dangerous. They do not do anything to livings. They will like this suggestion. Nuclear energy proponents will ... I do not know how they react.

> 2-2: They react differently, I think. Government and nuclear energy proponents will not support the Akkuyu citizens while environmentalists will support. They react different because they think different. They have different reasons for NPP. This suggestion is not the one that government will like. I mean wind and solar energy are

> renewable energy sources and they do not emit harmful gases. But government would probably say that, we already have them in some parts of Turkey but they are not sufficient and we need more energy for now and for future. NPP produces more energy and it does not stop like wind or solar. Therefore government does not want wind and solar and try to convince people to have a NPP. Nuclear energy proponents also may claim that wind and solar are not efficient as NPP so we should construct NPP. Environmentalists support them because they are less harmful. Ok wind turbines can be harmful for birds since we learned birds cannot see them and crash them but I do not think they will give more harm when we compare them with NPP. And nuclear energy proponents may say that huge areas are required for them and even they may not produce enough energy. But we have lots of empty areas and I think that they should be utilized.

The participant 2 was able to recognize differences in opinions among them but could not provide reasonable opinions associated with the given perspective before the course and therefore assigned to level 1. On the other hand his post answer revealed that he could recognize the differences in opinions and examine the issue from multiple perspectives. As a result he was assigned to level 4 for his post answer. At the pre interview, participant 2 referred to the differences in reactions of government, nuclear energy proponents, and environmentalists to the nuclear power plant construction but as it is evident in his answer, he could not provide reasonable claims for why they think differently. For example he told that government will not support the citizens but he could not evaluate it and could not present claims or ideas in parallel with the perspective of government. This is also true for nuclear energy proponents and environmentalists. During post interview, he also referred to the differences in opinions of these three stakeholders. However, this time, he was able to present ideas and opinions for each given perspective. For

example he was able to claim that government does not support the citizens' suggestion due to the huge amount of energy produced by nuclear power plant when compared to the wind and solar energy. He also provided claims and ideas for other perspectives and he could examine the issue from multiple perspectives.

Participant 6 stated that

> 6-1: I think there may be differences between them. I do not know exactly how government reacts to this solution. But in my opinion, it should focus on wind and solar. Akkuyu is in south part of Turkey and it receives sunlight more and this can be a very good alternative. The government should really pay attention to this. The local people are right because they will live with NPP and their ideas are most important. I wish nuclear energy proponents just look and say nothing. Actually this solution is a very positive one. But you know there is an opposing view that is NPP is better. They do not want wind or solar energy since they support nuclear and they think we should have it immediately to be a developed country. Environmentalists support the citizens. Very clean and environmentally friendly energy will be produced so they will support the Akkuyu citizens and will do everything to protest NPP. Can you imagine? There is wind outside and it blows whether you make use of it or not. Why should not we make use of it? It is free in terms of source and you do not have to do anything. Just wind comes and makes the turbines turn and you have the energy. This is amazing.
>
> 6-2: They will react differently. Government thinks that NPP is economic. They tell that we will have cheap energy, more energy and there will be job opportunities. It will not pay attention to wind and solar because wind and solar does not produce more energy like NPP. They may say that constructing wind turbines and solar panels also requires huge land areas and this also damages environment. And they may claim that a minimum of wind is required to make the turbines turn and produce electricity. However NPP is not like them. It produces energy all time. Wind turbines and solar panels also require maintenance and this has a cost too. Nuclear energy proponents may claim that nuclear energy help Turkey develop more and be independent. They say that wind and solar are not so environmentally friendly since their construction also damages environment and some birds crash the turbines and they may die. Nuclear proponents say that

> turbines also give harm to animals. When they broke down, to fix them is also expensive. And they do not meet the energy need. They may be helpful in local areas but for energy need across country, they are not sufficient. The environmentalists will support wind and solar since they are renewable energy sources. They may say that solar is the main energy source for the earth and we should make use of it. They may claim that wind and solar do not emit any gas to the atmosphere. Ok they may require land areas to be constructed but they will say that this will not give harm to people, environment, nature and animals as much as NPP. The government and nuclear energy proponents may say that the maintenance and repair of them is expensive. However they forget that NPP also requires maintenance and when it breaks down, it may cause serious problems. NPP is equal to radiation and the nuclear waste is so dangerous even you cannot imagine. Nuclear waste should be stored in safe places and checked regularly to prevent leakage. The environmentalists claim that the government will not care about nuclear waste in future and they will not check it regularly so we may face more serious problems in future.

Participant 6 was assigned to level 2 and 4 before and after course respectively. He focused on only one dimension of nuclear power plant which was environment and examined the issue from this perspective before course. He could not anticipate the reactions of government and nuclear energy proponents and stated that they should also focus on wind and solar because of environmental reasons. It is acceptable that nuclear power has environmental concerns but the multifacetedness of it should also be considered for a more informed decision. His post answer was more comprehensive in terms of different perspectives. The participant referred to the claims that each stakeholder propose for nuclear power plant in parallel with the perspective. For example he stated that government prefers nuclear power to wind and solar because of the amount of energy produced and offered some counter claims for other perspectives. For example he argued that wind and solar energy

also damages environment and presented some justifications for this. He also showed a similar reasoning for nuclear energy proponents and environmentalists by proposing claims. As a result he showed improvement in his reasoning by examining issue from multiple perspectives after the course.

4.1.3.2 Comparison of PSTs' Reasoning for Perspectives According to Depth Rubric

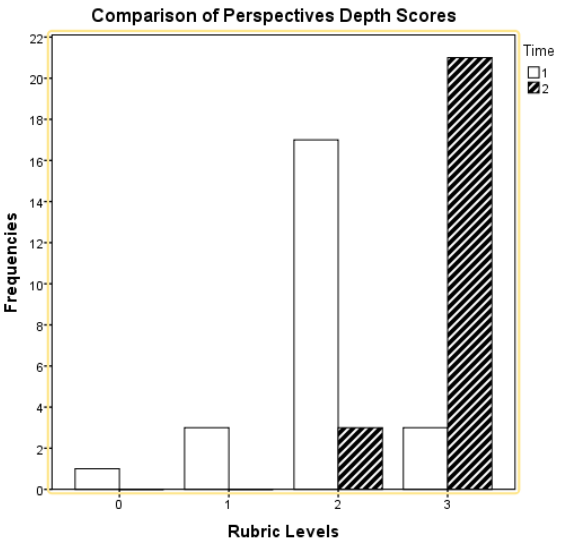

Figure 4.8 Frequency of PSTs in Each Level Regarding Perspectives-Depth before and after the SSI-Focused Course

Figure 4.8 provides a comparison of scores obtained using depth rubric before and after the course. Before the course one PST did not refer to multiple perspectives, 3 PSTs could value differences in opinions but could not perform analysis of these opinions. Seventeen (71%) PSTs could understand the multifacetedness of the nuclear power problem and provide claims or opinions for given perspectives. And only 3 PSTs could provide reasonable claims with further reasoning for them. The

analysis of post-interviews with depth rubric revealed that all PSTs gained a view that nuclear power is multi dimensional and there are different views, perspectives and ideas. Three of them could analyze the given perspectives and proposed some claims and ideas for them. The rest, 21 PSTs, could also offer a real analysis providing claims and opinions for different perspectives given but they also could perform reasoning for those claims and opinions. They backed those claims with scientific information.

These results were also supported with qualitative data. First, participant 6 (given in previous section) was discussed. This participant was assigned to level 2 and level 3 for his pre and post interview responses according to the depth rubric, respectively. This means he was aware of the differences in opinions and he could examine the issue from a given perspective. In his post answer, he could examine the issue from multiple perspectives. That is he could provide claims and ideas which are consistent with the given perspective and he could also reason for them. For example he referred to nuclear energy proponents and said “They say that wind and solar are not so environmentally friendly since their construction also damages environment and some birds crash the turbines and they die”. He referred to both one of the claims that can be proposed by nuclear energy proponents and the underlying reason for it. He was able to tie the arguments of different stakeholders with the backings for them. Another participant was also given below to illustrate the deep reasoning for multiple perspectives.

> 15-1: They react differently because they focus on different things. Government probably will think that how much they will cost [wind and solar energy] since they are responsible to pay the cost, they will think in terms of cost. The nuclear energy proponents may say that there is global warming and we cannot guarantee wind or solar. Environmentalists accept this since they [wind and solar energy] are natural sources and they do not give too much harm to the environment.
>
> 15-2: They give different reactions. Government most probably will think in terms of economy aspect of NPP and ignore others. Wind and solar energy do not produce much energy. They are not so efficient. They require more areas than NPP and they still do not produce same amount of energy. Moreover wind turbines, for example require a minimum level of wind to turn. If not, then they stop. I mean they do not produce energy continually so they are not so effective to meet the energy need of Turkey. These are what our government will say. The proponents may also talk about how cheap electricity will be produced and this will be reflected on bills. Some people believe that, I am sure. They may claim that we do not have enough area for wind turbines and solar panels to get the same amount of energy produced by NPP. They require maintenance much more than NPP. They also damage environment to be constructed. Environmentalists support the citizens and their suggestions. Although government and nuclear energy proponents may claim wind and solar is not sufficient and they are costly, environmentalists may tell them how clean wind and solar energy and do not threaten life of people, species.

Before the course, participant 15 was able to recognize that different people have different opinions and ideas and he could state some ideas of government, nuclear energy proponents and environmentalists in consistent with them. But there were no any backing, justification or further explanation. This does not mean that he could not reason but he could not perform a deep understanding. He offered a level 2 answer according to the depth rubric. In his post answer, he answered the question including details, further explanation and the reason for different parties' arguments. For example, in terms of government reactions to wind and solar

energy, he emphasized the economical aspect of nuclear power and compared the efficiency of nuclear energy with wind and solar energy. He referred to minimum level of wind required to make turbines work and produce electricity as a reason for why wind is not efficient compared to the nuclear power. His reasoning for multiple perspectives was more detailed and so he was assigned to level 3 according to the depth rubric. The above qualitative data also showed that the participants' reasoning for multiple perspectives improved after the SSI-focused course.

4.1.3.3 Comparison of PSTs' Reasoning for Perspectives According to Breadth and Depth rubric

The comparison of breadth and depth rubric before and after the course can give us a whole picture of the improvement. According to the analysis of interviews with breadth rubric before the course 20 (83%) PSTs reported that they are aware of different views and stakeholders and they stated claims for at least one of them. The analysis of these interviews with depth rubric showed that 17 (71%) of these PSTs could provide claims or opinions in parallel with the given perspective but could not go beyond. Only 3 (1%3) of them discussed different perspectives including their claims or opinions with further explanations, justifications or evidence. The analysis of post interviews based on breadth rubric displayed that all PSTs (24) were aware of differences in views or perspectives and exemplified at least one of them. The investigation of post-interviews with depth rubric pointed out that 21(88%) of total PSTs showed deep reasoning on different perspectives,

not only provided the congruent claims with perspectives but also supported them with rich, detailed information, backed with science.

Here the qualitative data was provided to demonstrate the differences between PSTs' reasoning according to the breadth and depth rubric. It was also demonstrated how participants used scientific knowledge in justifying some of their claims.

The next exemplar compared one of the participants' reasoning according to the both rubrics before and after the course.

> 4-1: Does our government really want to construct NPP in Akkuyu or other countries force it. The government is controlled by other countries and whatever they want, our government does. This suggestion is good for public but I do not think government pays attention to it. NPP can be better than wind and solar so they may want it. Proponents may say that Akkuyu does not receive enough sunlight and wind. Environmentalists take a bright view of it. Solar and wind are harmless. They are natural. So they support the citizens.
>
> 4-2: Government wants to construct it …You know the use of wind and solar is not efficient because they do not give much energy in a short time. Therefore the cost for their construction may not be so economical. Their maintenance is also costly. Government may claim that they also damage environment since large areas are required for wind and solar to get the same energy as nuclear power plant supplies. Wind turbines can be dangerous for birds since they may not see turbines and crash or I read some news that wind turbines fell over, blades flew off or there can be wind turbine fires…It supports NPP by saying, it produces more energy because of the source and reactions taking place in plant. The same amount of coal and uranium differ significantly in producing energy but really significant. And NPP does this in a smaller area not like wind and solar. Moreover its energy production is continuous. Wind and solar depend on the climate, time of the day, power of the wind or solar. They [proponents] think like government. Suggest that construction for wind and solar energy is costly but not efficient to produce more energy and to meet energy. It is

> not worth doing when you compare their cost and what you get from them. Their maintenance is also costly and again you do not get enough from them although you spend more but you get less. Require huge areas and this means damaging environment and habitat loss and degradation. Also they suggest that NPP do not release greenhouse gases like coal and so it can decrease the impact of them. NPP produces more in a small area and …same things as government. Wind and solar energy may stop sometimes. They are dangerous too accidents may occur I just mentioned for government. They may talk more about scientific aspect of NPP to produce energy. You know, uranium bombarded with neutron and then this cause a chain reaction and huge amount of energy obtained. They also do not support this suggestion. They may also say that we already have wind turbines and solar panels but these are not enough so more efficient one is necessary. We do not totally ignore wind and solar but we need to get energy in high amount in a short time, etc. They [environmentalists] directly focus on environment. They argue that NPP cause loss of ecosystem, habitat because radioactive waste are formed they release radiation for long and they do not decay. I mean they have half-life for billion years. This means the half of the initial amount decays for billion years but other half remains. They argue wind and solar are not dangerous as NPP. Some can be some disadvantageous, that is normal, but we cannot compare with NPP in terms of disadvantage. Huge areas are required, that is true, then let's tell people the importance of energy and learn how to use it efficiently. NPP produces more energy in a small area but it makes very large bad impact. It is small but extremely dangerous. It may prevent global warming but it gives harm to ecosystem, people, animals, plants. I think they defend themselves in this way and support citizens.

Participant 4 was assigned to level 4 and level 2 for breadth and depth rubric respectively based on his pre-interview response. This is because he could mention about ideas of government, nuclear energy proponents and environmentalists reasonably. However, he could not provide further explanations and details for justifying them. His post-interview response was assigned to level 4 and level 3 for breadth and depth rubric respectively. He discussed the ideas and claims of each given perspective and added the grounds for them. He sometimes used science

content knowledge to justify his reasoning. For example he stated that nuclear energy will produce much more energy because of the sources and reaction in the plant. He also used science to back his ideas in explaining radioactive materials and stated that they release radiation for long based on its half-life (time for a radioactive material to decay to its half of starting amount).

The results showed that PSTs' reasoning in terms of multiple perspectives improved substantially after the SSI-focused course.

4.1.3.4 Interpreting the Combination of PSTs' Reasoning for Perspectives

Based on the eight-point scale, Figure 4.9 compares composite scores at the beginning and at the end of the SSI-focused course. Most of the PSTs were assigned to points 3, 4 and 5 before the course. This shows that majority PSTs could examine issue from at least one perspective but they could not provide sophisticated reasoning for different perspectives before the course.

After the course, PSTs were mostly offered level 8 responses. The responses were all above level 3 and up. The comparison of composite scores in terms of perspectives allows the researcher to conclude that even though most PSTs discussed the issue from different perspectives before the course, they could provide rich reasoning about them only after the course.

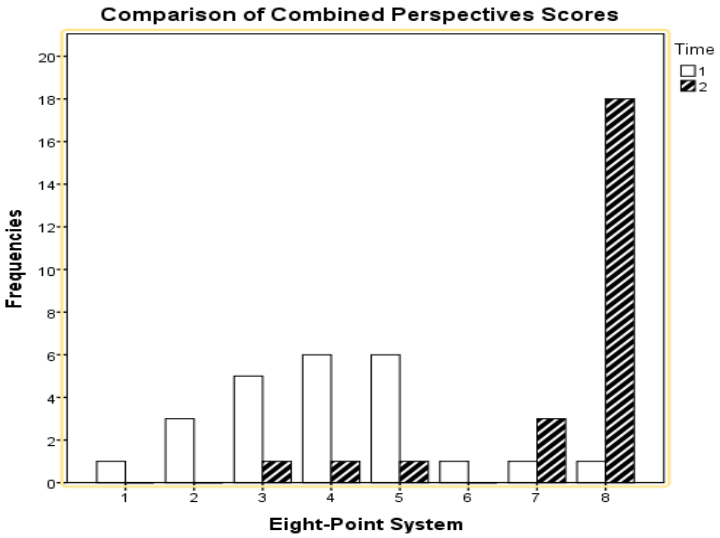

Figure 4.9 Frequency of PSTs in Each Level Regarding Perspectives Composite Scores before and after the SSI-Focused Course

In order to determine the magnitude of the difference in PSTs' reasoning for perspective-taking, Wilcoxon Signed Rank Test was conducted. The result of the test was given in Table 4.3.

Table 4.3 The Change in the PSTs' Composite Scores for the Perspectives

	Change for Perspectives
Z-Value	-4.133

A Wilcoxon Signed Rank Test revealed that the magnitude of the difference between PSTs' pre and post assessments was large in terms of composite perspective-taking scores, $z = –4.13$, $r = .59$. The median score on the perspective-taking increased from pre assessment ($Md = 4.0$) to post assessment ($Md = 8.0$). This result justifies that PSTs' reasoning for multiple perspectives developed after the course.

4.2 Section Two: PSTs' Socioscientific Reasoning after Phase 1 and Phase 2

In this section, how PSTs displayed improvement in SSR during the SSI-focused course was reported. The results based on the performance levels identified in breadth and depth rubrics were provided for the assessments after first and second phases.

4.2.1 PSTs' Socioscientific Reasoning after Phase 1

To remind briefly Phase 1 included teacher-led whole classroom discussions, the use of probing questions, the information presentation, debriefing sessions, and second-order discussions. Teacher-led whole classroom discussions were held in the context of STS, SSI, informal reasoning and nuclear power plant. Especially the ones about nuclear power plant included the use of probing questions, information presentation about it, debriefing sessions and second-order discussions. Instructor utilized probing questions which emphasized different perspectives regarding nuclear power plant. The aim of using these questions in teacher-led discussions was to contribute to the PSTs' reasoning in terms of multiple perspectives. During discussions guided by these questions, instructor presented specific information related to the nuclear power plant and the Akkuyu Bay where the power plant was intended to construct. The historical information, expert views, research results and scientific information were presented in the classroom. The aim of presenting a variety of information was to help PSTs to recognize the need of ongoing research during negotiation of SSI. After discussing each probing question integrated with information, debriefing sessions were carried out. These sessions were kind of

round-up of classroom discussions about nuclear power plant. In these sessions, Instructor reexamined and described the main perspectives about nuclear power plant discussed in the classroom; give the main information presented in the classroom; and return to earlier subject of discussions. The aim of debriefing sessions was to contribute to PSTs' socioscientific reasoning in terms of complexity, inquiry and multiple perspectives. Moreover second-order discussions which allow PSTs to think at a more abstract level and transfer their socioscientific reasoning to other socioscientific issues were carried out by the instructor. Instructor performed discussions to segue into theoretical issues about SSI from nuclear power plant; makes the characteristics of SSI more noticeable, makes general statements about the complexity, inquiry and multiple perspectives aspects. These discussions also intended to contribute to PSTs' socioscientific reasoning in terms of complexity, inquiry and multiple perspectives

After phase 1, PSTs' socioscientific reasoning was assessed. An investigation of the data revealed that PSTs' improved their socioscientific reasoning as compared to pre assessment results. In the following part, frequencies of PSTs in levels based on combined scores regarding complexity, inquiry, and multiple perspectives were provided respectively. The frequencies in the assessment after phase 1 were presented as compared to the pre assessment. Related excerpts were provided for each aspect of socioscientific reasoning.

Regarding complexity, the bar graph in Figure 4.10 reveals the number of PSTs in levels on composite complexity scores after phase 1.

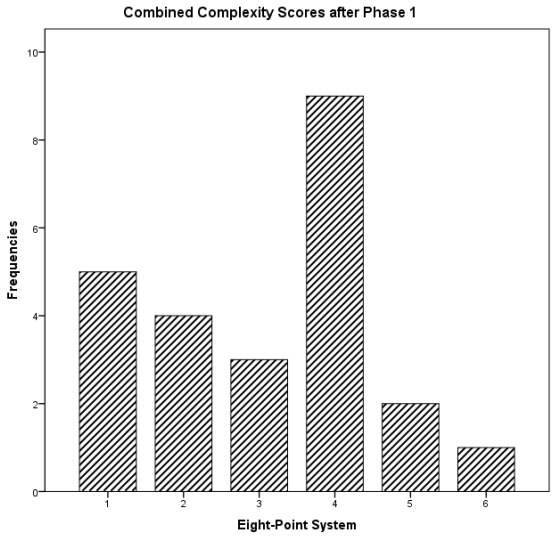

Figure 4.10 Frequency of PSTs in Levels Regarding Complexity Composite Scores after Phase 1

After phase 1, among 24 participants, data analysis indicated that 5 PSTs assigned to level 1 were not able to talk about complex nature of the issue and considered the nuclear power plant as a simple problem which can be solved easily. This number was 6 during the pre assessment. However as compared with the pre-assessment the number of PSTs assigned to levels two or three decreased while the number of PSTs assigned to levels four, five and six increased. As the case in pre-assessment, there were no PSTs in levels seven and eight after phase 1. The following excerpts exemplify the PSTs' reasoning in terms of complexity after phase 1.

For example, the following PST still believed that nuclear power plant is not complex.

> Nuclear power is not complex and challenging. Each country should get it.

The PST below also did not consider nuclear power as a complex and controversial issue after phase 1.

> It is not complex. Using a car in daily life is also dangerous if you are not careful.

The number of PSTs assigned to levels 2 and 3 was six and five during pre assessment respectively. On the other hand there were four and three PSTs in levels 2 and 3 after phase 1 respectively. This means that the PSTs who recognized the complexity associated with SSI without identifying any sources decreased after phase 1 while the PSTs who recognized the complexity and provided sources for complexity increased. Moreover they could identify more than one source after phase 1 as indicated by the increase in the number of PSTs assigned to level four and five. However among 24 PSTs, only 1 PSTs could provide detailed explanation for one source for complexity.

To exemplify, the following PST was able to talk about complexity associated with nuclear power plant and provided one source for it.

> Construction of nuclear power plant is a challenging problem due to safety issues.

Another participant was able to talk about two sources for complexity after phase 1.

> Nuclear power plants have both positive and negative sides. It may provide more energy but it causes bad results for environment.

Two PSTs provided three sources for why nuclear power is complex after phase 1. They referred to economy, society, and environment which makes nuclear power plant complex.

> Many living things and environment will be under danger. Radioactive waste will be produced. It is good for economy but people, environment, and ecosystem will be affected negatively. Thus it is challenging to construct.

Only one PST provided detailed explanation and justification when talking about why nuclear power plant is a complex issue to solve.

> Yes it is complex. In this problem, there are two sides: supporters of nuclear power plant construction and opponents of it. Supporters say that to have enough energy we need it. On the other hand, opponents argue that this is very harmful for ecology due to nuclear waste. These nuclear power plants use uranium as a source and it is radioactive which releases radiation for long years because it has a very long half life.

Regarding inquiry, the bar graph in Figure 4.11 displays the frequencies of PSTs in levels based on combined inquiry scores after phase 1.

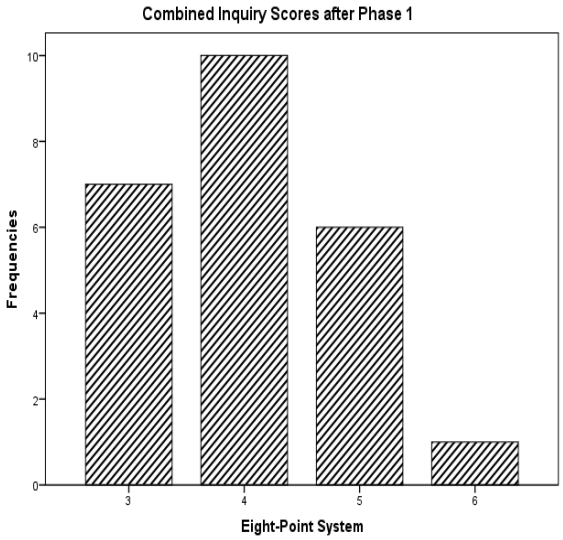

Figure 4.11 Frequency of PSTs in Levels Regarding Inquiry Composite Scores after Phase 1

All PSTs were able to talk about the need for more information to negotiate and resolve nuclear power plant and provided at least one specific line of information necessary for negotiating and resolving nuclear power plant. During pre assessment, among 24 participants, half of them were assigned to levels below level 3. However after phase 1, there were no PSTs under level 3. Moreover the number of PSTs at levels 4 and 5 increased. During pre assessment, none of the PSTs offered responses above level 5. On the other hand after phase 1, one PST provided further explanations and justification and therefore assigned to level 6. To exemplify, the PST below stated the need of information in deciding the construction of nuclear power plant and provided more than three specific lines of information without further explanations therefore he was assigned to level 5 after phase 1 in terms of inquiry aspect.

> I would obtain information about its cost, our uranium source, how we will store nuclear waste, whether we have enough nuclear engineers or other staff.

The following PST also expressed that the negotiation and resolution of nuclear power plant requires ongoing research and talked about two specific lines of information to be needed in decision making process. He could display higher level of reasoning on the energy gap in Turkey and therefore assigned to level 6 in terms of inquiry after phase 1.

> According to the proponents of nuclear energy, Turkey's high rate of economic growth and surging population has led to sharp increases in the demand of energy. It is true that increase in population will lead to energy need. There should be research on how much energy Turkey needs now and within the following years. The amount of energy produced by hydroelectric, solar energy, wind energy, geothermal energy should be calculated. How much energy was lost during transportation should also be investigated. The numbers of energy gap calculated by different institutions are very different from each other. There is something wrong about this information and should be carefully searched before deciding the construction of nuclear power plant.

Regarding multiple perspectives, the bar graph in Figure 4.12 reveals the number of PSTs in each level on combined perspective scores after phase 1.

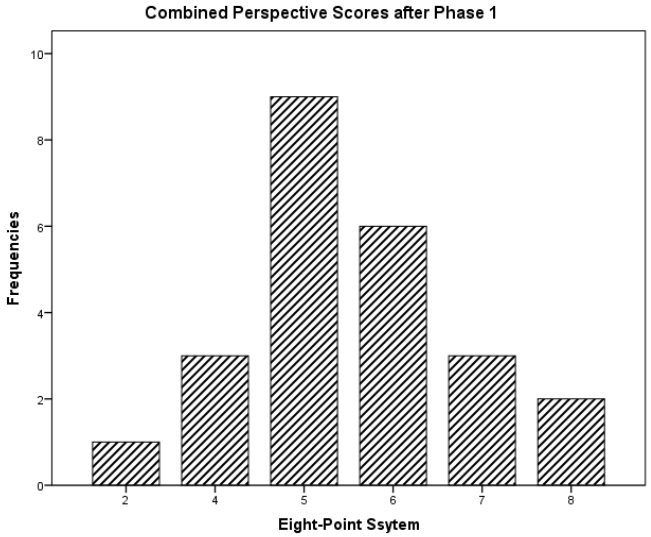

Figure 4.12 Frequency of PSTs in Levels Regarding Perspectives Composite Scores after Phase 1

After phase 1, all PSTs were able to recognize differences in opinions. During pre assessment, there were more PSTs assigned to level 5 and below. However, after phase 1, a majority of PSTs displayed reasoning at level 5 and above. There were already one PST at each level of 6, 7, and 8 in pre assessment. But as seen in the bar graph in Figure 4.12, the number of PSTs in these levels increased. This indicates that more PSTs were able to recognize the differences in opinions and could offer real analysis for multiple perspectives. Moreover half of them could also provide further explanations and justifications in parallel with the analyzed perspective and therefore were assigned to levels 6, 7, and 8.

A majority of PSTs were able to focus on the different perspectives before making a decision on nuclear power plant. For example the following PST stated that

> Nuclear power is a controversial issue. In deciding the construction of nuclear power plant, many issues should be considered because it has many advantageous and disadvantageous. Some say that it is safe, cheap, and clean energy source to reduce global warming. But others claim it is not. The safety is a problem and radioactive waste management is also a problem.

The above PST referred to safety, cost, global warming and waste management issues that should be considered before constructing a nuclear power plant. He was able to link the nuclear power plant as an alternative energy source for reducing global warming. Therefore he was assigned to level 6.

The following PST was also able to talk about the perspectives while discussing his personal decision for the construction of nuclear power plant. He could talk about the impact of nuclear power on environment, economy, and society with further explanations and was assigned to level 8.

> If I were responsible in construction of nuclear power plant, I would investigate different views in terms of environment, economy, and people. I think nuclear power plant is not clean as thought. The proponents of nuclear energy say that it is clearer than other energy sources, but its waste are very harmful for the nature and future generations. The waste of nuclear power plant is stored underground, and it affects the nature for long years due to long half life of radioactive materials. It is also not safe. It destroys nature. Producing of nuclear energy had risks in transporting, processing and storing. It also needs to be removed when it completed its life. It is also no t economical. The proponents claim that Turkey has a potential for thorium reserves and it has 380000 ton thorium reserves. However it has not turned into nuclear fuel. This makes Turkey dependent on other countries for technology which converts thorium into usable form for nuclear power plant. It has also impact on livings. Nuclear waste is radiating alpha, beta or gamma rays to be stable and this causes cancer.

The following PST also talked about economical, environmental, societal and political perspectives associated with nuclear power plant. He could make a detailed analysis in terms of each perspective and provide justifications for his explanations. Therefore he was also assigned to level 8 after phase 1. The excerpt below presents his explanations about the economical perspective of nuclear power plant. He could show a similar high level reasoning for other perspectives.

> It is said that nuclear energy is cheap, when it is compared with other energy sources since we can obtain high amount of energy with small amount of uranium. For instance, one kg of uranium gives 500000 kw/h energy while one liter of petroleum gives 4 kw/h. Moreover Turkey has its own uranium and thorium resources and Turkey can get cheaper energy. However, there is other side of the issue; it is not cheaper as it is seen. Since in order to build a nuclear power plant, we must pay high amount of money. Moreover, after completing its life, high amount of money is needed to dismantle a nuclear power plant and after that we will face another problem which is nuclear waste. In addition to this, it is too expensive to repair a failure; for instance, failure at Bruce and Pickering reactors due to axis slip, calandria tubes were repaired with 1.5 billion dollars per plant.

Another PST reflected on the political aspect of nuclear power plant in terms of reducing Turkey's dependence on foreign countries for energy. He was good at analyzing this aspect with detailed explanations. He was assigned to level 6 after phase 1 in terms of multiple perspectives.

> We are using natural gas from Russia and Iran and petroleum from Iraq. Thus, fluctuation price of natural gas and petroleum affect Turkey's economy in a bad way and these countries can cut the energy sources if there is a conflict between them and Turkey. Moreover, Turkey has uranium and thorium sources which can be used during 40-50 years. Therefore it is thought that nuclear power plant reduces Turkey's dependence on foreign sources. However uranium has to be

> enriched before using and this technology is not found in Turkey. So Turkey will pay for this. There is a reactor type which uses natural uranium but its cost is high, and it is new technology. Moreover, Turkey has thorium more than uranium, but there is not a reactor which uses thorium to produce energy. In addition to this, after 40-50 years, uranium sources will be consumed and Turkey will again become dependent country.

The above PSTs' quotations revealed that after phase 1, PSTs realize complexity, the need of ongoing inquiry and different perspectives associated with nuclear power plant. PSTs showed more notable improvement in multiple perspectives aspect since the number of PSTs at levels 6, 7, and 8 were more when compared to other aspects.

4.2.2 PSTs' Socioscientific Reasoning after Phase 2

Phase 2 included teacher-guided group activity in which PSTs were involved in a decision making activity about nuclear power plant as a group. During this activity, four groups of PSTs concentrated on different perspectives related to nuclear power plant. Three groups concentrated on economy, environment and science aspects of nuclear power separately. The fourth group discussed nuclear power plant in terms of all perspectives. In this phase, PSTs discussed advantageous and disadvantageous of nuclear power plant in terms of economical, environmental, political, and societal perspectives. They examined the nuclear power plant from different perspectives and the possible solutions were based on different criteria suggested by different perspectives. They judged the information they learned in previous classroom discussions and classroom readings about nuclear power plant

and stated the need for extra information for decision making about the construction of nuclear power plant. PSTs expressed dissatisfaction when they deal with the information about nuclear power plant. As a result they obtained information about nuclear power plant through different sources such as internet, readings or they ask instructor. Finally they displayed multidirectional thinking process while making decision about the construction of nuclear power plant. As a result, PSTs struggled in making decision about the construction of nuclear power plant.

After phase 2, PSTs' socioscientific reasoning was reassessed. An investigation of the data revealed that PSTs' improved their socioscientific reasoning as compared to results after phase 1. In the following part, frequencies of PSTs in levels based on combined scores regarding complexity, inquiry, and multiple perspectives were provided respectively. The frequencies in the assessment after phase 2 were presented as compared to the results after phase 1. Related excerpts were provided for each aspect of socioscientific reasoning.

Regarding complexity, the bar graph in Figure 4.13 reveals the number of PSTs in levels on composite complexity scores after phase 2.

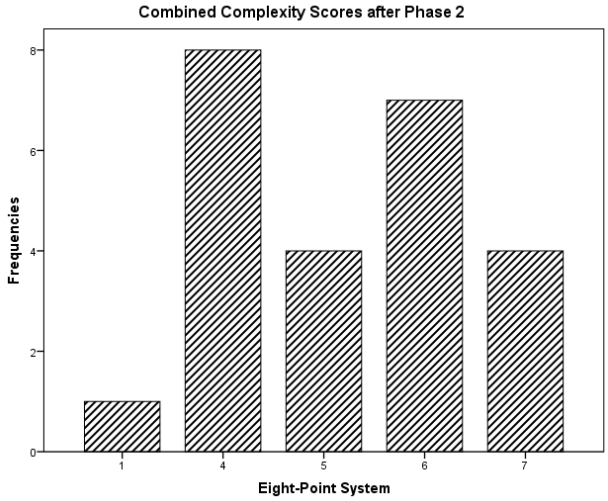

Figure 4.13 Frequency of PSTs in Levels Regarding Complexity Composite Scores after Phase 2

Data analysis indicated that almost all PSTs recognized the complexity associated with socioscientific issues when compared to the results after phase 1. There were 5 PSTs at level 1 which means that individuals cannot recognize the complexity. However after phase 2, this number was reduced to one showing an increase in PSTs' understanding that SSI is complex. More than half of the PSTs (15 PSTs) were assigned to level 5 and above after phase 2 while this number was only three after phase 1. This indicates that a majority of the PSTs participating in the SSI-focused course showed improvement in their understanding that the nuclear power plant is complex. They could also provide sources for why nuclear power is complex with further explanations and justifications for linking those sources with complex nature of the nuclear power.

The following PST was able to mention about complex nature of the issue and provide three sources for complexity without giving detailed explanations about them. Thus he was assigned to level 5 after phase 2.

> Discussing all different things made me think about how difficult to make a decision about nuclear power plant construction in Akkuyu. I can understand why it is decided to be constructed before 2000s but still not constructed. It needs to be thought carefully not to harm environment and livings on one side, also not to harm economy and politics on the other side. So difficult and complex…

Another PST also referred to pros and cons of nuclear power plant and stated complexity and difficulty in decision making about it. He talked about environmental, political, and economical aspects without mentioning details about them. Therefore he offered a level 5 response after phase 2.

> Nuclear power plants are scientific environmental dilemmas and are significantly hard to decide. I learned pros and cons of NPP construction. I concentrated on environmental negative effects but there are also positive effects for economy and politics. So it was difficult to make a balanced decision among all dimensions.

Regarding inquiry, the bar graph in Figure 4.14 shows the number of PSTs assigned to levels based on their combined inquiry scores after phase 2.

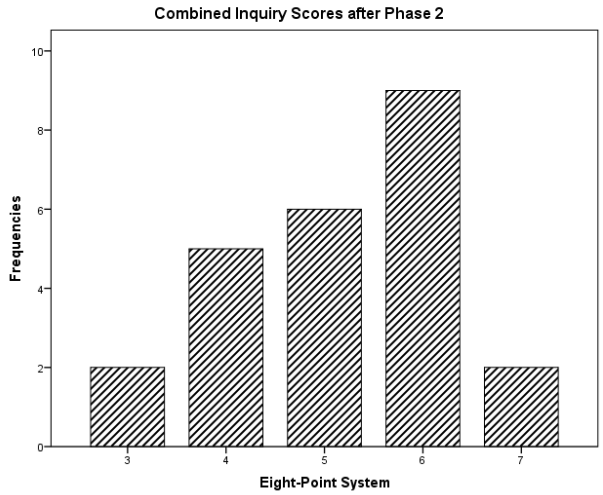

Figure 4.14 Frequency of PSTs in Levels Regarding Inquiry Composite Scores after Phase 2

A comparison of the results after phase 1 and phase 2 showed that after phase 1, almost all PSTs were assigned to levels 3, 4, and 5. This means that they all understood that SSI is subject to ongoing inquiry and provided specific lines of information for resolution of a specific SSI. However, they could not reason further why the information they specified in necessary after phase 1. When the results after phase 2 were investigated, it was found that almost all PSTs displayed reasoning at level 4 and above as seen in Figure 4.14. Moreover half of them offered level 6 and 7 responses. This means that they could not only provide specific line of information to negotiate and resolve SSI but also presented detailed explanations and justifications for that information. As a result, it was clear that a majority of PSTs showed higher levels of socioscientific reasoning after phase 2.

For example the PST below expressed that they needed more information and searched for it through web. He was able to talk about the importance of seismic

stability to construct a nuclear power plant. Based on his answer, he was assigned to level 6 because he provided further explanations for the relation between nuclear power plants and seismic background of the construction area.

> There is one thing that I am unhappy about this issue. The information about NPP varies greatly from one scientifically encountered article to another. We could not decide which one to consider as reliable and to use as evidence so we looked at internet for more information. For example the suggested area is not suitable for the construction of nuclear power plant. One of the criteria for selecting areas for nuclear power plant was the seismic stability of the construction area. However we found that Akkuyu Bay experienced earthquakes very close to it and this may be a threat for nuclear power plant. Earthquakes can cause nuclear accidents and leakages and can threaten the surrounding ecosystem.

The PST below referred to getting information in resolving the controversial issues and obtaining more information during the decision making process. His response included detailed information about nuclear waste and safety issues. He was assigned to level 7 after phase 2.

> I realized that if there is a debatable issue, firstly I should get information and investigate the issue and look for more information during decision making as we did as a group because we are not satisfied with information we already have. While we are focusing on the impact of nuclear waste on environment, we only said that it is dangerous for environment but the important point was why it is dangerous. We searched and found that nuclear waste includes radioactive materials emitting radiation until they are all consumed up. However this is not a one or two day process because they have long half life years. Nuclear waste has a great potential to threat both the environmental security and diversity. Nuclear waste must be cooled first and then put under the ground. It must be checked about 300 years in order to avoid any leakage of radiation.

Another PST below reflected on the obtaining more information through internet because of the fact that they may not know some information. He referred to the need of information in terms of different perspectives and provided a level 5 response in terms of inquiry after phase 2.

> To make decision about nuclear power plant, a great deal of information is necessary. And still there can be many unknown too. So as a group we searched for more through internet and discussed them. To decide for the construction of nuclear power plant, we needed information from different perspectives such as environmentalists, scientists, economists. Some people claim that nuclear energy is safe, cheap, and clean but we should learn about it from the experts.

Regarding multiple perspectives, the bar graph in Figure 4.15 shows the number of PSTs assigned to levels based on their combined perspectives scores after phase 2.

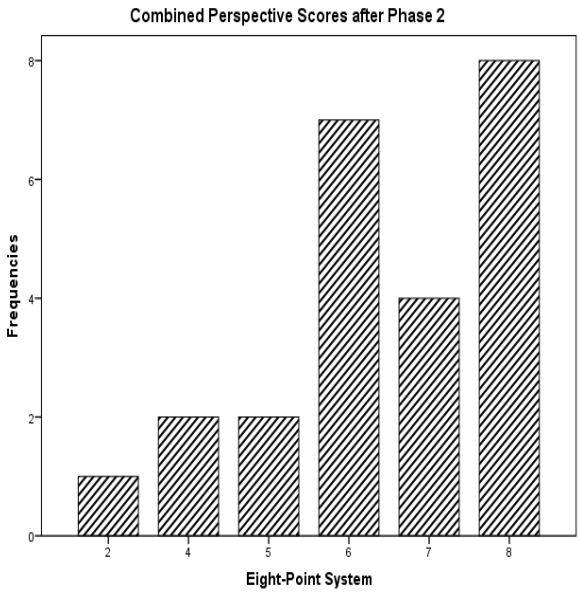

Figure 4.15 Frequency of PSTs in Levels Regarding Perspectives Composite Scores after Phase 2

After phase 2, among 24 participants, all PSTs valued the differences in opinions among individuals. This was also the case after phase 1. However the number of PSTs who both recognized the differences in opinions and analyzed the given perspectives with further explanations and justifications increased as compared to the phase 1. The number of PSTs assigned to levels 6, 7, and 8 increased from 11 to 19 PSTs after phase 2. This shows that a majority of PSTs recognized and stated differences in opinions and interests and further explanations, justification or reasoning for them.

The below excerpts show that PSTs showed a great understanding about different perspectives, interests, and ideas in discussing SSI. All participants referred to the role and necessity of multiple perspectives in making decision about SSI in their reflection papers. Then they were able to talk about different perspectives and their ideas. Therefore most of them were assigned level 6 and above after phase 2 regarding multiple perspectives. To exemplify, the below PSTs stated that

> I realized that each group may evaluate this issue from different perspectives based on different criteria. For example environmentalists explained their ideas with respect to ecological and environmental aspects. Because the criteria differ, their final conclusions differ and I learned that the reason of reaching different conclusions may result from looking different perspectives or using different criteria. I also learned that such an important decision that would seriously affect citizens requires different perspectives to be discussed and evaluated.

Another PST reflected on the multiple perspectives as

> While we are making a decision on nuclear power plant, I realized that there are different ideas about the topic. We had a chance to learn different views about it and to discuss good and bad things about it. For example we learned that it has not only environmental aspect but also economical and political aspects. Because we generally hear about the bad effects of nuclear power on environment and people. I was a great opponent of nuclear power. But now I can also think other perspectives and make a more balanced decision.

The following PST also talked about different perspectives of nuclear power plant.

> There are many aspects of nuclear energy such as environment, economy, and health. Decision makers should not bear ideas and evidences of only one side. They should gather information, ideas, and evidences from each group in order to make an effective decision. The ideas of each side have both weaknesses and strengths. The role of decision makers is to make balance between them.

The PST below stated the importance of multidirectional thinking about nuclear power and the roles of different views in decision making process.

> We have to think multidirectional about the issue. The decision making process needs cooperation of a variety of people and brain storming of all experts. If you make a critical decision, you must look from different perspectives and you must think impacts of your decisions on different agents. As a group we understood how different people think different. There can be different point of views about nuclear and decision makers have to listen to these views and evaluate them while making a decision.

CHAPTER 5

DISCUSSION AND IMPLICATIONS

This chapter provides discussion of findings presented in the previous chapter. It focuses on the depth rubric developed as a result of initial data analysis and the improvement in PSTs' socioscientific reasoning before, during and after SSI-focused course.

5.1 The Depth Rubric and the Improvement in PSTs' Socioscientific Reasoning in Response to SSI-Focused Course

In this part, the findings of the first research question were discussed. First research question investigated the change in PSTs' socioscientific reasoning in response to SSI-focused course before and after SSI-focused course. For this purpose, pre and post interviews were analyzed. The initial data analysis revealed that in addition to the rubric used by Sadler et al. (2011), a new rubric was developed for better addressing differences in PSTs' socioscientific reasoning. In the next section, the new assessment strategy for SSR was discussed first then the change in PSTs' SSR was discussed based on the two rubrics.

5.1.1 The New Rubric for Analyzing Socioscientific Reasoning: The Depth of SSR

The first significant trend to emerge from the data was the development of depth rubric to assess SSR. Socioscientific reasoning is a construct which describes important characteristics of SSI. It emphasizes that SSI discussions should be oriented toward understanding and practicing these invariant features of SSI. The assessment of individuals' socioscientific reasoning is another issue to be considered. The data analysis was first conducted by the previous rubric (called as breadth rubric in this study) developed by Sadler et al. (2011). The initial analysis revealed that this rubric was not capable of addressing differences between PSTs' socioscientific reasoning levels. With breadth rubric, we were able to assess PSTs' responses at knowledge or comprehension cognitive levels but cannot differentiate them at higher cognitive levels. Tal and Kedmi (2006) expressed that higher order thinking skills refer mainly to cognitive abilities, which are beyond the stages of recall knowledge, understanding and lower levels of application according to Bloom's Taxonomy. That is breadth rubric was able to assess lower level cognitive skills below the application level on Bloom Taxonomy. The main concern for the breadth rubric was that although some participants were assigned to the same level, they actually differ in their reasoning. The reason was that the breadth rubric assessed SSR in terms of quantity. The level descriptions of breadth rubric assessed the number of sources provided for complexity, the number of specific lines of inquiry, and the number of perspectives examined. It mainly focused on individuals' comprehension of complexity, perspectives, and inquiry and the

number of specific information related to each aspect. This was exemplified in chapter 3. To remind, PST 4 and 12 (quotations were provided in chapter 3) talked about complexity and listed sources for the complexity associated with nuclear power plant during the pre interviews. When we assessed their SSR with the breadth rubric, they were assigned to the same level. However PST 4 displayed a higher level of reasoning by justifying why those sources can be a potential reason for making nuclear power plant complex. He was able to develop opinions, evaluate evidence and provide scientific justification for his claims. Although the difference in two PSTs' reasoning could not be captured with breadth rubric, the development of depth rubric enabled researchers assess the differences in PSTs' reasoning. The reasoning PST 4 displayed is at a level more than comprehension because justification and evaluation are at the cognitive level of evaluation. Drapeau (2009) also supported that "depth of reasoning is often attributed to the original higher levels of Bloom's Taxonomy such as analysis, synthesis, and evaluation" (p.7). As a result, PSTs were assessed at higher cognitive levels with depth rubric.

To conclude, breadth rubric was not capable of capturing participants' cognitive differences. However depth rubric addressed the nuances in PSTs' SSR and could differentiate PSTs in terms of cognitive outcomes. In this study, depth rubric emerged after the initial analysis of data. There might be several reasons for this. First, Sadler et al. (2011) used the breadth rubric to analyze data obtained through an open-ended questionnaire. It was in congruent with the nature of the instrument

which was administered as a questionnaire to a larger sample and the answers were restricted. Since they could not interview with the participants, the responses were brief and limited. Therefore they may choose to analyze the responses in terms of quantity. However, in this study, PSTs were interviewed and in-depth information was obtained. It is widely known that interviews can provide in-depth information and insights about the phenomena being studied (King & Horrocks, 2010). Therefore through interviewing rather than using open-ended questionnaire, the participants presented deeper reasoning and this was reflected in their responses. Critical examination of data led to the development of depth rubric to meet the drawbacks of breadth rubric and to explore individuals' reasoning further. As a result, depth rubric was developed, validated and used to assess SSR in addition to the breadth rubric. Second, Sadler et al. (2011) studied with high school students while the participants of this study were the senior PSTs. Zeidler and Schafer (1984) found that third and fourth grade environmental science college students did reason at higher levels in resolving environmental dilemmas. The study of Weinstock, Neuman, and Glassner (2006) also suggested that the cognitive ability to assess different types of informal arguments was related to grade level.

5.1.2 The Change in PSTs' SSR during Pre and Post assessments

The findings of data analysis with breadth rubric showed that all PSTs demonstrated high levels of socioscientific reasoning after participating in SSI-focused course. Breadth rubric assessed whether individuals could understand the complexity, inquiry, and multiple perspectives aspects of SSR and list sources for

complexity, provide specific lines of inquiry, and discuss the issue from different perspectives. There was significant increase in PSTs' reasoning in terms of all aspects of SSR (i.e. complexity, inquiry, multiple perspectives) when the pre and post interviews were analyzed with breadth rubric. The comparison of PSTs' pre and post interview scores on depth rubric also showed that all PSTs demonstrated high levels of socioscientific reasoning after participating in SSI-focused course. Unlike breadth rubric, depth rubric did not evaluate the numbers associated with the aspects of SSR. Rather depth rubric assessed whether participants provided arguments and justifications for their understandings of complexity, inquiry, and multiple perspectives aspects of SSR.

The present study also documented statistically significant differences in students' pre- and post composite scores for each aspect of SSR. In order to be able to perform statistical analysis on PSTs' SSR scores, the scores obtained from breadth and depth rubric was combined for each individual and Wilcoxon signed rank test was performed for each aspect separately. As a result it was found that PSTs significantly performed better on complexity, inquiry, and perspectives aspects of SSR after SSI-focused course. The results of this study showed that students' experiences in a semester-long SSI-focused course may improve their reasoning in terms of complexity, inquiry, and perspectives. These experiences include understanding key issues, posing questions, providing arguments and justifications, evaluating information and evidence, thinking critically, collaborating with group members, and making decisions. These cognitive challenges PSTs experienced in

the course may influence the way they negotiate and resolve socioscientific issues. Reasoning, posing questions, providing arguments and justifications, evaluating information and evidence, systemic and critical thinking are all considered as higher order thinking skills (Cuccio-Schirripa & Steiner, 2000; Dori & Herscovitz, 1999; Driver et al., 2000; Duschl, 1990; Hogan, Nastasi, & Pressley, 1999, Russell, 1983; Zeidler, Lederman, & Taylor, 1992). These skills should not be considered as outcomes that should be reached at the end of a learning process (Resnick & Resnick, 1992). Rather they are the goals that should be addressed throughout a learning process. However attainment of these skills requires time and a variety of instructional strategies. For example Sadler et al. (2011) explored potential change in SSR through a variety of classroom implementations and found that there were no statistically significant differences in students' pre and post socioscientific reasoning. They attributed this to the short term intervention and suggested that changes in socioscientific reasoning may require longer term implementations (Sadler et al., 2011). There are also a number of studies that report improvement of higher order thinking skills such as reasoning requires intense and long interventions. For example, Dori, Tal, and Tsaushu (2003) aimed to improve high school students' higher order thinking skills such as application, question posing, providing arguments, value judgment, providing multiple solutions, recognizing complexity and uncertainty, and system thinking through case studies in biotechnology. Similar to this study, they also required students to work in small groups, formulate questions, search for and evaluate evidence, and express their own ideas in making decisions about controversial issues. They found that students

developed their higher order thinking skills and scored significantly higher in higher order thinking skills. They stated that small group and class discussions contributed to the development of these skills as students experienced peer interaction, expressed their ideas and justified them with evidence.

In this study the change in PSTs' reasoning may also be attributed to the fact that they discussed SSI through a variety of instructional strategies. It is suggested that students should receive guided assistance in practicing their thought processes (Stiggins & Chappuis, 2012). In this study, PSTs also received assistance to develop their reasoning in socioscientific issues through teacher-led discussions and group activities. These activities may be influential in the improvement of their reasoning in terms of complexity, inquiry and multiple perspective-taking associated with SSI. The study of Grace (2009) supported that students were better at reasoning about biological conservation issues after peer group discussions. Grace (2009) investigated the effect of peer group decision-making discussions in secondary school students' reasoning in conservation issues. In these discussions, students tried to make a decision on what should be done about the issue, why and how. Similar to the independent group discussions in this study, Grace (2009) was not involved in groups' decision-making discussions. After these discussions, students moved up to higher levels of reasoning (i.e. justified arguments including alternatives) from lower levels (i.e. non-justified arguments with single solutions). Ratcliffe (1997) also explored the 15-years-old pupils' decision-making on social issues such as use of energy more efficiently. In the decision-making discussions,

Ratcliffe (1997) asked students identify alternative actions for the issues, develop criteria for each alternative, evaluate information, consider advantages and disadvantages of alternative actions, and choose an action based on the this systematic discussion. In this study, PSTs were also engaged in similar systematic discussion of nuclear power plant and other socioscientific issues. Ratcliffe (1997) found that such systematic discussions about advantages and disadvantages of socioscientific issues, which mean a structured decision-making process, also may assist reasoning. Another study conducted by Seethaler and Linn (2004) revealed that eighth grade students could able to reason and use appropriate evidence to argue for their positions on genetically modified food (GMF) after they participated in a GMF-based curriculum. Similar to the SSI-course in this study, in GMF-based curriculum, students negotiated GMF, learned history of it, read articles, worked as groups, and presented posters and oral presentations. In the teaching and learning activities carried out in SSI-focused course, elements of argumentation such as claim, justification, and rebuttal are frequently used. The use of argumentation can also enhance PSTs' socioscientific reasoning. There is evidence in the literature that shows the development in reasoning can be facilitated through argumentation (Zohar & Nemet, 2002; Maloney & Simon &, 2006). For example Zohar and Nemet (2002) characterized students' reasoning abilities with various types of arguments after a genetics unit focused on argumentation. Positive gains in students' argumentation skills were attributed to the development in their reasoning in dilemmas which are part of students' daily lives. This study also provided empirical evidence for the development of reasoning about socioscientific issues

after a variety of classroom implementations. Sadler et al. (2007) emphasized that SSI practices should be oriented in a way that advances individuals' conceptualization of SSI in terms of its nature of complexity and their understanding that solving SSI includes investigating multiple ideas, perspectives and interest. In light of this there are studies that emphasize some classroom activities which might result in better learning outcomes in terms of socioscientific reasoning and decision making processes in the context of SSI (e.g. Eggert, Ostermeyer, Hasselhorn, & Bögeholz, 2013; Lee & Grace, 2012). These studies will be mentioned in the next section, since in this study, different classroom activities were also designed to support socioscientific reasoning.

5.2 SSI-Focused Course as the Classroom Design Experiment

In addition to the investigating the change in PSTs' socioscientific reasoning before and after SSI-focused course, their reasoning during SSI-focused course was also examined. During the SSI-focused course, three phases was developed. First phase included teacher-led whole classroom discussions, second one included teacher-guided group activities and the last one included independent group activities. After first and second phases PSTs' SSR was reassessed and it was found that their reasoning improved gradually during the SSI-focused course. The effect of teaching and learning activities in each phase was discussed below.

5.2.1 Teaching and Learning Activities

5.2.1.1 Teacher-Led Classroom Discussions

Teacher-led discussions aimed to assist PSTs to conceptualize the issue from different perspectives, to explore and elaborate on PSTs' ideas, to engage them with thinking, reasoning and reflection processes about SSI. Within the SSI-focused course, PSTs considered the complexity, inquiry and multiple perspectives aspects of nuclear power plant and the teacher-led discussion may explicitly support PSTs to comprehend about the role of these aspects in negotiating and resolving both nuclear power plant and other socioscientific issues. Tal and Kedmi (2006) emphasized that thoughtful whole classroom discussions in which teacher asks questions, encourage students to provide reasons, evidence, and justifications can support students' reasoning in socioscientific issues. In this study teacher also facilitated whole classroom discussions and engaged students in whole class questioning and answering sessions. These questions were not closed questions. The closed questions were also not accepted by scholars in order to promote reasoning skills (Ratcliffe & Grace, 2003). These questions focusing on different dimensions of nuclear power plant may help students learn about different interests, ideas and thoughts and also reason about them. PSTs discussed nuclear power plant from different perspectives and they talked about why different perspectives exist. As a result this may contribute to their socioscientific reasoning, specifically the multiple perspectives dimension. Tal and Kedmi (2006) found that teachers mostly used whole class discussions in dealing with socioscientific issues and these discussions made students aware on the issues by actively engaging them

in debates. They concluded that teacher-guided discussions can be effective in achieving higher level of reasoning and higher quality explanations since teachers can foster students to carry out thoughtful work while asking them to provide evidence for claims, identify conflicting values, provide alternatives and critique others' ideas. Tal and Kedmi (2006) emphasized that "in order for students to communicate effectively with others in the process of decision-making in the context of socioscientific issues, they need to learn to ask questions, obtain evidence, understand characteristics and limitations of scientific evidence, identify value positions or ideologies of both sides and have access to appropriate social criteria for judging credibility of scientists" (p.622). Teacher-led discussions can provide opportunities for their effective communication during group activities. In the following sections teacher-led classroom discussions and group activities were discussed in detailed. The teacher carefully engaged PSTs in activities and discussions to support them in comprehending the complexity, inquiry, and perspectives aspects of SSR. The instructor did not only introduced new ideas and concepts but also provided support and guidance for PSTs to develop socioscientific reasoning. The instructor's activities and implementations might be reflected as developed thinking and reasoning skills on the part of PSTs. Mercer (1995) referred to the role of interaction and talk among learners in supporting learning and cognitive development. Especially the use of conflicting ideas within discussions can enhance PSTs' understandings about aspects of SSR. Mercer (1996) emphasized that when two opposite world-views are interacted, the attempts to resolve the conflict occurred results in some learning and improved

understanding. This is also supported by the concept socio-cognitive conflict by the followers of Piaget to explain how individuals' understandings can be enhanced through use of different understandings of the events (Mercer, 1996). Gambrell (2004) also suggested that providing opportunities for students to interact with one another and to challenge the ideas of others supports higher level of thinking. In terms of negotiating SSI, the socio-cognitive conflict may have a potential role for development of understandings about SSI since these issues already include conflicts and dilemmas. Within SSI-focused course, PSTs have been challenged and exposed to cognitive conflicts through discussing opposing ideas and they tried to find a solution to these ideas to solve the nuclear energy crisis. In the next section the specific aspects of teacher-led classroom discussions were negotiated in detailed.

5.2.1.1.1 Aspects of Teacher-Led Classroom Discussions

5.2.1.1.1.1 Probing Questions

Within the SSI-focused course, teacher-led discussions about nuclear power plant were initiated by probing questions. The nature of the questions revealed that these questions emphasized different perspectives related to the nuclear power plant. As a result, PSTs did not only investigate the nuclear energy from a single perspective rather they discussed different claims proposed by different stakeholders. Instructor asked the questions one by one and set the stage for PSTs to negotiate about each one. The use of probing questions framed the nuclear power plant from different perspectives which includes economy, society, politics, and environment. Framing

is introduced as a tool for the construction of social reality and emphasized for cognitive categorization (Scheufele, 1999). Entman (1993) described framing as "to frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation. Framing is a systematic way of delivering information to help public understand and form opinions about science related topics (Nisbet & Scheufele, 2007). Framing, as in this study, can be a way to discuss controversial issues in classrooms. Gardner and Jones (2010) also emphasized that instructors may choose to present information about controversial issues through framing. They expressed that "framing theory examines how science content is delivered to the public through scientists, the media, non-governmental organizations, and other communicating institutions" (p.5). Framing can have a significant role in individuals' thinking and decisions. Nisbet and Scheufele (2007) supported this by comparing the climate change and stem cell research and stated that stem cell research could not receive enough attention from public since scientists could not successfully employ framing for the stem cell research. Public did not have enough information about stem cell research and could not form opinions about it. However, framing has some limitations since it may bring certain aspects of the issue to the forefront and to hide others (Chong & Druckman, 2007). Therefore considerable attention should be paid to how the issues were framed. In this study, nuclear power plant was also framed in terms of economy, environment, society, and politics. No one aspect has been prioritized over others. By this way, PSTs had

a chance to discuss different aspects of nuclear power plant as they referred to them in their interviews and reflections. They considered these aspects while they make decisions on nuclear power plant. It was found that framing affects decision making process when different descriptions of the same problem emphasize different aspects of the outcomes (Kahneman, 2002). Shafir (1993) studied behavior of people in deciding when they are faced with choosing among options. He framed his study on pros and cons of the options with different weights on pros and cons. He found that the choosing or rejecting an option depends on the positive and negative features of it. That is, if an option has positive features, individuals choose it but if it has negative features, it is mostly rejected. Gamson (1992) states that frames diagnose, evaluate, and prescribe. That is, frames define problems in terms of causes, costs and benefits, diagnose causes with the underlying forces, make moral judgments through evaluating causes and consequences, and recommend prescription to treat the problem. Entman (1993) emphasized that framing includes selection and highlighting elements on which arguments about the problem are proposed and then their evaluation and solution are discussed. In framing, selected element constitutes the topic of discussion. Framing may help individuals understand the problem, in addition to how they negotiate pros and cons, evaluate them and deciding an action to take. Kahneman and Tversky (1984) proposed that framing is a valuable reflective tool which assists decision makers in their evaluation of causes and values tied to the consequences of their choices. Therefore framing may support cognitive engagement in discussions of controversial topics. In this study, it was also supported that framing a

controversial issue in terms of different perspectives may help individuals to understand that controversial issues have more than one aspect and all should be examined carefully before making a decision.

5.2.1.1.1.2 Presenting Information

In this study, instructor presented a variety of information during teacher-led classroom discussions. These were historical information, research results, expert views, and scientific information. Presentation of such information may be helpful for PSTs' developing socioscientific reasoning especially the inquiry aspect of it because PSTs referred to the information presented in their post-interviews and written reports. Being informed about socioscientific issues is an important issue for negotiation and resolution of these issues. If individuals do not have adequate knowledge and information, they may rely on social values and pick up information sources to confirm what they already think and believe (Nisbet & Scheufele, 2007). In order to prevent this, individuals should be informed and knowledgeable about socioscientific issues to be able to make thoughtful negotiations and informed decisions. Legrenzi, Girotto, and Johnson-Laird (1994) identified some key components for how people reach decisions in daily life. One of these components was seeking information. They conducted a study about people's decisions about whether or not to go to a movie. They found that when people have to make a decision, they mostly tend to request information to help them make a decision. They also added that to obtain more information they ask questions about the task or issue on which they have to make a decision. The

present study also utilized a similar approach. PSTs were required to make a decision about the nuclear power plant construction and they seek for more information (such as seismic stability of the place on which the power plant will be constructed) and asked questions about different issues related to the nuclear power before making a decision. During the SSI-focused course, PSTs read many articles and research studies about nuclear power plant as well as the instructor presented a variety of information. Presenting information and discussing them in the classroom may develop PSTs' understanding for the need of ongoing inquiry to negotiate and resolve socioscientific issues. Individuals may not have enough knowledge about these issues and their reasoning may be low. However, after gaining necessary information, they can show higher levels of reasoning.

Instructor explicitly referred to the role of science in negotiating and resolving SSI. Moreover instructor taught the scientific information which is related to the nuclear power. PSTs used this information in stating the need for more information and the specific lines of information. They also used it to justify their ideas and claims when they are asked to take positions in terms of different perspectives. The role of science in socioscientific issues cannot be disregarded. As Sadler and Zeidler (2005) emphasized that these issues have science aspect. In the SSI literature there is also an assumption that an individual's content knowledge has a role in his reasoning (Leighton & Bisanz, 2003; Patronis et al., 1999; Sadler & Donnelly, 2006; Sadler & Zeidler, 2005; Yang & Anderson, 2003) Being aware of the learning of science as a major goal of science education, discussion of SSI should enhance students'

understanding of science concepts (Sadler et. al., 2007). Wu and Tsai (2007) also recommended the integration of specific science content for better reasoning. Another point is that socioscientific issues involve scientific ideas but students may not rely on them in negotiating SSI. Students depend on many sources of information such as newspapers, magazines, friends, family in developing their ideas and positions regarding socioscientific issues (Sadler, 2004). Kolstø et al. (2006) also discussed that scientific content knowledge is not sufficient alone in negotiation and resolution of SSI and emphasized the need of different sorts of scientific information and research journals. Therefore as the case in this study, a variety of information including scientific, historical, or research results should be provided so that PSTs understand the need of ongoing research and more information in negotiation and resolution of socioscientific issues.

5.2.1.1.1.3 Debriefing Sessions

Debriefing was also conducted in the SSI-focused course to support PSTs' learning and reasoning. Debriefing sessions were often initiated by the instructor and followed with a discussion between the instructor and PSTs. From the perspective of researcher, debriefing sessions were influential on PSTs' socioscientific reasoning. The instructor summarized, reviewed, and introduced the main ideas discussed in the whole classroom discussions. Literature review revealed that debriefing is mostly a part of nursing education. For example, Dreifuerst (2009) described debriefing as "the process whereby faculty and students reexamine the clinical encounter, fosters the development of clinical reasoning and judgment

skills through reflective learning processes" (p. 109). Although the subject matter is different in nursing education, the aim is the same with this study. The debriefing in SSIs also includes the reexamination of the SSI discussed, foster development of socioscientific reasoning skills allowing PSTs reflecting on ideas. Dreifuerst (2009) emphasized that significant learning occurs when deep insight is made explicit through reflection during debriefing. Warrick, Hunsaker, Cook and Altman (1979) stated that the debriefing sessions are essential for making an experiential learning exercise as a meaningful learning experience. After experiential learning in which a task or activity is designed to teach concepts and ideas through active student involvement, debriefing of concepts, ideas, values and insights in a structured way may enhance learning. Therefore in this study through structured debriefing sessions in which instructor guided discussion and learning insights in terms of aspects of SSR can be influential for the improvement of PSTs' SSR.

5.2.1.1.1.4 Second-Order Discussions

Second-order discussions were conceptualized in this study as discussions about SSI as a theoretical construct. Within SSI-focused course, there occurred many activities and discussions about nuclear power plant as a specific SSI. However there also occurred discussions focusing on complexity, inquiry and multiple perspectives aspects of socioscientific reasoning after PSTs practiced these aspects. From the perspective of the researcher, second-order discussions may serve as an effective and complimentary theoretical discussion in addition to the classroom discussions and activities about nuclear power plant. It was aimed that students

develop an understanding for reasoning on socioscientific issues and learn about the nature of socioscientific issues through second-order discussions. Second order discussions might help students develop necessary knowledge and skills for negotiating socioscientific issues and for informed decision making because they explicitly discuss the aspects of SSR through these discussions. Explicit approach is a common approach in teaching the tenets of nature of science. There are a number of studies that provided evidence for successful nature of science teaching through explicit approach (Abd-El-Khalick & Lederman, 2000; Akerson, Abd-El-Khalick, & Lederman, 2000; Khishfe, 2008). In the nature of science literature, it was noticed that different nature of science activities was carried out to highlight tenets of NOS, then whole class discussions explicitly referring each tenet occurred (Akerson et al., 2000). By the same token, within the SSI-focused course, discussions and group activities were performed about nuclear power plant then the invariant features of socioscientific issues (i.e. complexity, inquiry, multiple perspectives) were explicitly discussed through second-order discussions. As explicit discussions improves individuals' nature of science views, it was believed that explicit discussions about invariant features of SSI enhances the PSTs' socioscientific reasoning in terms of those features.

5.2.1.2 Group Activities

In the present study, the results also revealed that group activities enhanced the PSTs' socioscientific reasoning in terms of complexity, inquiry, and multiple perspectives. In group activities, learners can display a variety of ways to describe,

explain, make connections, draw conclusions, and find solutions. Group members reason together, share negotiation, evaluate claims and evidences and reach a consensus on the problem. They can be richer in terms of higher cognitive level interactions than teacher-led discussions providing sustained and active engagement in learning (Galton, Hargreaves, & Pell, 2009). Teacher-guided group activities and independent group activities included decision making on different SSIs. "Decision making is an inherently complex process, encumbered by multiple possibilities and agendas" (Pedretti, 1999, p. 178). While working on socioscientific issues, decision making can be more complex since SSI is also complex in nature and requires high level reasoning and understanding of the issue and the decision making process. Eggert, Ostermeyer, Hasselhorn, and Bögeholz (2013) agree that SSI and its negotiation in classrooms requires high mental processes in which students obtain and evaluate information from different points of view through argumentation and reasoning processes. As Sadler (2004) argued SSI is complex and requires more complex reasoning rather than simple cause and consequence system. The issue should be understood well enough to acknowledge its complexity and multidimensionality. Then investigating different kinds of information and views follows it. Solutions or decisions are based on different information and views. Tentative solutions can be suggested reflecting the dynamic nature of the issue. For informed decisions, a wide range of interests, viewpoints, experiences, information, facts related to scientific, social, economical or political should be critically but constructively investigated and the final decision should reflect all views, at least at a reasonable degree to provide balance among them.

Public involvement in decision making about science and social issues including environmental and health concerns goes back late 1990s in time (Rowe & Frewer, 2000). Obtaining the ideas of public about those issues is an important issue for a government before getting started since public can protest the actions of government and do not trust in government's activities and actions any more. These results were also in consistent with Pedretti's (1999) study which also included a decision making activity on a controversial issue. She also emphasized that such decision making activities help students address multiple perspectives related to the issue, and complex relations between science and society. Students' reflections after decision making activity provided justification for the contribution of the activity to their understanding of different perspectives, complexity of the issue and the need for more but reliable information in solving such socioscientific issues. There are also many studies having findings which reveal that group work and collaboration in the groups result in higher levels of reasoning through discussing and elaborating each others' ideas (Hogan, 2002; Mercer, Wegerif, & Dawes, 1999; Resnick, Michaels, & O'Connor, 2010). Therefore the group activities in this study also had similar influences on students' socioscientific reasoning about nuclear power.

Kuhn (2005) stated that group activities offer opportunities for students to reveal their own perspective, explore others' perspective and integrate evidence in resolving conflicts. Grace (2009) and Lee (2010) also considered the group activities more effective in promoting reasoning in controversial issues. In this

study the effect of group activities was more evident with respect to socioscientific reasoning since PSTs were challenged by complexity, multi-perspective reasoning and doing research about the issue during group activities more. This was evidenced by their statements in reflection papers directly referring to the aspects of socioscientific reasoning and also their organization of group discussions. Tal (2005) also studied with pre-service teachers on a local environmental problem. The pre-service teachers in Tal's study stated that group investigation was most effective in discussing the problem. Kirschner, Paas, and Kirschner (2009) claimed that when the learning task is complex and requires higher order thinking, it is more effective for students to share the cognitive load within a group and reduce this load. Being aware of the fact that negotiating and resolving SSI is complex and requires reasoning from multiple perspectives, group activities will provide benefit in sharing information processing and reduce the cognitive load (Eggert et al., 2013). Eggert et al. (2013) also hypothesized the effectiveness of group activities over traditional instruction in terms of improving socioscientific reasoning and their study approved their hypothesis. Group activities and peer discussions were seen more effective since "they are more vocal, and [students] feel freer to express ideas while they have the opportunity to interrelate values with complex conceptual issues. In this way, they learn to build qualified arguments. The discussions are more varied, generative and exploratory, even when the task is demanding" (Tal & Kedmi, 2006, p. 622). Therefore in this study, the group activities were believed to be more effective. Two types of group activities were carried out in the SSI-focused course as teacher-guided and independent group activities. Teacher-guided

group activities similar to the teacher-led discussions included nuclear power plant as SSI context. The assessment of SSR in pre and post interviews was also based on the nuclear power plant. That is the assessment and the intervention SSI contexts were the same in this study. This is different from previous studies on SSR. Sadler et al. (2007) and Sadler et al. (2011) used different SSI contexts in the intervention and in the assessment. However in this study the independent group activities included different SSI contexts and PSTs were able to make thoughtful negotiations in terms of SSR and informed decisions on each SSI. Therefore although nuclear power plant was used both in the intervention and in the assessment, PSTs were able to reason, negotiate, and make decisions in other SSIs. This shows that the improvement in PSTs' socioscientific reasoning was observed not only in the context of nuclear power plant but also in other SSI contexts. The next two sections discuss the teacher-guided and independent group activities in terms of their contribution to SSR.

5.2.1.2.1 Teacher-Guided Group Activities

Teacher-guided group activities included four groups discussing the different perspectives associated with nuclear power plant. Three groups examined the nuclear energy from different perspectives but from the same perspective within group. More specifically, they negotiated the economical, environmental/societal, and scientific perspectives of nuclear power separately. Each group argued on the specific topic they were given, presented their arguments with evidence, and provided recommendations to the fourth group which represents government to

make a decision. The fourth group negotiated the nuclear energy from multiple perspectives. PSTs participated in a decision making process in small groups under the guidance of instructor and examined different perspectives and multiple sources of information. Pedretti (1999) referred to the decision making as "an inherently complex process, encumbered by multiple possibilities and agendas" (p. 178). The analysis of group discussions revealed that they referred to many viewpoints and the need of more information to make an informed decision. The groups also referred to how complicated to make a decision on these issues. The groups showed a need for more information and did research for it. The groups' written reports and reflection papers included evidence for the improvement of PSTs' SSR in terms of complexity, inquiry, and multiple perspectives. There may be several reasons for this. First this might be due to the nature of activity since PSTs were required to examine different perspectives, justify their arguments, and reach an informed and sound decision. They justified their arguments through scientific and social information. When they struggled with the lack of information, they asked for relevant information. Second, PSTs engaged in a fruitful discussion which was critical but at the same time constructive. In these discussions PSTs' shared their ideas, justified them with evidence, and criticized others' ideas. The communication within the group can support their understandings and reasoning. Moreover, group discussions allow greater proportion of PSTs to contribute to the group task (Hudgins & Edelman, 1986). The PSTs who did not participate in teacher-led discussions had a chance to negotiate the issue in group discussions. Hogan (2002) also emphasized the exploration and co-construction of ideas within

groups and recommended that individuals should be prepared not only for developing knowledge and skills but also interacting effectively on intellectual tasks in groups.

5.2.1.2.2 Independent Group Activities

SSI-focused course included independent group activities in addition to the teacher-guided group activities. The last two weeks of the SSI-focused course were devoted to the independent group activities. PSTs were required to select a socioscientific issue different than nuclear power and negotiate it as a small group. They were independent in selecting issue and organizing their discussions. There were four groups who discussed different SSIs (i.e. stem cell, genetically modified food, genetic screening, and animal testing). The most prominent pattern in these groups was the inclusion of different viewpoints, rich social and scientific information. The groups showed an effort to value all ideas from different stakeholders. The group members had different roles as a proponent, opponent, scientist, economist, citizen, politician, and physician. They presented their claims and evidence for backing their claims. Members displayed different ideas so counterarguments were frequently observed. Independent group activities allowed students to organize their own cognition. These activities let students to transfer their learning in the classroom to new situations. This independent small group activity was an indication of students' deeper understanding of socioscientific issues and their reasoning on complexity, perspectives, and inquiry. Their independently organizing the discussion in terms of many perspectives and presenting a rich information

from different sources enable researcher to conclude that SSI-focused course is influential in improving students' reasoning on SSI. In this case, their ability to engage in reasoned discussion of socio-scientific issues might have been enhanced by teaching that explicitly focused on complexity, inquiry, and perspectives aspects of SSR. PSTs were provided many opportunities before participating in independent group activities to practice skills for negotiating and resolving SSIs. Looking at ideas and reasoning emerged among groups showed an understanding for complexity, inquiry and multiple perspectives.

5.3 Implications for Socioscientific Reasoning and SSI-Based Courses

This study investigated the change in PSTs' socioscientific reasoning before, during, and after a SSI-focused course. Based on the results this study has several implications.

First, it offers a new, valid and reliable assessment for socioscientific reasoning. In this study, based on the data analysis, a new rubric was developed to assess SSR. This provides an in-depth assessment of SSR. It facilitates the assessment of students at higher cognitive levels. It also enables the researchers to capture the variability in students' socioscientific reasoning. SSR is a new construct but it has importance for science education especially for achieving the scientific literacy (Sadler et al., 2007). A number of studies emphasized the socioscientific issues and students' reasoning on these issues (Hofstein et al., 2011; Tal & Kedmi, 2006; Zeidler & Sadler, 2011). Due to the fact that scientifically literate citizens are necessary in such a world that is continually improving in technology and scientific

knowledge (Kolstø, 2001b), science curricula should focus on SSI more than before. However what students gain if SSI was taught in classrooms is also an important issue to be considered. This study, similar to the previous studies (e.g Sadler et al., 2007), indicated that students can promote their reasoning if they participated in SSI-based courses. As a result, the assessment of SSR will be another issue. The present study also advanced the way to assess SSR. The depth rubric developed in this study helps teachers and researchers to assess SSR. It is developed in the context of nuclear power plant but the nature of rubric is not focused on a specific SSI. The level descriptions are open to assess SSR in all SSI contexts. Therefore researchers or teachers can safely use it in assessing students' SSR in different SSIs.

Second it implies that socioscientific reasoning can be developed through SSI-based classroom interventions. A body of literature showed that students' reasoning can be promoted through classroom practices (e.g. Eggert et al., 2013; Grace, 2009; Lee, 2010). All these studies used different instructional approaches but commonly emphasized the group activities to foster students' reasoning. The instructional strategies that specifically aimed to develop students' reasoning in terms of complexity, inquiry, and multiple perspectives should be utilized in science classroom. By this way, students can engage in activities to enhance their socioscientific reasoning and can show more sophisticated reasoning.

Finally it offers some useful teaching and learning activities which might potentially enhance the socioscientific reasoning. Although the group activities

emphasized in the literature, the results of this study implied that teacher-led classroom discussions including probing questions, presentation of information, debriefing sessions, and second-order discussions have potential to foster socioscientific reasoning. For example during teacher-led discussions, pros and cons of nuclear power plant were discussed in terms of multiple perspectives. Ratcliffe (1997) referred to this and stated that systematically discussing advantages and disadvantages of socioscientific issues also may assist reasoning. Lewis and Leach (2006) suggested that teaching strategies that will develop knowledge and skills and an awareness of how to apply these to new situations are desirable. The SSI-based classroom activities should be well-designed to facilitate students gain necessary knowledge and skills in negotiating and resolving SSIs. That is students should have a general knowledge about SSI and skills in performing socioscientific reasoning. This study proposed several important classroom activities that educators can make use in designing SSI-based activities to support socioscientific reasoning. Teacher-led classroom discussions and group activities can be useful in development of SSR. However these activities should specifically touch to the aspects of SSR. Such as using probing questions with emphasis on different perspectives can be valuable in students' development of multiple perspectives aspect of SSR. Similarly, presenting and discussing different information can support the inquiry aspect of SSR. Through debriefing sessions and second-order discussions, complexity, inquiry and multiple perspectives aspects of SSR can be comprehended and students can transfer their reasoning to other issues. In group activities, students can share the responsibilities and this

collaboration may improve their reasoning (Tal & Kedmi, 2006). Students may discuss different perspectives as a group and engage in decision-making activity. They can search for information to support their perspectives and try to reach a decision which is balanced in terms of all perspectives. The decision-making processes require understanding of complexity, inquiry, and multiple perspectives of SSR. Overall a combination of teacher-led discussions and small group activities including decision making can have a potential to develop individuals' socioscientific reasoning.

5.4 Conclusion

The present study examined to what extent PSTs' reasoning on complexity, inquiry, and multiple perspectives improved after they participated in classroom discussions and activities in a SSI-focused course. It also examined the teaching sequence to see how much the teaching and learning activities contributed to the PSTs' reasoning on socioscientific issues. PSTs' reasoning was found to be significantly changed after they participated in classroom discussions and activities. They understood the complexity associated with the socioscientific issues and could examine them from different perspectives. While they negotiating the socioscientific issues, they used different types of information including historical, scientific information to justify their claims. When they struggled in decision making process, they realized that the information they have is not sufficient to make an informed decision and they need to do research before making a decision. They were engaged with different teaching and learning

activities during the SSI-focused course. Teacher-led classroom discussions with different opportunities and group activities were found to be potential source of PSTs' development of socioscientific reasoning. The discussion on a socioscientific issues including its pros and cons in terms of multiple perspectives and presentation and discussion of different kinds of information may positively affect PSTs' socioscientific reasoning. Moreover group activities providing an opportunity for participants to be involved in a decision making process may help PSTs advance their reasoning on socioscientific issues.

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APPENDICES

APPENDIX A

A. TURKISH SCIENCE AND TECHNOLOGY CURRICULUM GOALS IN 2006

(FEN VE TEKNOLOJİ DERSİ ÖĞRETİM PROGRAMI'NIN VİZYONU)

Günümüzde yaşanan hızlı ekonomik, sosyal, bilimsel ve teknolojik gelişmeler yaşam şeklimizi önemli ölçüde değiştirmiştir. Özellikle bilimsel ve teknolojik gelişmelerin hayatımıza etkisi, günümüzde belki de geçmişte hiç olmadığı kadar açık bir biçimde görülmektedir. Küreselleşme, uluslararası ekonomik rekabet, hızlı bilimsel ve teknolojik gelişmeler gelecekte de hayatımızı etkilemeye devam edecektir. Bütün bunlar dikkate alındığında ülkeler, güçlü bir gelecek oluşturmak için her vatandaşın fen ve teknoloji okuryazarı olarak yetişmesinin gerekliliğinin ve bu süreçte fen derslerinin anahtar bir rol oynadığının bilincindedir. Fen ve Teknoloji Dersi Öğretim Programı'nın vizyonu; bireysel farklılıkları ne olursa olsun bütün öğrencilerin fen ve teknoloji okuryazarı olarak yetişmesidir.

Fen ve teknoloji okuryazarlığı, genel bir tanım olarak; bireylerin araştırma, sorgulama, eleştirel düşünme, problem çözme ve karar verme becerileri

geliştirmeleri, yaşam boyu öğrenen bireyler olmaları, çevreleri ve dünya hakkındaki merak duygusunu sürdürmeleri için gerekli olan fenle ilgili beceri, tutum, değer, anlayış ve bilgilerin bir bileşimidir.

Fen ve teknoloji okuryazarı olan bir kişi, bilimin ve bilimsel bilginin doğasını, temel fen kavram, ilke, yasa ve kuramlarını anlayarak uygun şekillerde kullanır; problemleri çözerken ve karar verirken bilimsel süreç becerilerini kullanır; fen, teknoloji, toplum ve çevre arasındaki etkileşimleri anlar; bilimsel ve teknik psikomotor beceriler geliştirir; bilimsel tutum ve değerlere sahip olduğunu gösterir. Fen ve teknoloji okuryazarı bireyler, bilgiye ulaşmada ve kullanmada, problemleri çözmede, fen ve teknoloji ile ilgili sorunlar hakkında olası riskleri, yararları ve eldeki seçenekleri dikkate alarak karar vermede ve yeni bilgi üretmede daha etkin bireylerdir.

Fen ve teknoloji okuryazarlığı için 7 boyut düşünülebilir:

1. Fen bilimleri ve teknolojinin doğası
2. Anahtar fen kavramları
3. Bilimsel Süreç Becerileri (BSB)
4. Fen-Teknoloji-Toplum-Çevre (FTTÇ) ilişkileri
5. Bilimsel ve teknik psikomotor beceriler
6. Bilimin özünü oluşturan değerler
7. Fen'e ilişkin tutum ve değerler (TD)

Öğrencilerin fen ve teknoloji okuryazarı olarak yetiştirilebilmeleri için yukarıda belirtilen fen ve teknoloji okuryazarlığının yedi boyutu dikkate alınmalıdır. Düz anlatım, not tutturma ve doğrulama tipi laboratuar etkinlikleri gibi öğretmen merkezli geleneksel öğretim yöntemleri öğrencilerin fen ve teknoloji okuryazarlığını geliştirmede yeterli olamamaktadır. Eğitim süreci öğrencilerin öz güvenlerini ve motivasyonlarını artırıcı nitelikte olmalıdır. Öğrenciler sürekli alma ihtiyacını duymak yerine kendi kendilerine araştırabilen, sorgulayabilen bireyler olacak şekilde yönlendirilmelidir.

Fen ve Teknoloji Dersi Öğretim Programı'nın Amaçları

Çeşitli ülkelerdeki program reform hareketleri incelendiğinde, toplumdaki tüm bireylerin fen ve teknoloji okuryazarı olarak yetiştirilmesinin vurgulandığı görülmektedir. Tüm vatandaşların fen ve teknoloji okuryazarı olarak yetişmesini amaçlayan Fen ve Teknoloji Dersi Öğretim Programı'nın genel amaçları aşağıda sunulmuştur:

Öğrencilerin;

- Doğal dünyayı öğrenmeleri ve anlamaları, bunun düşünsel zenginliği ile heyecanını yaşamalarını sağlamak,
- Her sınıf düzeyinde bilimsel ve teknolojik gelişme ile olaylara merak duygusu geliştirmelerini teşvik etmek,
- Fen ve teknolojinin doğasını; fen, teknoloji, toplum ve çevre arasındaki karşılıklı etkileşimleri anlamalarını sağlamak,

- Araştırma, okuma ve tartışma aracılığıyla yeni bilgileri yapılandırma becerileri kazanmalarını sağlamak,
- Eğitim ile meslek seçimi gibi konularda, fen ve teknolojiye dayalı meslekler hakkında bilgi, deneyim, ilgi geliştirmelerini sağlayabilecek alt yapıyı oluşturmak,
- Öğrenmeyi öğrenmelerini ve bu sayede mesleklerin değişen mahiyetine ayak uydurabilecek kapasiteyi geliştirmelerini sağlamak,
- Karşılaşabileceği alışılmadık durumlarda, yeni bilgi elde etme ile problem çözmede fen ve teknolojiyi kullanmalarını sağlamak,
- Kişisel kararlar verirken uygun bilimsel süreç ve ilkeleri kullanmalarını sağlamak,
- Fen ve teknolojiyle ilgili sosyal, ekonomik ve etik değerleri, kişisel sağlık ve çevre sorunlarını fark etmelerini, bunlarla ilgili sorumluluk taşımalarını ve bilinçli kararlar vermelerini sağlamak,
- Bilmeye ve anlamaya istekli olma, sorgulama, mantığa değer verme, eylemlerin sonuçlarını düşünme gibi bilimsel değerlere sahip olmalarını, toplum ve çevre ilişkilerinde bu değerlere uygun şekilde hareket etmelerini sağlamak,
- Meslek yaşamlarında bilgi, anlayış ve becerilerini kullanarak ekonomik verimliliklerini artırmalarını sağlamaktır.

APPENDIX B

B. TURKISH SCIENCE AND TECHNOLOGY CURRICULUM GOALS IN 2013

(FEN BİLİMLERİ DERSİ ÖĞRETİM PROGRAMININ TEMELLERİ)

Fen Bilimleri Dersi Öğretim Programının Vizyonu

Fen Bilimleri Dersi Öğretim Programının vizyonu; "Tüm öğrencileri fen okuryazarı bireyler olarak yetiştirmek" olarak tanımlanmıştır.

Araştıran-sorgulayan, etkili kararlar verebilen, problem çözebilen, kendine güvenen, işbirliğine açık, etkili iletişim kurabilen, sürdürülebilir kalkınma bilinciyle yaşam boyu öğrenen fen okuryazarı bireyler; fen bilimlerine ilişkin bilgi, beceri, olumlu tutum, algı ve değere; fen bilimlerinin teknoloji-toplum-çevre ile olan ilişkisine yönelik anlayışa ve psikomotor becerilere sahiptir.

Fen okuryazarı bireyler, fen bilimlerine ilişkin temel bilgilere (Biyoloji, Fizik, Kimya, Yer, Gök ve Çevre Bilimleri, Sağlık ve Doğal Afetler) ve doğal çevrenin keşfedilmesine yönelik bilimsel süreç becerilerine sahiptir. Bu bireyler, kendilerini toplumsal sorunlarla ilgili problemlerin çözümü konusunda sorumlu hisseder, yaratıcı ve analitik düşünme becerileri yardımıyla bireysel veya işbirliğine dayalı alternatif çözüm önerileri üretebilirler. Bunlara ek olarak fen okuryazarı bir birey,

bilgiyi araştırır, sorgular ve zamanla değişebileceğini kendi akıl gücü, yaratıcı düşünme ve yaptığı araştırmalar sonucunda fark eder. Bilginin zihinsel süreçlerde işlenmesinde, bireyin içinde bulunduğu kültüre ait değerlerin, toplumsal yapının ve inançların etkili olduğunun farkındadır. Fen okuryazarı bireyler, sosyal ve teknolojik değişim ve dönüşümlerin fen ve doğal çevreyle olan ilişkisini kavrar. Ayrıca, fen bilimleri alanında kariyer bilincine sahip olan bu bireyler, bu alanda görev almak istemeseler bile fen bilimleri ile ilişkili mesleklerin, toplumsal sorunların çözümünde önemli bir rolü olduğunun farkındadır.

Bilgi	Beceri	Duyuş	Fen-Teknoloji-Toplum-Çevre
a. Canlılar ve Hayat b. Madde ve Değişim c. Fiziksel Olaylar ç. Dünya ve Evren	a. Bilimsel Süreç Becerileri b. Yaşam Becerileri - Analitik düşünme - Karar verme - Yaratıcı düşünme - Girişimcilik - İletişim - Takım çalışması	a. Tutum b. Motivasyon c. Değerler ç. Sorumluluk	a. Sosyo-Bilimsel Konular b. Bilimin Doğası c. Bilim ve Teknoloji ilişkisi ç. Bilimin Toplumsal Katkısı d. Sürdürülebilir Kalkınma Bilinci e. Fen ve Kariyer Bilinci

Fen Bilimleri Dersi Öğretim Programının Amaçları

Fen Bilimleri dersi öğretim programı 1739 sayılı Milli Eğitim Temel Kanunu'nun 2. maddesinde ifade edilen Türk Milli Eğitiminin genel amaçları ile Türk Milli Eğitimin Temel İlkeleri esas alınarak hazırlanmıştır.

Tüm bireylerin fen okuryazarı olarak yetişmesini amaçlayan Fen Bilimleri Dersi Öğretim Programı'nın temel amaçları şunlardır:

- Biyoloji, Fizik, Kimya, Yer, Gök ve Çevre Bilimleri, Sağlık ve Doğal Afetler hakkında temel bilgiler kazandırmak,
- Doğanın keşfedilmesi ve insan-çevre arasındaki ilişkinin anlaşılması sürecinde, bilimsel süreç becerilerini ve bilimsel araştırma yaklaşımını benimseyip karşılaşılan sorunlara çözüm üretmek,
- Bilimin toplumu ve teknolojiyi, toplum ve teknolojinin de bilimi nasıl etkilediğine ilişkin farkındalık geliştirmek,
- Birey, çevre ve toplum arasındaki karşılıklı etkileşimi fark etmek ve toplum, ekonomi, doğal kaynaklara ilişkin sürdürülebilir kalkınma bilincini geliştirmek,
- Fen bilimleri ile ilgili kariyer bilinci geliştirmek,
- Günlük yaşam sorunlarına ilişkin sorumluluk alınmasını ve bu sorunları çözmede fen bilimlerine ilişkin bilgi, bilimsel süreç becerileri ve diğer yaşam becerilerinin kullanılmasını sağlamak,
- Bilim insanlarının bilimsel bilgiyi nasıl oluşturduğunu, oluşturulan bu bilginin geçtiği süreçleri ve yeni araştırmalarda nasıl kullanıldığını anlamaya yardımcı olmak,
- Bilimin, tüm kültürlerden bilim insanlarının ortak çabası sonucu üretildiğini anlamaya katkı sağlamak ve bilimsel çalışmaları takdir etme duygusunu geliştirmek,

- Bilimin, teknolojinin gelişmesi, toplumsal sorunların çözümü ve doğal çevredeki ilişkilerin anlaşılmasına olan katkısını takdir etmeyi sağlamak,
- Doğada meydana gelen olaylara ilişkin merak, tutum ve ilgi geliştirmek,
- Bilimsel çalışmalarda güvenliğin önemini fark ettirmek ve uygulamaya katkı sağlamak,
- Sosyo-bilimsel konuları kullanarak bilimsel düşünme alışkanlıklarını geliştirmektir.

APPENDIX C

C. INTERVIEW PROTOCOL

Akkuyu Nuclear Power Plant

Akkuyu Bay is located in Mersin, on the southeast Mediterranean coast. Akkuyu Bay has a potential for tourism and the number of tourists visiting Akkuyu increases each year. This contributes to the national economy to a large extent. In Turkey, there were several attempts for a nuclear power plant in the past and Akkuyu was also considered as a nuclear power plant site and the nuclear power plant construction license was obtained in the past for Akkuyu. More recently Akkuyu has again become an area for construction of nuclear power plant. There is an increasing energy demand in Turkey and Turkey receives its electricity mostly from natural gas, coal, and hydroelectric power. Using coal and hydroelectric power is relatively inexpensive compared to the natural gas. However coal burning results in air pollution and hydroelectric power damages ecological systems. Because of these problems and increasing energy demand, The Ministry of Energy and Natural Resources suggested that nuclear energy generation should be considered as an option for energy demand to prevent the energy crisis in future. Nuclear energy proponents also supported the nuclear power plant construction and in fact they claimed that Turkey is late to take the advantages of nuclear energy.

Therefore the Turkish government decided to construct the first nuclear power plant in Akkuyu Bay. The nuclear power plant will supply some of the energy demand and will minimize the coal burning air pollution and bad impacts of hydroelectric power on ecology.

Akkuyu Bay is a sensitive ecological area serving as the habitat for many birds, fish and especially the monk seals. Monk seal is an endangered species. A nuclear power plant may give harm to the ecosystem and to the birds, fish, and monk seals in Akkuyu.

Citizens, civil organizations and environmentalists were concerned about the health of the Akkuyu residents and the surrounding ecosystem. They concluded that nuclear power plants may cause some problems related to safety, seismic stability, radioactive waste, cost, ecosystem and living species in Akkuyu Bay. Therefore, they are trying to decide what to do.

Interview questions to follow the scenario.

1. Explain the situation in your own words.
2. Can Akkuyu Bay situation be solved easily?
    A. Yes
    B. No

If A, then: Explain why you think the Akkuyu Bay situation should be easy to solve.

If B, then: Explain why you think the Akkuyu Bay situation cannot be solved easily

3. If you were responsible for deciding how to resolve the Akkuyu Bay situation, would you need additional information regarding the situation before making your decision?
    A. Yes, I would need to have additional information to make a decision.
    B. No, I have sufficient information to make a decision.

If A, then: What kinds of additional information would be necessary for you to make a decision regarding the Akkuyu Bay situation?

If you were responsible for deciding how to resolve the Akkuyu Bay situation, what would you recommend doing as a next step? Please explain why this would be an effective strategy.

If B, then: If you were responsible for deciding how to resolve the Akkuyu Bay situation, what would you recommend doing as a next step? Please explain why this would be an effective strategy.

4. In the previous prompt, you were asked to suggest a course of action for the Akkuyu Bay situation.
    A. Describe the strengths of your proposed approach.
    B. Describe the weaknesses of your proposed approach.

5. A group of concerned Akkuyu citizens gathered to discuss a solution for the Akkuyu Bay situation. The group suggested that nuclear power plant should not be constructed for the health of the citizens in Akkuyu and for the surrounding ecosystem and living species. The energy demand should be met from sun and wind. For example; the wind turbines can be constructed out at sea and abundant sunlight in Mediterranean region should be utilized.
    A. How do you think the Turkish government would respond to this suggestion? Please explain your response.
    B. How do you think nuclear energy proponents would respond to this suggestion? Please explain your response.
    C. How do you think environmentalists would respond to this suggestion? Please explain your response.
6. In response to the previous questions, you commented on how three different groups (government, nuclear energy proponents, and environmentalists) would respond to a proposed solution. Which of the following statements most accurately reflects your responses?
    A. The government, nuclear energy proponents, environmentalists would have similar responses to the proposed suggestion.
    B. The government, nuclear energy proponents, environmentalists would have different responses to the proposed suggestion.

If A, then: Explain why you expect the government, nuclear energy proponents, and environmentalists to have similar responses to the proposed suggestion.

If B, then: Explain why you expect the government, nuclear energy proponents, and environmentalists to have different responses to the proposed suggestion.

APPENDIX D

D. OPEN-ENDED QUESTIONS

1. What is nuclear energy?
2. What is the radioactivity?
3. What is radioactive waste?
4. What is the relationship between the radioactivity, radioactive waste and nuclear energy?
5. What is the controversy associated with nuclear power plant construction?
6. Is nuclear power plant construction a challenging problem? Why or why not?

APPENDIX E

E. FIRST REFLECTION PAPER

In reflection paper that you will submit, first write your ideas about the past two weeks' classroom discussions and what they contributed to your learning. Then answer each question below and support your ideas.

1. Is Turkey Facing Energy Gap? Justify your response.
2. Is Nuclear Energy Cheap? Justify your response.
3. Is Nuclear Energy Clean? Justify your response.
4. Is Nuclear Energy Safe? Justify your response.
5. Is nuclear energy reduces Turkey's dependence on foreign sources? Justify your response.
6. Is Radioactive Waste Dangerous? Justify your response.
7. What is your personal opinion about nuclear power plant construction? (write a general view about it)

APPENDIX F

F. SECOND REFLECTION PAPER

In second reflection paper that you will submit, write your ideas for each question below.

1. What did you learn from this activity?
2. What would you change if you were planning to do the activity again?
3. What problems did you encounter in the activity?
4. Write your personal decision on nuclear energy?
5. Write your personal recommendations to the authorities about nuclear energy?
6. How do the authorities react to your recommendations?

APPENDIX G

G. TRANSLATED INTERVIEW EXCERPTS

1. Excerpt given for the complexity aspect of SSR

4-1: Not easy. This is nuclear. We had bad experience in the past. I think it should not be constructed. It can be very dangerous.

4-1: Kolay değil. Bu nükleer. Geçmişte kötü deneyimlerimiz oldu. Bence kurulmamalı. Çok tehlikeli olabilir.

4-2: Of course not easy. NPP has advantageous and disadvantageous. That's why it is difficult to decide. Everyone treats according to their own benefits. Ok it will provide more energy since bombarding uranium with neutron that's fission and huge energy comes out. And also we have rich uranium source and this will decrease the cost for the source. On the other hand, as a result of NPP, environment and people can get damaged. Nuclear waste is radioactive and its radioactivity does not stop in a short time. It keeps releasing radiation for long. It should get cold first which requires time and then should be kept

4-2: Tabiki kolay değil. Nükleer santralin hem avantajları hem de dezavantajları var. Bu yüzden karar vermesi zor bir durum. Herkes kendi çıkarına gore hareket ediyor. Tamam, daha fazla energy sağlayacak çünkü uranyum nötron bombardımanına tab tutulacak ve çok büyük enerji elde edilecek. Uranyum kaynaklarımız da bol bu da kaynak maliyetini düşürecek. Ama diğer taraftan çevre ve insanlar nükleer santralden etkilenecekler. Nükleer atık radyoaktif ve uzun sure radyoaktifliği devam ediyor. Yıllarca radyasyon yayacak. Bu atık öncelikle soğutulmalı ki zaman gerekli sonar yer altına gömülmeli ki diğer sorunları beraberinde getiriyor. Saklamak

underground which results in other problems. Checking them in underground is required. The type of container is really important to prevent leakage of radioactive material. I mean lots of issues should be considered before making a decision. The health of people and other living things in that area also gets threatened. NPP probably will use the sea water in Akkuyu for cooling and it will be also sent back to the sea. So the marine life will be affected by radioactive materials too. People may swim in the sea and can be affected. This requires good evaluation of all these issues and it is difficult.

için kullanılan kutu ya da konteynır her neyse radyasyon sızıntılarına izin vermemeli ve bud a belli aralıklarla control edilmeli. Demek istediğim karar vermeden once dikkate alınması gereken o kadar çok nokta var ki. O bölgede yaşayan insanların sağlıkları tehdit altında olacak. Santral soğutma işlemleri için deniz suyunu kullanacak sonar bu su tekrar denize verilecek. Sonuçta da denizde yaşayan canlılar da radyasyon alacak. Insanlar denizde yüzebilir onlar etkilenecek. Bu konu gerçekten tüm bunların iyi değerlendirilmesini gerektiriyor bu yüzden de zor.

23-1: It cannot be solved easily. Some people may support the construction of NPP but the people living there do not want it due to the risk of radiation. Therefore environmentalists and local people protest too much and resist so the situation become more difficult.

23-1: Kolayca çözüme ulaşılamaz. Bazı insanlar santralin kurulmasını destekliyor ama orada yaşayanlar radyasyon riskinden dolayı istemiyor. Bu yüzden çevreciler, yerel halk protesto ediyorlave direniyorlar bud a durumu daha karmaşık yapıyor.

23-2: Cannot be solved easily…This is so controversial. Yes it has good points but it has also bad ones. Therefore it is difficult to deal with. We all know how dangerous NPP is and experienced it in Chernobyl even

23-2: Kolayça çözülemez. Bu çok tartişmali bir konu. Evet, iyi şeyleri var ama ayni zamanda kötüleri de var. Bu yüzden üztesinden gelmek zor. Hepimiz biliyoruz ki nükleer santral tehlikeli ve çernobilde bunu yaşadik ki bizim ülke

it is not in our country. But how will we supply energy. This is also important issue to consider because energy is very important for Turkey and its development. But it has also some drawbacks. Environment and society can be affected due to nuclear waste, radiation. Sea water will probably used to cool down in NPP and it will be returned to the sea which can carry some radioactive materials to the sea. Soil can be influenced from radiation and agricultural production can be also under risk. So energy need, economy are on one side, environment, people, health, etc. are on the other side. Difficult to decide.

sinirlarimizda bile değildi. Ama enerji ihtiyacimizi nasil karşilayacağiz. Bu da üzerinde durulmasi gerekn önemli bir konu çünkü Türkiyenin gelişmesi için. Ama nükleer santralin de sakıncaları var. Çevre, toplum nükleer atıktan, radyasyondan etkilenebilir. Muhtemelen santraldeki soğutma işlemleri için deniz suyu kullanılacak ve tekrar denize dökülecek ki bu giden su radyoaktif maddleri denize taşıyabilir. Toprak radyasyondan etkilenebilir ve tarım ürünleri risk altında olabilir. Yani energy ihtiyacı, ekonomi bir tarafta, çevre, insanlar, sağlık diğer tarafta. Karar verilmesi zor.

12-1: It can be solved easily because there are many people dealing with it. Of course it requires research and planning but at the end, after weighing negative and positive aspects, can be decided accordingly.

12-1: Kolayca çözülebilir çünkü bu durumla ilgilenen bir sürü insane var. tabiki iyi bir araştırma ve planlama gerektiriyor. Sonunda negative pozitif yönleri tartılır ve karar verilir.

12-2: It is rational not to decide easily. I mean we should not decide quickly. Because it has impact on both human, animals, and environment but it also affects economy, our dependency on foreign sources. We cannot think just ecosystem there and decide

12-2: Kolay karar verilmesi mantıklı değil. Demek istediğim çabuk karar vermemliyiz. Çünkü hem insanlar, hayvanlar, çevre hem de economi, dış ilişkiler üzerinde etkisi var. Sadece ekosistemi düşünüp diğer etmenleri görmemezlikten gelip karar veremeyiz.

accordingly ignoring other dimensions. But we cannot only consider economy and ignore ecosystem, environment, people, and health. NPP is efficient in terms of energy production, we get more energy, and we use uranium that we have.

Diğer taraftan sadece ekonomiyi düşünüp ekosistem, çevre, insanların sağlığını da görmemezlikten gelemeyiz. Nükleer santral enerji üretimi açısından çok verimli. Daha çok enerji ederiz ve bu enerjiyi elde etmek için de kaynağımız var.

15-1: Two sides have strong supports. I mean there are people who want the construction of NPP and who are against it. For NPP, instead of Akkuyu, we may find another place which does not have a lot of livings. I mean a rural place far from people, livings etc.

15-1: İki tarafın da güçlü destekleri var. Yani nükleer santralin kurulmasını isteyenler ve istemeyenlerin. Akkuyu yerine, başka bir yer bulabiliriz çok canlının yaşamadığı. Yani böyle kırsal insanlardan, canlılardan vs. uzak bir yer.

15-2: Well I think difficult. It has many disadvantages compared to advantages. It will meet the energy need to a large amount. This is its positive side. However we should think the harm given to environment. There are radioactive materials released from NPP. Their effects last for long years because of the life time of radioactive elements. They continually release radiation. This is so bad. People can get radiation directly. They also can get radiation through their foods because the food also keeps

15-2: …..Sanırım zor. Avantajlarını göre dezavantajları daha fazla. Enerji ihtiyacını büyük ölçüde karşılayacak. Bu olumlu yanı. Ama çevreye verdiği zararı da düşünmek zorundayız. Santralden çıkan radyoaktif maddeler var. Bunların etkisi uzun yıllar sürüyor çünkü radyoaktif elementlerin yarı ömrü denilen bir durum var. Sürekli radyasyon yayıyorlar. Bu çok kötü bir şey. Insanlar direk radyasyon alıyorlar. Ayrıca yediklerinden de radyasyon alabilirler çünkü gıdalar da radyasyonu tutuyor ve bud a insanlar iki kat zarar verir. Nükleer atık çok tehlikeli.

radiation and this gives double harm to the people. Nuclear waste is really dangerous. We should keep them underground but how? We do not have necessary equipments and these also cost too much and then we should keep them under control for years. I am not sure that Turkey can do this. In this problem, everyone is right actually. Government wants to get bigger and bigger and so just focus on economy and ignores other issues. This is what developing countries do. The energy is required to develop. But on the other hand, there is a group of people trying to protect natural life, the health of society, the ecological system.

Yer altında saklamamız gerekiyor ama nasıl? Gerekli donanımız yok zaten bununda masrafı çok ve bu atıkları yıllarca kontrol etmeliyiz. Ben Türkiyenin bunu sağlayabileceğini düşünmüyorum. Nükleer santral konusunda herkes haklı aslında. Hükümet büyümek istiyor bu yüzden ekonomi üzerinde duruyor ve diğer şeyleri görmemezlikten geliyor. Gelişmekte olan ülkelerin izlediği bir yöntem bu. Enerji gelişmek için gerekli. Ama diğer yandan doğal yaşamı, toplumun sağlığını ekosistemi korumaya çalışan da bir grup var.

2. Excerpts given for the inquiry aspect of SSR

17-1: Some alternative places for NPP can be mentioned. Public should be informed about NPP. Some people protest it without knowing nothing but some knows about NPP and do not want it. The ideas of these people can be mentioned.

17-1: Nükleer santral için alternative yerlerden bahsedilebilirdi. Halk nükleler santral konusunda bilgilendirilmeli. İnsanlar bilmeden protesto ediyorlar ve istemiyorlar. Bu insanların fikirlerine yer verilmeli.

17-2: Detailed information is required. Geological background should be mentioned, for example. Earthquake is biggest enemy of NPPs. I need more information about NPP. This is like newspaper article. For example what disadvantageous NPP has? What about the rate of decay of radioactive materials and how long is required for them to be stable without releasing radiation. How ecosystem is affected? It will be better if these are considered.

17-2: Detaylı bilgi gerekli. Örneğin, jeolojik açıdan geçmişinden bahsedilmeli. Deprem nükleer santralin en büyük düşmanı. Kesinlikle daha fazla bilgiye ihtiyacım var. Bu daha çok gazete yazısı gibi olmuş. Örneğin nükleer santralin dezavantajlarından bahsedilmeli. Radyoaktif maddelerin bozunma hızıyla ilgili ve karalı hale geçmeleri için ne kadar sure gerekli ki radyasyon yaymasınlar. Ekisistem nasıl etkilenecek. Bunların da üzerinde durulsa iyi olacak.

2-1: It seems enough. If I were, I will not construct it.

2-1: Yeterli görünüyor. Ben olsaydım kurmazdım.

2-2: I need extra information of course. These are so superficial. I want to learn earthquake risk of Akkuyu. I want to learn how much radioactive material will be released and how the level of radiation affects people and livings. What people think about NPP? They

2-2: Tabiki ekstra bilgiye ihtiyacım var. bunlar çok yüzeysel. Akkuyudaki deprem riskini öğrenmek istiyorum. Ne kadar radyoaktif madde açığa çıkacak ve radyasyon insanları, canlıları etkileyen nasıl etkileyecek. İnsanların nükleerle ilgili fikri ne? İstiyorlar mı

want it or not. How will it affect environment and species? Lots of things I need. I want to learn the amount of money to construct it, to deal with nuclear waste, to maintain it, to deconstruct it when it is shut down because we learned that it has a life time and cannot work forever. So these are needed to be investigated in detail to construct or not to construct it. We should know whether it is worth doing or not. And also I want to compare the energy produced with NPP and other power plants. Actually I want to compare NPP and other power plants in terms of all their advantages and disadvantages.

4-1: Of course I need more information. How is it constructed? What happens in case of an accident? I need detailed information. What happens to the regions after constructing NPP? These should be investigated.

4-2: I need a serious research. Well, it says we have insufficient energy. First I will investigate how much energy we need and can we meet it through other energy sources. We can really have energy need because our population increases and we develop in industry

istemiyorlar mı? Çevre ve türler nasıl etkilenecek? Bir sürü şeye ihtiyacım var. Kurulmasının maliyeti nedir, nükleer atıkların üstesinden nasıl gelinecek, santralın bakım masrafları ve yıkımı ne kadar tutacak? Çünkü öğrendiğimiz kadarıyla her nükleer santralin bir ömrü var sonsuza kadar çalışamaz. Yani bunlar daha detaylı incelemenmesi gereken konular. Yapmaya değer mi yoksa değmez mi? ayrıca nükleer santralden üretilen enerji miktarıyla diğer santrallerden üretilen enerji miktarını karşılaştırılmasını isterim. Aslında tüm avantaj ve dezavantajları açısından karşılaştırılmasını isterim.

4-1: Tabiki daha fazla bilgiye ihtiyacım var. Nasıl kuruluyo? Kaza anında neler oluyor? Detaylı bilgi lazım. Kurulan bölgede neler oluyor? Bunlar araştırılmalı.

4-2: Ciddi bir araştırmaya ihtiyaç var. …Enerji açığımız olduğundan bahsedilmiş. Öncelikle ne kadar enerjiye ihtiyacımız var ve diğer enerji kaynaklarıyla karşılayabilir miyiz bunu araştırırdım. Nüfus hızla artıyor ve sanayide teknolojide gelişiyoruz bu

and technology. Then I search for NPP worldwide. What happened in countries where NPP was constructed? What happened to environment? Species may become extinct. Plants, foods may get radiation. I read that after Chernobyl, tea and nuts were radiated in Black Sea region. I will also search Akkuyu. I do not know if it is in earthquake zone. If so, this may cause accidents and leakages. I also want to know the thoughts of people living there about NPP. It directly affects people. They may want since you know it creates jobs opportunities. Or they may not want since bad experience in the past. What else? I think that's all. I communicate with economists, environmentalists, citizens. This is so important to make a decision which could be doing it or not.

yüzden eerjiye ihtiyacımız olduğu doğru. Sonra dünyadaki nükleer santralleri araştırırdım. Nükleer santral kurulan ülkelerde neler olmuş? Çevreye ne olmuş? Türler yok olabilir. Bitkiler, yiyecekler radyasyondan etkilenebilir. Çernobilden sonra Karadenizde çay ve fındıkta radyasyon tespit edildi. Akkuyuyu da araştırırım. Deprem bölgesinde mi bilmiyorum. Eğer öyleyse bu kazalara ve sızıntılara yol açabilir. Orda yaşayan yerel halkın fikrini öğrenmek isterim. Sonuçta bu onları direk etkileyecek. Iş imkanı doğacağı için santralin kurlumunu destekleyebilirler. Ya da geçmişteki kötü denyimlerden sonra istemeyebilirler de. Başka. Sanırım bu kadar. Ekonomistlerle, çevrecilerle, vatandaşlarla iletişime geçerim. Bunun yapılmasına ya da yapılmamasına karar vermeden once araştırılması önemlidir.

23-1: Yes. Why Akkuyu? Is there a special reason for it? It can be another place, more rural. There are many areas, not productive or touristic. I need justification for Akkuyu so that I become convinced otherwise I do not want it.

23-2: No, these are not enough to make

23-1: Evet var. Neden Akkuyu? Özel bir sebebi mi var? Başka bir yer daha kırsal mesela… Birçok alan var verimsiz, turistik olmayan. Akkuyunun seçilme nedenini öğrenmeliyim ve ikna olmalıyım lazım yoksa santrali istemiyorum ben.

23-2: Hayir, bunlar iyi bir karar

a good decision. For example, detailed information was not given about seismic stability. It is so important for NPP to function safely and also for nuclear waste to be stored in safe and not to be polluted with radioactive materials. How radiation affects people and other livings. What levels of radiation are risky for them? Up to a level it is not dangerous. We all get radiation through roentgen but that is minimum and do not affect much. I also want to know how nuclear waste will be stored If NPP is constructed. That is also highly radioactive and needs long years to decay. Half life of uranium to decay is very long. I do not know the exact number but it is really long. Turkey is not so careful about such dangerous things. You know the nuclear waste tragedy in Istanbul and Izmir. Without NPP, we have nuclear accident.

9-1: According to me it is enough. It gives advantageous and disadvantageous and then asks for what to do. That's enough for me.
9-2: Of course I need. For example it says there will be energy need but we do

verebilmek için yeterli değil. Örneğin sismik açıdan durum ne detaylı bilgi verilmemiş. Nükleer santralin güvenli bir şeklde çalışabilmesi için bu çok önemli. Aynı zamanda nükleer atıkların güvenli bir şekilde depolanması ve radyoaktif madde kirliliğine yol açmaması açısından da önemli. Sonra radyasyon insanları diğer canlıları nasıl etkiliyor? Hangi seviyedeki radyasyon bunlar için riskli? Bir seviyeye kadar tehlikeli değil. Hepimiz röntgen vasıtasıyla radyasyon alıyoruz ama bu minimum ve fazla etkilemiyor. Nükleer atıkların nasıl depolanacağı ile ilgili de bilgi istiyorum. Bu atıklar çok radyoaktif ve bozunmaları için yıllar gerekli. Uranyumun yarı ömrü çok uzun. Tam olarak bilmiyorum ama bayağı uzundu. Türkiye bu gibi tehlikeli konularda çok dikkatli değil. İstanbul ve İzmir'deki nükleer atık kazalarını biliyorsunuz. Nükleer santralimiz olmadan nükleer kazamız var bizim.
9-1: Bana gore yeterli. Avantajlarından ve dezavantajlarından bahsediyor ve ne yapılması gerektiğini soruyor. Bu benim için yeterli.
9-2: Tabiki ihtiyacım var. Örneğin, enerji ihtiyacı olduğundan bahsedilmiş

not know how much? It is said that nuclear energy will be cheaper than other energy sources but how much? Because some nuclear energy opponents claim that nuclear energy is more expensive since its construction was expensive and it should be deconstructed which requires another costs. Moreover nuclear waste should be stored and checked which means another cost. The information about how nuclear waste will be stored is not given. This is a really serious problem. They need to be stored in safe containers otherwise they can mix with water which can be used in agriculture. Then people may also get it. It mentions about seismic stability briefly. I really need the seismic status of Akkuyu. In case of an earthquake nuclear power plant can be damaged.

6-2: It is not enough and I need more information. I want to learn more about ecology in Akkuyu, seismic background of it. We learned that seismic stability is required to construct a NPP otherwise it may be dangerous. I also investigate if we really need energy. It is also important to know our uranium resources. If they are not sufficient then

ama ne kadar? Nükleer santralin diğer enerji kaynaklarından daha ucuz olduğu söylenmi ama ne kadar? Çünkü bazı nükleer santral karşıtları nükleer enerjinin daha pahalı olduğunu söylüyor. Sebep olarak da kurulumunun masraflı olduğu ayrıca yıkılması gerektiği ve bunun da ayrıca bir masraf olduğu söyleniyor. Sonra nükleer santral depolanmalı ve control edilmeli bu da ekstra bir maliyet. Nükleer santralin nasıl depolanacağı ile ilgili bilgi verilmemiş. Bu çok ciddi bir problem. Güvenilir şartlarda depolanmalı yoksa radyasyon suyla karışabilir ve tarımda kullanılırsa insanlar etkilenebilir. Sismic durumdan kısaca bahsetmiş. Akkuyunun seismic durumu nedir gerçekten öğrenmeliyim. Deprem durumunda nükleer santral zarar görebilir.

6-2: Yeterli değil ve daha fazla bilgiye ihtiyacım var. Akkuyunun ekolojisi, deprem geçmişini öğrenmek istiyorum. Nükleer santralin kurulması için sismik açıdan kararlılık olmasını gerektiğini öğrendik aksi takdirde tehlikeli olabilir. Ayrıca gerçekten enerji ihtiyacımız olup olmadığını da araştırırdım. Uranium kaynaklarımız hakkında bilgi sahibi

we may import it and this also requires a different budget. This may not be beneficial because we want to construct NPP since it produces cheap energy but if we do not have enough uranium then it does not produce cheap energy. I also look for what we will do with nuclear waste. It is another problem. Where will they be kept? They emit radiation for years. We should bury them underground but we should also check them regularly. If there is any leakage to underground water or the place we bury is an earthquake zone then serious results occur. Ok we want to construct a NPP but we do not consider its waste. It is not like domestic waste. So I should do research about nuclear waste and how to deal with it. Of course I do not mean I will decide to construct it but I will consider its advantages and disadvantages in terms of different aspects and then I will think. I mean I will not decide quickly.

olmak da önemli. Eğer yeterli değilse, ithal etmek zorunda kalabiliriz bud a ayrı bir bütçe gerektirir. Bu zaten çok faydalı olmaz çünkü nükleer santalin kurulma gerekçelerinden birisi ucuz enerji sağlayacak olması. Eğer yeterli uranyumua sahip değilsek ucuz enerji üretemeyiz. Nükleer atıkla nasıl başa çıkacağımızı da araştırırdım. Bu ayrı bir sorun. Nerede saklanacak? Yıllarca radyasyon yayıyorlar. Yeraltına gömmemiz gerekiyor ve düzenli control etmemiz gerekiyor. Eğer herhangi bir sızıntı olursa yeraltı sularına karışabilir ya da gömdüğümüz yerde deprem olursa ciddi sonuçlar oluşabilir. Tamam nükleer santralin kurulmasını istiyoruz ama atıkları düşünmüyoruz. Ev atığına benzemiyor bu. Bu yüzden nükleer atık ve onunla nasıl başa çıkacağımızla iligili araştırma yapardım. Tabiki kurmaya karar verdiğimi söylemiyorum. Ama avantajlarını dezavantajlarını, farklı açılardan değerlendirir ve düşünürdüm. Çabuk karar vermeyeceğimi demek istiyorum.

10-2: There is. Information should be collected on how much energy need Turkey has. Then I need the data for how much harm coal plant gives. The

10-2: Var. Ne kadar enerji gerektiğiyle ilgili bilgi alınmalı. Kömür santrallerin ne kadar zarar verdiğiyle ilgili bilgiye ihtiyacım var. farklı enerji kaynaklarının

comparison of different energy sources in terms of their efficiency should also be given. If NPP is constructed, what advantageous and what disadvantageous it will have. I need detailed information.

enerji verimliliğiyle ilgili karşılaştırılması verilmeli. Eğer nükleer santral kurulacaksa, avantajları, dezavantajları ne olacak. Detayşı bilgiye ihtiyacım var.

3. Excerpts given for the multiple perspectives aspect of SSR

2-1: Government, nuclear energy proponents and environmentalists will react in a different way but government and nuclear energy proponents can share some common views. Government does not probably support the Akkuyu citizens. Environmentalists support the Akkuyu citizens. As far as I know wind and solar energy are not dangerous. They do not do anything to livings. They will like this suggestion. Nuclear energy proponents will ... I do not know how they react.

2-1: Hükümet, nükleer enerjiyi savunanlar ve çevreciler bu çözüme farklı tepki verirler. Ama hükümetin ve nükleer enerjiyi savunanların ortak fikirleri olabilir. Hükümet Akkuyu halkını desteklemeyecektir. Çevreciler destekleyeceklerdir. Bildiğim kadarıyla rüzgar ve güneş enerjisi tehlikeli değil. Canlılara birşey yapmıyorlar. Çevreciler bu fikri severler. Nükleer enerjiyi savunanlar…. Nasıl tepki vereceklerini bilmiyorum.

2-2: They react differently, I think. Government and nuclear energy proponents will not support the Akkuyu citizens while environmentalists will support. They react different because they think different. They have different reasons for NPP. This suggestion is not the one that government will like. I mean wind and solar energy are renewable energy sources and they do not emit harmful gases. But government would probably say that, we already have them in some parts of Turkey but they are not sufficient and we need more energy for now and for future. NPP produces more energy and it does not

2-2: Sanırım farklı tepki verirler. Hükümet ve nükleer enerjiyi savunanlar Akkuyu halkını desteklemezler ama çevreciler destekler. Farklı tepki verirler çünkü farklı düşünüyorlar. Nükleer santral için farklı sebepleri var. hükümetin beğeneceği bir öneri değil yani rüzgar ve güneş. Bunlar yenilenebilir enerji kaynakları ve zararlı gaz salınımı yapmıyorlar. Ama hükümet muhtemelen Türkiyenin bazı bölgelerinde zaten bunların olduğunu, ama yeterli olmadığını gelecekte daha çok enerjiye ihtiyacımız olduğunu söyleyecektir. Nükleer santral çok enerji üretiyor ve rüzgar ya da güneş gibi

stop like wind or solar. Therefore government does not want wind and solar and try to convince people to have a NPP. Nuclear energy proponents also may claim that wind and solar are not efficient as NPP so we should construct NPP. Environmentalists support them because they are less harmful. Ok wind turbines can be harmful for birds since we learned birds cannot see them and crash them but I do not think they will give more harm when we compare them with NPP. And nuclear energy proponents may say that huge areas are required for them and even they may not produce enough energy. But we have lots of empty areas and I think that they should be utilized.

durmuyor. Bu yüzden hükümet rüzgar ve güneş önerisini istemez ve insanları nükleer santral için ikna etmeye çalışır. Nükleer santrali savunanlar ise güneş ve rüzgarın nükleer kadar verimli olmadığını ve nükleer santral kurmamız gerektiğini söylerler. Çevreciler halkı destekler çünkü rüzgar, güneş daha az zararlı. Tamam bunlar da zararlı olabiliyor mesela rüzgar tribünleri kuşlar için tehlikeli olabiliyor. Kuşların bu tribünleri görmeyip çarptığını öğrenmiştik. Ama ben bunların verdiği zararın nükleer ile karşılaştırılabilecek kadar çok olduğunu düşünmüyorum. Sonra nükleer enerjiyi savunanlar bunlar için çok fazla alan gerektiğini ve buna rağmen yeterli enerji üretemediklerini iddia edebilirler. Ama çok fazla boş alanımız var ve bence bunlar değerlndirilmeli.

6-1: I think there may be differences between them. I do not know exactly how government reacts to this solution. But in my opinion, it should focus on wind and solar. Akkuyu is in south part of Turkey and it receives sunlight more and this can be a very good alternative. The government should really pay attention to this. The local people are

6-1: Bence aralarında farklılıklar olabilir. Bu öneriye hükümetin nasıl tepki vereceğini tam olarak bilmiyorum. Ama bence rüzgar ve güneş enerjisi üzerinde durmalılar. Akkuyu Türkiye'nin güneyinde ve daha fazla güneş alan bir bölge. Bu çok iyi bir alternative olabilir. Hükümet buna kulak vermeil. Yerel halk haklı çünkü nükleer

right because they will live with NPP and their ideas are most important. I wish nuclear energy proponents just look and say nothing. Actually this solution is a very positive one. But you know there is an opposing view that is NPP is better. They do not want wind or solar energy since they support nuclear and they think we should have it immediately to be a developed country. Environmentalists support the citizens. Very clean and environmentally friendly energy will be produced so they will support the Akkuyu citizens and will do everything to protest NPP. Can you imagine? There is wind outside and it blows whether you make use of it or not. Why should not we make use of it? It is free in terms of source and you do not have to do anything. Just wind comes and makes the turbines turn and you have the energy. This is amazing.

6-2: They will react differently. Government thinks that NPP is economic. They tell that we will have cheap energy, more energy and there will be job opportunities. It will not pay attention to wind and solar because wind and solar does not produce more

santral ile onlar yaşayacaklar ve onların fikirler en önemlisi. Nükleer enerjiyi savunanların bakakalıp hiçbirşey söyleyememelerini diliyorum. Aslında halkın getirdiği öneri çok olumlu. Ama biliyorsunuz nükleerin daha iyi olduğunu savunan bir kesim de var. rüzgar ya da güneşi istemiyorlar çünkü nükleeri destekliyor ve bir an önce gelişmiş ülke olabilmemiz için kurulması gerektiğine inanıyorlar. Çevreciler halkı destekler. Temiz ve çevre dostu enerji üretilecek bu yüzden Akkuyu halkının yanında yer alırlar ve nükleere karşı çıkmak için ellerinden geleni yaparlar. Düşünebiliyor musunuz? İster kullanın ister kullanmayın dışarıda rüzgar esiyor. Neden bundan faydalanmayalım. Kaynağı bedava ve öyle birşey yapmanıza da gerek yok. Rüzgar geliyor tribünleri döndürüyor ve enerjiye sahipsiniz. Bu harika.

6-2: Farklı tepki verirler. Hükümet nükleerin ekonomik olduğunu düşünecek. Ucuz enerjiden ve iş imkanlarından bahsedecek. Rüzgar ya da güneş önerisine kulak asmayacak çünkü bunlar fazla enerji üretmiyor. Rüzgar tribünlerinin ya da güneş

energy like NPP. They may say that constructing wind turbines and solar panels also requires huge land areas and this also damages environment. And they may claim that a minimum of wind is required to make the turbines turn and produce electricity. However NPP is not like them. It produces energy all time. Wind turbines and solar panels also require maintenance and this has a cost too. Nuclear energy proponents may claim that nuclear energy help Turkey develop more and be independent. They say that wind and solar are not so environmentally friendly since their construction also damages environment and some birds crash the turbines and they may die. Nuclear proponents say that turbines also give harm to animals. When they broke down, to fix them is also expensive. And they do not meet the energy need. They may be helpful in local areas but for energy need across country, they are not sufficient. The environmentalists will support wind and solar since they are renewable energy sources. They may say that solar is the main energy source for the earth and we should make use of it. They may claim that wind and solar do not emit any gas

panellerinin kurulması için geniş çaplı araziler gerektiğinden bunun da çevreye zarar vereceğinden bahsedebilirler. Ayrıca tribünlerin dönmesi ve enerji üretilmesi için minimum hızda bir rüzgar gerekli. Ancak nükleer bunlar gibi değil. Devamlı enerji üretimi söz konusu. Ayrıca rüzgar tribünlerin ve güneş panellerinin de bakım masrafları var. Nükleer enerjiyi savunanlar nükleer enerjinin Türkiye'nin gelişmesine ve dış ülkelerden bağımsız olmasına katkısı olacağını iddia edebilirler. Ayrıca rüzgar ve güneş enerjiilerinin de çok masum olmadığını söyleyebilirler. Bunların kurulumu için çok büyük alanlar gerekli ve çevreye zarar verebilir. Ya da kuşlar tribünlere çarpıp ölebiliyorlar. Yani hayvanlara zararları oluyor. Bozuldukları zaman tamir masrafları çok ve ihtiyaç duyulan enerjiyi karşılamıyorlar. Yerel bölgelerde faydalı olabilir ancak ülke çapında yetersiz kalıyorlar.Çevreciler rüzgar ve güneş enerjisini savunacaklardır çünkü yenilenebilir enerji kaynakları. Güneşiin dünya içinde ana enerji kaynağı olduğunu, ve faydalanmamız gerektiğini söyeleceklerdir. Rüzgar ve güneş

to the atmosphere. Ok they may require land areas to be constructed but they will say that this will not give harm to people, environment, nature and animals as much as NPP. The government and nuclear energy proponents may say that the maintenance and repair of them is expensive. However they forget that NPP also requires maintenance and when it breaks down, it may cause serious problems. NPP is equal to radiation and the nuclear waste is so dangerous even you cannot imagine. Nuclear waste should be stored in safe places and checked regularly to prevent leakage. The environmentalists claim that the government will not care about nuclear waste in future and they will not check it regularly so we may face more serious problems in future.

15-1: They react differently because they focus on different things. Government probably will think that how much they will cost [wind and solar energy] since they are responsible to pay the cost, they will think in terms of cost. The nuclear energy proponents may say that there is global warming

enerjisi üretiminde atmosphere zararlı gaz salınımı olmamakta. Büyük alanlar gerektirdiği doğru ancak insanlara çevreye, doğaya hayvanlara nükleer santral gibi zarar vermez. Hükümet ve nükleer enerjiyi savunanlar rüzgar tribünleri ve güneş panellerinin bakımı ve tamirinin pahalı olduğunu iddia edebilirler demiştim ama unuttukları birşey var nükleer santral de bakım gerektiriyor ve bozulduğu zaman çok daha ciddi sorunlara yol açabiliyor. Nükleer santral eşittir radyasyon demek ve nükleer atıklar çok tehlikeli. Bu atıklar güvenli yerlerde depolanmalı ve sızıntılar açısından sürekli control edilmeli. Çevreciler hükümetin nükleer atıklara gereken ehemmiyeti göstermeyeceklerini, düzenli controller yapmayacaklarını ve bu yüzden çok daha ciddi sorunlarla gelcekte karşı karşıya kalacağımızı iddia edebilirler.

15-1: Farklı tepki verirler çünkü farklı şeylere odaklanıyorlar. Hükümet muhtemelen rüzgar ve güneşin ne kadar maliyeti olduğunun üzerinde duracaktır çünkü parayı onlar ödeyecek ve maliyet açısından olaya bakacaklar. Nükleer enerjiyi savunanlar küresel ısınma olduğundan bahsedebilir ve rüzgar ve

and we cannot guarantee wind or solar. Environmentalists accept this since they [wind and solar energy] are natural sources and they do not give too much harm to the environment.

güneş enerjisinin garantisi olmadığını söyleyebilir. Çevreciler bu öneriyi Kabul ederler çünkü doğal kaynaklar ve çevreye çok zarar vermeyeceklerdir.

15-2: They give different reactions. Government most probably will think in terms of economy aspect of NPP and ignore others. Wind and solar energy do not produce much energy. They are not so efficient. They require more areas than NPP and they still do not produce same amount of energy. Moreover wind turbines, for example require a minimum level of wind to turn. If not, then they stop. I mean they do not produce energy continually so they are not so effective to meet the energy need of Turkey. These are what our government will say. The proponents may also talk about how cheap electricity will be produced and this will be reflected on bills. Some people believe that, I am sure. They may claim that we do not have enough area for wind turbines and solar panels to get the same amount of energy produced by NPP. They require maintenance much more than NPP. They also damage environment to be constructed.

15-2: Farklı tepki verirler. Hükümet ekonomi açısında olaya bakacak ve nükleeri düşünecek diğerlerini göz ardı edecektir. Rüzgar ve güneşten çok fazla enerji elde edilemiyor. Çok verimli değiller. Nükleere kıyasla daha büyük alanda kuruluyorlar ama aynı miktarda enerji bile üretemiyorlar. Rüzgar enerjisinin çalışması için minimum seviyede rüzgar lazım. Yoksa enerji üretimi durur. Demek istediğim sürekli bir enerji üretimi yapmıyorlar. Tabi bud a Türkiye'nin enerji ihtiyacını karşılamada etkili değil. Bunlar hükümetin dile getireceği sebeplerdir. Nükleeri savunanlar yine aynı şekilde ucuz elektrikten ve faturaların düşeceğinden olaya gireceklerdir. Buna inanan bir kesim var eminim. Bunlar da nükleer santralden elde edilen enerjiyi rüzgar tribünlerinden ya da güneş panellerinden elde edebilmek için gerekli olan tribün ve panellerin kurulacak kadar büyük alanların olmadığını savunacaklardır. Bakım

Environmentalists support the citizens and their suggestions. Although government and nuclear energy proponents may claim wind and solar is not sufficient and they are costly, environmentalists may tell them how clean wind and solar energy and do not threaten life of people, species.

gerektirdiğinden, kuruldukları çevreye zarar verdiklerinden bahsedeceklerdir. Hükümet ve nükleeri savunanlar rüzgar ve güneşin yetersiz ve masraflı olduğunu iddia ederken çevreciler de bunların temiz enerji kaynakları olduğunu insanları türleri tehdit etmediğini savunacaklardır. Çevrecilerin halkın önerisini destekleyeceklerini düşünüyorum.

4-1: Does our government really want to construct NPP in Akkuyu or other countries force it. The government is controlled by other countries and whatever they want, our government does. This suggestion is good for public but I do not think government pays attention to it. NPP can be better than wind and solar so they may want it. Proponents may say that Akkuyu does not receive enough sunlight and wind. Environmentalists take a bright view of it. Solar and wind are harmless. They are natural. So they support the citizens.

4-1: Gerçekten hükümet mi kurmak istiyo yoksa diğer ülkeler mi diretiyor bunu. Hükümet diğer ülkelerin kontrolü altında ve onların dediklerini yapıyor. Bu öneri halk için iyi ama hükümet dinlemez bile. Nükleer santral rüzgar ve güneşe gore daha iyi o yüzden nükleeri tercih edeceklerdir. Nükleeri savunanlar Akkuyunun yeterli güneş ve rüzgar almadığını söyleyebilirler. Çevreciler daha ılımlı bir yaklaşım sergileyeceklerdir. Rüzgar ve güneş zararsız doğal. Bu yüzden halkı destekleyeceklerdir.

4-2: Government wants to construct it …You know the use of wind and solar is not efficient because they do not give much energy in a short time. Therefore the cost for their construction may not be so economical. Their maintenance is also costly. Government may claim that they also damage environment since large areas are required for wind and solar to get the same energy as nuclear power plant supplies. Wind turbines can be dangerous for birds since they may not see turbines and crash or I read some news that wind turbines fell over, blades flew off or there can be wind turbine fires…It supports NPP by saying, it produces more energy because of the source and reactions taking place in plant. The same amount of coal and uranium differ significantly in producing energy but really significant. And NPP does this in a smaller area not like wind and solar. Moreover its energy production is continuous. Wind and solar depend on the climate, time of the day, power of the wind or solar. They [proponents] think like government. Suggest that construction for wind and solar energy is costly but not efficient to produce more energy and to meet

4-2: Hükümet kurmak istiyor. …Biliyorsunuz rüzgar ve güneşin kullanımı çok etkili değil çünkü kısa zamanda çok enerji vermiyor. Bu yüzden bunların kurulması çok ekonomik olmayabilir. Bakımları masraflı. Hükümet bunların da çevreye verdiği zararları öne sürebilir çünkü nükleer santralden elde edilecek enerjinin aynısını almak için geniş araziler kullanılacaktır. Tribünlerin kuşlar için zararlı olduğu çünkü onları farketmedikleri ve çarpmadan dolayı öldükleri ya da tribünlerin düştüğü etrafa parçalar fırlattığı hatta rüzgar tribünlerinde yangınlar çıktığıyla ilgili haberleri okuduk. Hükümet nükleeri daha çok enerji üreteceği için istiyor. Reaksiyonlar sonucu ve kullanılan kaynak sonucu fazla enerji üretiliyor. Aynı miktarda kömür ve uranium önemli derecede farklı miktarlarda enerji üretiyor. Ama gerçekten farklı… Ve nükleer bunu küçük alanda yapıyor rüzgar ve güneşle kıyasladığım durumdan konuşuyorum. Ayrıca nükleerin enerji üretimi durmuyor. Oysa rüzgar ve güneş iklime, günün saatine, rüzgarın ya da güneşin gücüne gore değişiyor. Nükleeri savunanlar da

energy. It is not worth doing when you compare their cost and what you get from them. Their maintenance is also costly and again you do not get enough from them although you spend more but you get less. Require huge areas and this means damaging environment and habitat loss and degradation. Also they suggest that NPP do not release greenhouse gases like coal and so it can decrease the impact of them. NPP produces more in a small area and …same things as government. Wind and solar energy may stop sometimes. They are dangerous too accidents may occur I just mentioned for government. They may talk more about scientific aspect of NPP to produce energy. You know, uranium bombarded with neutron and then this cause a chain reaction and huge amount of energy obtained. They also do not support this suggestion. They may also say that we already have wind turbines and solar panels but these are not enough so more efficient one is necessary. We do not totally ignore wind and solar but we need to get energy in high amount in a short time, etc. They [environmentalists] directly focus on environment. They argue that

hükümet gibi düşüneceklerdir. Rüzgar ve güneşin kurulumu pahalı ama yeterli enerji üetmiyor ve ihtiyacı karşılamıyor. Maliyetle elde ettiğimizi karşılaştırınca bunları yapmaya değer bulmayacaklardır. Hemde bakımları masraflı. Çok harcıyorsunuz ama az karşılığını alıyorsunuz. Geniş alanlar tahrip edilmek zorunda bud a çevreye zarar verecek, yaşam alanlarının kaybına, türlerin coğrafik nedenlerle birbirinden ayrılmasına yol açacaktır. Ayrıca nükleeri savunmalarında onun kömür santralleri gibi sera gazı salınımına yol açmadığı ve bu gazların etkisinin azalması etkili olacaktır. Nükleer santral küçük bir alanda çok iş yapıyor. Hükümetle aynı şeyler. Rüzgar ve güneş enerjisi üretimi arada durabilir. Onlar da tehlikeli ve kazalara yol açabiliyor yukarda bahsetmiştim. Nükleeri savunanlar bilim boyutundan da konuşabilir. Nükleerin enerji elde etmesiyle ilgili. Biliyorsunuz ya uranium nötronla bombardıman ediliyor ve bu bir zincir reaksiyon oluşturuyor. Sonuçta çok enerji elde ediliyor. Rüzgar ve güneş enerjisini desteklememelerinin nedenlerinden biri de zaten bunların olduğu ama yetersiz kaldığı ve daha

NPP cause loss of ecosystem, habitat because radioactive waste are formed they release radiation for long and they do not decay. I mean they have half-life for billion years. This means the half of the initial amount decays for billion years but other half remains. They argue wind and solar are not dangerous as NPP. Some can be some disadvantageous, that is normal, but we cannot compare with NPP in terms of advantage. Huge areas are required, that is true, then let's tell people the importance of energy and learn how to use it efficiently. NPP produces more energy in a small area but it makes very large bad impact. It is small but extremely dangerous. It may prevent global warming but it gives harm to ecosystem, people, animals, plants. I think they defend themselves in this way and support citizens.

verimlisine ihtiyaç duyduğumuz da olacaktır. Rüzgarı ve güneşi tamamen bırakmadıklarını ama kısa sürede çok enerjiye ihtiyacımı olduğunu iddia edeceklerdir. Çevreciler ise çevre üzerinde duracaklar. Nükleerin ekosistem kaybına yok açtığı, habitat zarar verdiği çünkü nükleer atıkların radyasyon yaydığı uzun sure bozunmadığı gibi şeylerden bahsedeceklerdir. Yani milyarlarca yıl yarı ömrü olan radyoaktif maddelerden bahsediyorum. Bu şu demek ilk baştaki madde miktarının yarıya inmesi için yıllarca yıl geçecek sonra gerisi aynen kalacak. Çevreciler rüzgar ve güneşin nükleer kadar zararlı olmadığı, dezavantajlarının olduğu ama avantajlarıyla kıyaslanamayacağını savunacaklardır. Bunlar için geniş alanlar gerektiği ama insanlara enerjinin öneminin anlatılmasını ve tasarruf etmemiz gerektiğini hatırlatmalıyız. Nükleer santral küçük alanda çok üretiyor ama kötü anlamda etkisi de çok büyük. Küresel ısınmayı önleyebilir ama ekosisteme insanlara hayvanlara bitkilere zarar veriyor.

APPENDIX H

H. CURRICULUM VITAE

PERSONAL DETAILS

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EDUCATION

2006-2014 : PhD Student in Elementary Education, METU

2001-2006 : B.S. in Elementary Science Education, METU

ACADEMIC AND PROFESSIONAL EXPERIENCE

2006-present : Research Assistant in Department of Elementary Education, Middle East Technical University, Ankara, Turkey

07/2012-08/2013 : Visiting Scholar, University of Missouri, Department of Learning, Teaching, and Curriculum

RESEARCH INTEREST

Socioscientific Issues, Teacher Beliefs

AWARDS AND SCHOLARSHIPS

2006-2011 : National Scholarship for PhD Students by the Scientific and Technological Research Council of Turkey (TÜBİTAK)

2014 : International Committee Scholarship, National Association of Research in Science Teaching (NARST)

MEMBERSHIP

National Association of Research in Science Teaching (NARST)

European Science Education Research Association (ESERA)

American Educational Research Association (AERA)

PROJECT

June, 2008 : Scientific and technological research council of Turkey (TUBİTAK) Little Teachers are Touching the Science (Trainer)

August, 2008 : Scientific and technological research council of Turkey (TUBİTAK) Little Teachers are Touching the Science (Trainer)

January, 2009 : Scientific and technological research council of Turkey (TUBİTAK) Little Teachers are Touching the Science (Trainer)

NATIONAL AND INTERNATIONAL PUBLICATIONS/ CONFERENCES

Cansiz, M., & **Türker, N**. (2011). Scientific literacy investigation in science curricula: The case of Turkey. *Western Anatolia Journal of Educational Sciences, Special Issue*, 359-366.

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Yılmaz-Tüzün, Ö. & **Türker, N**. (2008). Validation of mentoring for effective primary science teaching instrument for a Turkish sample. Paper presented in *National Association for Research in Science Teaching (NARST)*.

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TEACHING EXPERIENCE

Probability and Statistics

Laboratory Applications in Science I and II

School Experience

Science, Technology, and Society

Measurement and Assessment

Educational Inquiry

Advanced Educational Research

Qualitative Research in Elementary Education

Basic Science in Early Childhood Education

APPENDIX I

I. EXTENDED TURKISH SUMMARY

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ SOSYOBİLİMSEL KONULARDA MUHAKEME YETENEKLERİNİN GELİŞTİRİLMESİ

Giriş ve Literatür

Kök hücre, klonlama, genetiği değiştirilmiş gıdalar, küresel ısınma ve nükleer santral gibi konular bireylerin günlük hayatta karşılaşabilecekleri olaylara örnek olarak verilebilir. Bireyler bu konularda bir tartışma ve karar verme sürecine girebilirler. Örneğin nükleer santral kurulmalı mı kurulmamalı mı ya da genetiği değiştirilmiş gıdalar yasaklanmalı mı yoksa yasaklanmamalı mı gibi tartışmalar olur ve her birey bir muhakeme süreci yaşar. Bu konularla ilgili genellikle bireyler arasında ikilemler oluşur çünkü farklı fikirler ve karşıt görüşler mevcuttur. Farklı ve karşıt görüşlerin olması bu konuları çelişkili, karmaşık, çözümü kolay ve tek olmayan yapmaktadır (Sadler, 2004). Sadler (2004) bu konuları sosyobilimsel konular olarak isimlendirmiştir çünkü bu konuların hem bilimsel hem de sosyal yönü vardır. Ayrıca teknolojiyle bağlantısı da vardır.

Bireylerden beklenen bu konuları derinlemesine tartışmaları ve her yönü değerlendirerek bir karara varmalarıdır. Basit ve sadece tek bir açıdan verilmiş

kararlar istenmemektedir. Bu nedenle sosyobilimsel konularda karar verme üzerine odaklanmış bilimsel çalışmaların sayısı artmaktadır (Sadler, 2003). Geleceğin vatandaşı olarak öğrenciler bu konular üzerinde nasıl tartışılacağını ve karar verileceğini öğrenmelidirler. Sosyobilimsel konuların öğretilmesi özellikle de bilimsel okuryazar bireyler yetiştirmek açısından fen eğitiminin bir amacı olarak görülmüştür (Hofstein, Eilks, & Bybee, 2011; Lee, Chang, Choi, Kim, & Zeidler, 2012; Sadler, Barab, & Scott, 2007; Zeidler, Sadler, Simmons, & Howes, 2005). Fen eğitimindeki son gelişmeler de bilimsel okuryazarlık ve vatandaşlık eğitimini vurgulamakta ve bu yüzden sosyobilimsel konuların fen eğitimine dahil edilmesi gerektiğini göstermektedir (Barrue & Albe, 2013).

Bunların ışığı altında bu çalışma fen bilgisi öğretmen adaylarının sosyobilimsel konularda muhakeme yeteneklerinin geliştirilmesini ve geliştirilmesine yardımcı olabilecek sınıf içi aktiviteleri belirlemeyi amaçlamaktadır. Bilim bağlamında muhakeme daha çok formal muhakeme olarak bilinip mantık ve matematiğin kurallarına dayalı olarak gelişmiştir. Formal muhakeme, bireylerin genellikle iyi tanımlanmış problemler üzerinde kendilerine sunulan nedenleri ve sonuçları doğru veya yanlış olarak değerlendirmesini kapsayan bir süreçtir (Evans & Thompson, 2004). İnformal muhakeme ise nedenlerin ve sonuçların açık ve kesin olmadığı, iddiaların ve delillerin değerlendirildiği, çelişkili, karmaşık ve iyi tanımlanmamış problemlerin tartışma ve çözümünü kapsayan bir süreçtir (Means & Voss,1996). Shaw (1996) ise iyi tanımlanmamış problemlerin daha çok günlük hayatta karşılaştığımız, seçim yapmak ya da karar vermek zorunda olduğumuz sorunlar

olduğunu belirtmiştir. Sadler (2004) ise bilim insanlarının doğadaki olayları açıklarken formal muhakemeye başvurduklarını, vatandaşların da günlük hayattaki çelişkili konular için informal muhakemelerini kullandıklarını vurgulamıştır.

Sosyobilimsel konuları tartışma ve çözüme ulaştırma açısından informal muhakemenin yanı sıra bu konuların doğasını ve bazı değişmez özelliklerini de anlamak gereklidir. Öğrenciler bu özellikleri içselleştirmeli ve bunlar üzerine muhakeme edebilmelidir. Sadler, Barab, ve Scott (2007) sosyobilimsel konuların özelliklerini kompleks, sürekli araştırmaya dayalı, çok yönlü ve şüphecilik gerektiren olarak tanımlamışlardır. Öğrencilerin bunlar üzerine muhakemeleri ise sosyobilimsel muhakeme olarak isimlendirilmiştir. Sonuç olarak sosyobilimsel muhakeme sosyobilimsel konuların dört temel özelliği olan kompleks, sürekli araştırmaya dayalı, çok yönlü ve şüphecilik gerektiren bir yapıdır. Bu dört temel özellik öğrencilerin sosyobilimsel konuları derinlemesine araştırmalarını ve tartışmalarını, daha iyi akıl yürütmelerini, bütün etmenleri göz önünde bulundurarak mantıklı ve bilinçli bir karara varmalarını amaçlamaktadır. Sadler ve diğerlerinin (2007) öne sürdüğü sosyobilimsel muhakeme üzerine yapılan bir diğer çalışmada da dört temel özellikten ikisi olan çok yönlü ve şüphecilik kavramları her ikisini de kapsayacak şekilde çok yönlü olma özelliğinin altında toplanmıştır (Sadler, Klosterman, & Topcu, 2011). Bu çalışmada da sosyobilimsel muhakeme kompleks, sürekli araştırmaya dayalı ve çok yönlü olarak üç boyutta incelenmiştir.

Kompleks boyutu sosyobilimsel konuların doğası gereği vardır. Zeidler ve Sadler (2011) sosyobilimsel konuların tanımında kompleks olduklarının vurgulandığını

belirtmişlerdir. Sosyobilimsel konular iyi tanımlanmamış problemlerdir ve kesin ve tek çözümleri yoktur (Sadler, 2004). Farklı çözümler ortaya çıkabilir. Öğrencilerin sosyobilimsel konuların kompleks olduğunu kavramaları önemlidir çünkü bunu kavrayabilen öğrenciler daha bilinçli, delile dayalı, mantıklı kararlara varmaktadırlar. Sosyobilimsel konuların kompleks olduğunu kavrayamayan öğrenciler ise basit, tek düze, ve tek yönlü çözüm önerileri sunmaktadırlar.

Sosyobilimsel konuların çok yönlü olması demek bu konuları tartışırken farklı etmenleri dikkate alıp incelemektir ve farklı etmenler arasında dengeli bir karara varmayı gerektirmektedir. Sosyobilimsel konular ikilemler içerdiği için karşı fikirler, görüşler olacaktır çünkü bireyler farklı fikirlere, ilgi alanlarına, önceliklere ve önyargılara sahiptir. Bu noktada herkesin önyargıları olduğunu ve sundukları bilgilerin ve delillerin önyargılarından etkilendiğini unutmamak ve araştıran sorgulayan bir tavır takınmak gerekir. Bu nedenle bireyler farklı etmenler üzerinde durarak sosyobilimsel konuları tartışabilir ve farklı çözümlere ulaşabilirler. Bireylerden beklenen sosyobilimsel konuları farklı etmenler açısından incelemeleri ve tartışmalarıdır. Bu noktada iyi muhakeme yapabilenler akılcı kararlar verebilir ve kararların arkasındaki nedenleri delillerle açıklayabilir. Aksi takdirde ise bireyler tek etmen açısından sosyobilimsel konuları inceler, çözüm önerileri tek etmeni kapsamaktadır ve diğer etmenler açısından dengeli değildir.

Sosyobilimsel konuların tartışılması ve çözüme ulaşılması sürekli araştırmaya dayalıdır çünkü bu konular önceden de belirtildiği üzere iyi tanımlanmamıştır ve belirsizlikler vardır (Sadler et al., 2007). Bu konularla ilgili tartışırken bilgi

eksikliği doğacaktır ve bu da ek araştırmalara, bulgulara ihtiyaç duyulacaktır. Bireylere sunulan bilgiler yetersiz ve/veya taraflı olabilir. Bu yüzden sosyobilimsel konuları derinlemesine tartışabilmek ve bu konularla ilgili akılcı kararlar verebilmek için bireyler araştırma ve sorgulama yapmanın önemini kavrayabilmeli ve bu beceriyi edinmelidirler. Bunu gerçekleştirebilen bireyler sosyobilimsel bir olayla karşılaştığında eldeki bilgileri değerlendirebilir ve eksiklikleri fark edip tamamlama girişiminde bulunur. Muhakeme analiz etme, değerlendirme, tahminlerde ve çıkarımlarda bulunma gibi çeşitli düşünme tarzlarını içeren zihinsel bir süreçtir (Stiggins, Arter, Chappuis, & Chappuis, 2004). Stiggins et al. (2004) altı çeşit muhakeme tipi öne sürmüştür. Bunlar analitik muhakeme, sentez, karşılaştırmalı muhakeme, sınıflama, tümevarımsal muhakeme, tümdengelim ve değerlendirme muhakemedir. Analitik muhakeme ve değerlendirici muhakeme özellikle sosyobilimsel konularla ilgili yargıda bulunma ve karar verme süreçlerinde kullanılan muhakeme çeşitleridir. Analitik muhakemede bireyler bütünün parçalarını belirleyip parçalar arasında ve parçalarla bütün arasında iliksi kurmaya çalışırlar; değerlendirme muhakemesinde ise bir fikir, görüş ya da karar bildirip bunları savunurlar (Stiggins et al., 2004). Bunun içinde bir iddia, iddiayı dayandırdıkları kıstas ve iddiayı destekleyen deliller sağlarlar. Sosyobilimsel muhakeme daha çok analitik ve değerlendirme muhakeme tiplerini içermektedir. Bireyler sosyobilimsel konularla karşılaştıklarında destekleyici ya da karşıt iddiaları dikkatlice değerlendirebilmelidirler. Gerekirse bilgi alış verisinde bulunup, araştırmalar yapıp deliller sunabilmelidirler. Akilci kararlar verebilmek için sosyobilimsel konularla ilgili farklı etmenleri belirleyebilmeli ve

inceleyebilmelidir. Bu sayede bireyler sosyobilimsel konuların kompleks, sürekli araştırmaya dayalı ve çok yönlü olduğunu kavrayabilir ve ulaştıkları çözümler ileri düzey bir muhakemenin urunu olur. Bu çalışmada da katılımcıların sosyobilimsel konularda özellikle analitik ve değerlendirme muhakeme yeteneklerini kullanmaları beklenmektedir. Örneğin katılımcılar sosyobilimsel konuların çok yönlü olduğunu kavrayabilmeleri için nükleer santrale karşı farklı tarafların nasıl tepkiler vereceği, bu tarafların nasıl iddialar ortaya atacağı ve iddialarını nasıl destekleyeceğini belirlemeleri beklenmektedir. Eğer bunları sosyobilimsel konuların kompleks ve sürekli araştırmaya dayalı özellikleri için de yapabiliyorlarsa, sosyobilimsel muhakemelerinin ileri düzeyde olduğu söylenebilir. Bu çalışmanın amacı da zaten fen bilgisi öğretmen adaylarının sosyobilimsel muhakemelerini geliştirmektir.

Araştırma Amacı ve Soruları

Bu çalışmada öğretmen adaylarının sosyobilimsel muhakemelerini sosyobilimsel konular üzerine tasarlanmış bir ders yardımıyla geliştirmektir. İki ana araştırma sorusu çalışmaya yön vermiştir.

1. Fen bilgisi öğretmen adaylarının sosyobilimsel muhakemeleri sosyobilimsel konular üzerine tasarlanmış ders ile nasıl değişmiştir?

   a. Öğretmen adaylarının sosyobilimsel konuların kompleks olduğunu kavramaları sosyobilimsel konular üzerine tasarlanmış ders öncesi ve sonrası nasıl değişmiştir?

b. Öğretmen adaylarının sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavramaları sosyobilimsel konular üzerine tasarlanmış ders öncesi ve sonrası nasıl değişmiştir?
c. Öğretmen adaylarının sosyobilimsel konuların çok yönlü olduğunu kavramaları ve incelemeleri sosyobilimsel konular üzerine tasarlanmış ders öncesi ve sonrası nasıl değişmiştir?

2. Fen bilgisi öğretmen adaylarının sosyobilimsel muhakeme yetenekleri sosyobilimsel konulara göre tasarlanmış olan ders süresince nasıl değişmiştir?

a. Öğretmen adaylarının sosyobilimsel konuların kompleks olduğunu kavramaları sosyobilimsel konular üzerine tasarlanmış derste uygulanan birinci ve ikinci aşamalardan sonra nasıl değişmiştir?
b. Öğretmen adaylarının sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavramaları sosyobilimsel konular üzerine tasarlanmış derste uygulanan birinci ve ikinci aşamalardan sonra nasıl değişmiştir?
c. Öğretmen adaylarının sosyobilimsel konuların çok yönlü olduğunu kavramaları ve incelemeleri sosyobilimsel konular üzerine tasarlanmış derste uygulanan birinci ve ikinci aşamalardan sonra nasıl değişmiştir?

Çalışmanın Önemi

Sosyobilimsel konular öğrencilerin gerçek hayatta karşılaşabilecekleri bilimle ilişkili sosyal konulardan haberdar olmalarına olanak vermektedir (Sadler & Fowler, 2006). Sadler ve Fowler (2006) fen eğitimin bilim, teknoloji ve toplum

arasındaki dinamik etkileşimi yansıtması gerektiğini savunmaktadırlar. Toplumun bireyleri olarak öğrenciler mutlaka bu konularla gelecekte iç içe olacaklardır. Bu yüzden sosyobilimsel konuların fen eğitimine dahil edilmesi önemlidir. Ayrıca bu konuların tartışılabilmesi ve çözüme ulaştırılabilmesi için gerekli olan bilgi ve becerilerin de öğrencilere kazandırılması önemlidir. Sosyobilimsel konuların fen eğitimine dahil edilmesi bilimsel bilginin farkında olan bilimsel okur yazar vatandaşlar yetiştirebilmek için önemli olduğu araştırmacılar tarafından da desteklenmektedir (Driver, Newton, & Osborne, 2000; Kolsto, 2001a). Tüm dünyada bilimsel okur yazar bireyler yetiştirmek fen eğitiminde son yapılan yeniliklerde dile getirilmiştir. Türkiye'de de 2006 yılında fen müfredatında yapılan yeniliklerle bilimsel okuryazarlık fen eğitimin bir amacı olmuştur (MEB, 2006). Sosyobilimsel konular da 2013 yılında fen müfredatına fen eğitimin amacı olarak eklenmiştir (MEB, 2013).

Öğrencilerin sosyobilimsel konularda muhakeme edebilmeli bu nedenle onların bu becerileri sınıf ortamında kazanmaları gerekmektedir. Doğal olarak öğretmenlerin de bu konularda bilgi ve beceri sahibi olmaları sınıf içi uygulamalarının verimini artıracaktır. Öğretmenler sosyobilimsel konularla ilgili çeşitli aktiviteler yaptırabilmeli ve öğrencilere rehber olabilmelilerdir. Bu nedenle öğretmenlerin, mesleğe başlamadan önce öğretmenlik eğitimleri sırasında sosyobilimsel konuları öğrenmeleri ve muhakeme etmelidirler. Bu öğretmenlerin hem kişisel hem de geleceğin öğretmenleri olarak profesyonel gelişimleri açısından önemlidir. Bu

sayede öğrencilerini sosyobilimsel konularla ilgili daha iyi yönlendirebilir ve onlara gerekli bilgi ve becerinin kazandırılmasını sağlayabilirler.

Bu çalışma aynı zamanda sosyobilimsel muhakeme yeteneklerinin gelişebildiği ile ilgili kanıt sağlamıştır. Bu anlamda literatürde yeterli çalışma bulunmamaktadır. Sadler et al. (2011) sosyobilimsel muhakeme ile ilgili daha çok çalışma yapılması gerektiğini savunmuştur. Ayrıca bu çalışmada sosyobilimsel konular üzerine bir ders tasarlanmıştır. Bu da bu alandaki literatüre katkı sağlamış ve sosyobilimsel muhakeme yeteneklerinin gelişmesine katkı sağlayacak bir takım aktiviteler önerilmiştir.

Çalışmanın diğer bir önemi ise sosyobilimsel muhakeme yeteneklerinin değerlendirilmesinde önceki çalışmalarda kullanılan rubriğin gelişmesine katkıda bulunmak ve bu yeteneklerin daha detaylı değerlendirilmesine olanak sağlayan ikinci bir rubrik geliştirilmesine olanak sağlamaktır.

Yöntem

Çalışma modeli

Bu çalışmaya yön veren iki ana araştırma sorusu temel alınarak çalışmada tasarım tabanlı araştırma modeli kullanılmıştır. Tasarım tabanlı araştırma ilk olarak Brown (1992) ve Collins (1992) tarafından tasarım deneyleri adıyla ortaya çıkmıştır. Cobb, Confrey, diSessa, Lehrer ve Schauble (2003) tasarım tabanlı araştırma modelinin döngüsel olarak yapılan analiz ile tasarlanan ve geliştirilen ders içi

deneyler olduğunu ifade etmişlerdir. Tasarım deneyleri öğrenme ortamını anlamada önemli bir role sahiptirler (Cobb ve diğerleri, 2003).

Bu çalışmada sınıf tasarım deneyi uygulaması yapılmıştır. Cobb ve diğerleri (2003) herhangi bir tasarım deneyi uygulanırken kuram, öğrenme amaç ve çıktıları, öğrencilerin ön bilgilerinin tasarım deneyini hazırlamada önemli bir role sahip olduğunu vurgulamaktadırlar. Bu çalışmada sosyobilimsel konular üzerine tasarlanan ders içerdiği aşamalar detaylı bir şekilde verilmiştir.

Sınıf Tasarım Deneyi: Sosyobilimsel Konular Üzerine Ders

Bir dönem boyunca sosyobilimsel konular üzerine tasarlanmış olan fen-teknoloji-toplum dersi durum olarak ele alınmış ve incelenmiştir. Toplamda haftada üç saat olmak üzere 36 saat ders yapılmıştır. Dersin hazırlanma aşamasında sosyobilimsel muhakeme ile ilgili amaç ve çıktılar belirlenmişlerdir ve öğretmen adaylarının ön sosyobilimsel muhakemeleri görüşme yoluyla tespit edilmiştir. Ders üç aşamadan oluşmaktadır.

İlk aşamada öğretmen rehberliğinde fen-teknoloji-toplum, sosyobilimsel konular ve informal muhakeme ile ilgili okumalar ve makaleler tartışılmıştır. Bu tartışmaların sonunda genel tekrarlar yapılmış ve sosyobilimsel konuların değişmeyen özellikleri üzerine açık tartışmalar yapılmıştır. Öğretmen ilk üç hafta fen-teknoloji-toplum üzerinde durmuştur. “Science, Technology and Society”, “Meaning of STS for Science Teachers” (Yager, 1996); “The Congruency of the STS Approach and Constructivism” (Lutz, 1996); “What is STS Science Teaching?” gibi kitap

bölümleri ve makaleler tartışılmıştır. Bu tartışmaların amacı fen bilgisi öğretmen adaylarını fen-teknoloji-toplum hakkında bilgilendirmek ve bunların fen eğitimindeki yerini öğretmenlere benimsetmektir. Tartışmalar öğretmen rehberliğinde, öğretmen adaylarının aktif katılımını destekleyici şekilde olmuştur. Öğretmen adayları fikirlerini beyan etmiş ve birbirlerinin fikirleri üzerine konuşmuşlardır. Sonraki iki hafta "Beyond STS: A Research-Based Framework for Socioscientific Issues Education" (Zeidler et al., 2005), "Patterns of Informal Reasoning in the Context of Socioscientific Decision Making" (Sadler & Zeidler, 2005), and "Preservice Science Teachers' Informal Reasoning about Socioscientific Issues: The influence of issue context" (Topcu, Sadler, & Yilmaz-Tuzun, 2010) adlı makaleler tartışılmıştır. Bu sayede fen-teknoloji-toplum yaklaşımından sosyobilimsel konular yaklaşımına geçiş sağlanmış ve öğretmen adayları bilimsel okuryazarlık hakkında bilgi sahibi olmuşlardır. Bu iki yaklaşım arasındaki fark vurgulanmıştır. Son olarak da informal muhakeme üzerinde durulmuş ve akılcı, duygusal ve sezgisel informal muhakeme örüntüleri örneklendirilmiştir. Sonraki üç hafta ise "Toward a Global Understanding of Nuclear Energy and Radioactive Waste Management" (Powell, Robinson, & Pankratius, 1994) adlı makale ve nükleer santralin pozitif ve negatif yönleri tartışılmıştır. Nükleer santralin pozitif ve negatif yönlerini ekonomi, çevre, politika ve toplum açısından ele alan, sınıf içi tartışmaları yönlendiren sorular sorulmuştur.

İkinci aşamada öğretmen öğretmen rehberliğinde grup aktiviteleri ile yaptırılmıştır. Bu aktivitede öğretmen adayları gruplar halinde farklı roller üstlenerek (çevreci, iş

adamı, politikacı gibi) nükleer santral ile ilgili iddialar ve deliller ortaya koyup nükleer santralin kurulup kurulmaması ile ilgili önerilerini ve kararlarını açıklamışlardır. Bu aktivitede de politikacıları temsil eden grup üyeleri diğer gruplara dağılmış ve çevreci, iş adamı ve bilim adamlarının iddialarını ve dayanaklarını dinlemişlerdir. Sonuçta nükleer santralin kurulmasında karar verme yetkisi hükümette gözüktüğü için politikacıları temsil eden grup diğer grupların fikirlerini değerlendirerek bir karara varmaya çalışmışlardır.

Üçüncü aşamada fen bilgisi öğretmen adayları öğretmenden bağımsız grup aktiviteleri gerçekleştirmişlerdir. Her grup nükleer santralden farklı bir sosyobilimsel konu seçip tartışmış ve akılcı kararlar vermeye çalışmışlardır. Genetiği değiştirilmiş gıdalar, deney hayvanları, kök hücre, genetik tarama grupların tartıştığı sosyobilimsel konulardır.

Katılımcılar

Çalışmanın katılımcıları Orta Doğu Teknik Üniversitesi, 2010-2011 sonbahar dönemi, fen-teknoloji-toplum dersine kayıtlı son sınıf fen bilgisi öğretmen adaylarıdır. Bu ders fen bilgisi öğretmen adaylarının son sınıfta aldıkları zorunlu bir derstir. Derste 33 öğretmen adayı kayıtlıdır. Yaşları 22 ile 26 arasında değişmektedir. Tamamı biyoloji, fiziki kimya içerikli temel fen derslerini tamamlamışlardır. Ayrıca eğitim derslerinin birçoğunu da tamamlamışlardır. Bir katılımcı hariç diğerleri çevre ile ilgili bir ders almıştır. Otuz üç öğretmen adayı görüşmeler hariç diğer tüm veri toplama yöntemlerine katılmışlardır. Gönüllülük

esasına dayanarak 33 öğretmen adayından 24'ü ile ders öncesi ve sonrası görüşme yapılmıştır. Görüşme yapılan öğrencilerin hepsi sosyobilimsel konuları duyduklarını ancak bu dersteki gibi tartışma ya da karar verme sürecini içeren aktivitelere katılmadıklarını bildirdiler.

Veri Toplama

Çalışmanın verisi dersin verildiği bir dönem boyunca toplanmıştır. Ön-son görüşmeler, açık uçlu sorular, dokümanlar, video/ses kayıtları çalışmanın veri kaynağını oluşturmuştur. Önceden de bahsedildiği gibi 24 fen bilgisi öğretmen adayı gönüllü olarak görüşmelere katılmıştır. Derse kayıtlı tüm öğretmen adayları diğer veri toplama yöntemlerine dahil olmuştur.

İlk veri toplama aracı fen bilgisi öğretmen adaylarıyla birebir yapılan görüşmelerdir. Ön ve son görüşmeler fen bilgisi öğretmen adaylarının ders öncesi ve sonrasında sosyobilimsel muhakemelerini değerlendirip ders sonunda öğretmen adaylarının muhakeme yeteneklerinde değişiklik olup olmadığını araştırmak için kullanılmıştır. Her görüşme 20 ile 30 dakika sürmüştür. Sadler ve diğerlerinin (2011) küresel ısınma için geliştirdikleri görüşme protokolü gerekli değişiklikler yapılarak nükleer santral için uyarlanmıştır. Protokolde Akkuyu'da kurulması planlanan nükleer santral ile ilgili durum anlatılmış ve sonrasında görüşme soruları sıralanmıştır. Görüşmeye katılan katılımcılar önce durumu okuyup sonrasında araştırmacı soruları onlara tek tek yöneltmiştir.

İkinci olarak fen bilgisi öğretmen adayları nükleer santral ile ilgili açık uçlu sorular cevaplandırmışlardır. Katılımcılara nükleer enerji, radyoaktivite, nükleer atık ve nükleer santralin neden bir sorun olabileceği ile ilgili sorular sorulmuşur. Açık uçlu sorular da ders öncesi ve sonrası uygulanmıştır.

Üçüncü olarak fen bilgisi öğretmen adaylarından çeşitli dokumanlar toplanmıştır. Bunlar öğretmen adaylarının sınıf içindeki tartışma ve aktivitelerden sonraki sosyobilimsel muhakemelerini öğrenmek amaçlı sorular içermektedir. Katılımcılar ilk olarak nükleer santralin pozitif ve negatif yönlerini tartıştıktan sonra görüş ve düşüncelerini kendilerine verilen soruları cevaplandırarak belirtmişlerdir. İkinci olarak nükleer santral ile ilgili grup aktivitesinden sonra bu aktivite ile ilgili düşüncelerini yine kendilerine sorulan soruları cevaplandırarak bildirmişlerdir. Ayrıca bu grup aktivitesinde gruplar iddialarını, dayanaklarını, önerilerini belirten raporlar hazırlamışlardır.

Dördüncü olarak video ve ses kayıtları veri toplama aracı olarak kullanılmıştır. Ders bir dönem boyunca kayıt altına alınmıştır ve nükleer santral üzerine yapılan grup aktivitesinde her grubun tartışması ses kaydı yapılmıştır.

Veri Analizi

İlk araştırma sorusu olan fen bilgisi öğretmen adaylarının sosyobilimsel muhakemeleri sosyobilimsel konular üzerine tasarlanmış ders ile nasıl değiştiği öncelikli olarak öğretmen adaylarının ön ve son görüşmelerinin analiz edilmesiyle belirlenmiştir. Açık uçlu sorularla bu sorunun cevabı desteklenmiştir. Bu noktada

veri analizi başka bir araştırmacı ile beraber yapılmıştır. Önce beş fen bilgisi öğretmen adayının ön ve son görüşmeleri Sadler ve diğerlerinin (2001) hazırladığı rubriğe göre analiz edilmiştir. Bu rubrik sosyobilimsel muhakemeyi kompleks, sürekli araştırmaya dayalı ve çok yönlü olmasına göre değerlendirmektedir. Sıfırdan dörde kadar seviyeler bulunmaktadır. Bu rubrik bireylerin;

- Sosyobilimsel konuların kompleks olduğunu kavrayıp kavrayamadıklarını ve kompleks olmasını sağlayan nedenleri ortaya çıkarmalarını,
- Sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu idrak edip edemediklerini ve gerekli olan bilgileri sunup sunamadıklarını,
- Sosyobilimsel konuların çok yönlü olduğunu anlayıp anlayamadıklarını ve bu konuları tartışırken çeşitli görüş ve fikirler arasındaki farklılığı belirleyip belirleyemediklerini değerlendirmektedir.

İki araştırmacının yukarıda bahsedilen rubrikle, birbirinden bağımsız yaptığı ilk analizlerde, toplamda elde edilen otuz değerlendirmenin dokuzunda tutarsızlık gözlemlenmiştir. Bir araya gelen araştırmacılar bunların değerlendirme sırasında yapılan bireysel hatalardan olduğunu anlamış ve bu dokuz tutarsızlık bu şekilde ortadan kalkmıştır. İlk analizde, iki araştırmacı da yukarıda bahsedilen rubriğin öğretmen adaylarının sosyobilimsel muhakemelerini değerlendirmede yetersiz kaldığı hemfikrine varılmıştır. Eldeki veriler çok daha derin bir muhakeme değerlendirmesinin yapılması gerektiğini göstermektedir. Örneğin katılımcılardan biri sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu belirtmiş ve görüşme protokolünde verilen durumda bazı bilgilerin eksik olduğunu söylemiştir.

Sonuç olarak da bu bilgilere üç tane örnek vermiştir. Yukarıda bahsedilen rubrik kullanıldığında bu katılımcı rubrikteki en yüksek seviyede bir açıklama yapmış olmaktadır. Diğer bir katılımcı da aynı şekilde bir cevap vermiş ancak eksik olduğunu düşündüğü bilgiler hakkında detaylı açıklamalar, savunmalar yapmış hatta bilimsel bilgi ile desteklemiştir. İkinci katılımcı da bu rubriğe göre en yüksek seviyede bir açıklama yapmıştır. Yani bu iki katılımcının da muhakeme seviyesi eşit kabul edilmiştir ancak ikinci katılımcının daha ileri bir seviyeyi hak ettiği kanaatine varılmıştır. Bu nedenle bu tarz farkları göz ardı etmemek için ilk rubriğe ek olarak ikinci bir rubrik geliştirmiştir. Sıfırdan üçe kadar seviyeler bulunmaktadır. İlk rubric "breadth rubric" ikinci rubric ise "depth rubric" olarak isimlendirilmiştir. İkinci rubric katılımcıların;

- Sosyobilimsel konuların kompleks olduğunu anlamalarını, bunun için sebepler belirtmelerini ve bu sebeplerle ilgili detaylı açıklama, dayanak göstermelerini,
- Sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavramalarını, bu konular üzerine muhakeme yapabilmek için hangi bilgilerin de gerekli olduğunu belirtmelerini ve bu bilgilerin neden gerekli olduğu ile ilgili detaylı açıklama, dayanak göstermelerini,
- Sosyobilimsel konuların çok yönlü olduğunu kavramalarını, bu konuları tartışırken çeşitli görüş ve fikirler arasındaki farklılığı belirlemelerini ve bu farklılıkların neden kaynaklanabileceği ile ilgili detaylı açıklama, dayanak göstermelerini değerlendirmektedir.

İkinci rubriğin güvenirlik ve geçerliliğini sağlamak için iki araştırmacı fen bilgisi öğretmen adaylarının ön ve son görüşmelerini her iki rubriği de kullanarak analiz etmişlerdir. Sonuçta iki araştırmacı arasında otuz değerlendirmeden beş tutarsızlık oluşmuş ve bunlar üzerinde de hemfikre varılmıştır. İlk rubrik için iki araştırmacı arasındaki ölçüm güvenirlik katsayısı %93, ikincisi için ise %90 bulunmuştur.

İki rubrikten elde edilen sosyobilimsel muhakeme puanları birleştirilmiş ve 8 seviyeden oluşan sıralı bir ölçek haline getirilmiştir. Böylece her fen bilgisi öğretmen adayının birinci ve ikinci rubrikten aldığı puanı temsil eden tek bir ön görüşme puanı ve son görüşme puanı olmuştur. Bu ön ve son görüşme puanları istatiksel analize tabi tutularak fen bilgisi öğretmen adaylarının sosyobilimsel muhakeme yeteneklerindeki değişim bulunmuştur.

İkinci araştırma sorusunun analizi için birinci araştırma sorusu kapsamında geliştirilen rubriklerde tanımlanan seviyeler kullanılmıştır. Öğretmen adaylarının birinci ve ikinci aşamadan sonra sosyobilimsel muhakeme açısından nasıl geliştikleri bu rubrikler kullanılarak ortaya çıkarılmıştır.

Bulgular ve Tartışma

Çalışmanın bulguları iki kısımda verilmiştir. İlkinde fen bilgisi öğretmen adaylarının sosyobilimsel muhakeme yeteneklerindeki değişim kompleks, sürekli araştırmaya dayalı ve çok yönlü alt boyutları doğrultusunda verilmiştir.

Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Muhakeme Yetenekleri

Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Konuların Kompleks Olduğunu Kavramalarındaki Değişim

Ön ve son görüşmeler ilk rubriğe (breadth rubric) göre analize edilmiştir. Önceden de belirtildiği gibi bu rubrikte 0'dan 4'e kadar seviyeler bulunmaktadır. Sıfır sosyobilimsel konuların kompleks olduğunu kavrayamamaya, 4 ise sosyobilimsel konuların kompleks olduğunu kavrama ve bununla ilgili nedenler ortaya koyabilme yeteneğinin olduğundan bahsetmektedir. Ön görüşmelerin ilk rubrikle kompleks olma açısından analizine göre; altı öğretmen adayı (25%) sosyobilimsel konuların kompleks olduğunu kavrayamamış ve basit ve mantıksız çözümler öne sürmüştür. Öğretmen adaylarının diğer altısı ise (25%) kompleks olma özelliğini kavramış ancak nedenler ortaya koyamamışlardır. Beş (21%) öğretmen adayı ise kompleks olma özelliğini kavramış ve bir neden ortaya koyabilmiştir. Altı (25%) öğretmen adayı iki tane neden sunabilmiştir. Sadece bir (%4) öğretmen adayı sosyobilimsel konuların kompleks olduğunu kavrayıp üçten fazla neden sıralayabilmiştir ve ilk rubriğe göre en yüksek seviye olan 4. seviyede değerlendirilmiştir. Son görüşmelerin ilk rubrikle analizine göre ise; sadece bir (4%) öğretmen adayı sosyobilimsel konuların kompleks olmağını belirtmiştir. Kalan 23 öğretmen adayı ise bu konuların kompleks olduğunu kavrayıp bir iki, üç ve daha fazla sebepler belirtmişlerdir. Ön görüşmelerde öğretmen adaylarının kompleks özeliğini kavrayabilmeleri açısından sosyobilimsel muhakemeleri düşükken son görüşmelerde arttığı gözlemlenmiştir.

Ön ve son görüşmeler ikinci rubriğe (depth rubrik) göre de analiz edilmiştir. Bu rubrikte sıfırdan üçe kadar seviyeler bulunmaktadır. Sıfır ilk rubrikte olduğu gibi sosyobilimsel konuların kompleks olduğunu kavrayamamaya, üç ise kompleks olduğunu kavrayıp, bunun için sebepler göstermeyi ve bu sebeplerle ilgili detaylı açıklama, dayanak belirtmeyi ölçmektedir. Ön görüşmelerin ikinci rubrik kullanılarak kompleks olma açısından analizine göre; Altı öğretmen adayı altı öğretmen adayı (25%) sosyobilimsel konuların kompleks olduğunu kavrayamamış, diğer altısı kavrayabilmiş ancak sebep gösterememiştir. On ikisi (50%) bu konuların kompleks olduğunu kavrayabilmiş ve sayısına bakılmaksızın sebepler gösterebilmiştir. Ancak hiçbir öğretmen adayı belirtikleri sebepler için açıklama ya da dayanak gösterememiş ve ikinci rubriğe göre en üst seviye olan 3. seviyede değerlendirilememişlerdir. Son görüşmelerin ikinci rubrikle kompleks olma açısından analizine göre ise; 14 (58%) öğretmen adayı sosyobilimsel konuların kompleks olma özelliğiyle ilgili 3. seviyede bir muhakeme göstermişlerdir. Dokuzu (38%) kompleks olma özellğini kavramış ve sebepler belirtmiştir. Bir tanesi ise bu özelliği halen kavrayamamıştır.

Yöntemde bahsedildiği gibi iki rubrikten elde edilen puanlar sıralı bir ölçek haline getirilmiş ve her öğretmen adayının sosyobilimsel konuların kompleks olduğunu kavramalarına yönelik bir ön görüşme ve bir son görüşme puanı bulunmaktadır. Bu puanlar üzerinden yapılan Wilcoxon Signed Rank testine göre fen bilgisi öğretmen adaylarının sosyobilimsel konuların kompleks olduğunu kavradığını gösteren muhakeme yeteneklerinde anlamlı bir artış gözlemlenmiştir.

Ön ve son görüşmeler ilk rubriğe (breadth rubric) göre analize edilmiştir. Önceden de belirtildiği gibi bu rubrikte 0'dan 4'e kadar seviyeler bulunmaktadır. Sıfır sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavrayamamaya, 4 ise sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavrama ve spesifik olarak hangi bilgilerin de gerekli olduğunu ortaya koyabilme yeteneğinin olduğundan bahsetmektedir. Ön görüşmelerin ilk rubrikle sürekli araştırmaya dayalı olma açısından analizine göre; üç öğretmen adayı (13%) sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavrayamamıştır. Öğretmen adaylarının diğer dokuzu ise (38%) sürekli araştırmaya dayalı olma özelliğini kavramış ancak spesifik bilgiler ortaya koyamamışlardır. Altı (25%) öğretmen adayı ise sürekli araştırmaya dayalı olma özelliğini kavramış ve bir spesifik bilgi ortaya koyabilmiştir. Üç (13%) öğretmen adayı iki tane bilgi sunabilmiştir. Üç (%13) öğretmen adayı sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavrayıp üç veya daha fazla spesifik bilgi belirtmişlerdir ve ilk rubriğe göre en yüksek seviye olan 4. seviyede değerlendirilmişlerdir. Son görüşmelerin ilk rubrikle analizine göre ise; üç (13%) öğretmen adayı sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavrayıp bir spesifik bilgi belirtmişlerdir. Sekiz (33%) aday ise iki spesifik bilgi belirtmişlerdir. On üç (54%) öğretmen adayı ise sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavrayıp üç ya da daha fazla spesifik bilgi belirtmişlerdir. Ön görüşmelerde öğretmen adaylarının

sürekli araştırmaya dayalı özelliğini kavrayabilmeleri açısından sosyobilimsel muhakemeleri düşükken son görüşmelerde arttığı gözlemlenmiştir.

Ön ve son görüşmeler ikinci rubriğe (depth rubrik) göre de analiz edilmiştir. Bu rubrikte sıfırdan üçe kadar seviyeler bulunmaktadır. Sıfır ilk rubrikte olduğu gibi sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavrayamamaya, üç ise sürekli araştırmaya dayalı olduğunu kavrayıp, spesifik bilgilerden bahsedip ve bu bilgilerin neden gerekli olduğu ile ilgili detaylı açıklama, dayanak belirtmeyi ölçmektedir. Ön görüşmelerin ikinci rubrik kullanılarak sürekli araştırmaya dayalı olma açısından analizine göre; Üç öğretmen adayı (13%) sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavrayamamış, dokuzu kavrayabilmiş ancak spesifik bilgi gösterememiştir. On ikisi (50%) bu konuların sürekli araştırmaya dayalı olduğunu kavrayabilmiş ve sayısına bakılmaksızın spesifik bilgiler gösterebilmiştir. Ancak hiçbir öğretmen adayı belirtikleri bilgiler için açıklama ya da dayanak göstememiş ve ikinci rubriğe göre en üst seviye olan 3. seviyede değerlendirilememişlerdir. Son görüşmelerin ikinci rubrikle sürekli araştırmaya dayalı olma açısından analizine göre ise; 18 (75%) öğretmen adayı sosyobilimsel konuların sürekli araştırmaya dayalı olma özelliğiyle ilgili 3. seviyede bir muhakeme göstermişlerdir. Altısı (25%) sürekli araştırmaya dayalı olma özeliğini kavramış ve spesifik bilgiler belirtmiştir.

İki rubrikten elde edilen puanlar birleştirilmiş ve her öğretmen adayının sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavradığını gösteren bir ön görüşme ve bir son görüşme puanı oluşmuştur. Bu puanlar üzerinden yapılan

Wilcoxon Signed Rank testine göre fen bilgisi öğretmen adaylarının sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavradığını gösteren muhakeme yeteneklerinde anlamlı bir artış gözlemlenmiştir.

Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Konuların Çok Yönlü Olduğunu Kavramalarındaki Değişim

Ön ve son görüşmeler ilk rubriğe (breadth rubric) göre analize edilmiştir. Önceden de belirtildiği gibi bu rubrikte 0'dan 4'e kadar seviyeler bulunmaktadır. Sıfır sosyobilimsel konuların çok yönlü olduğunu kavrayamamaya, 4 ise sosyobilimsel konuların çok yönlü olduğunu kavrama ve verilen perspektifleri değerlendirebilme yeteneğinin olduğundan bahsetmektedir. Ön görüşmelerin ilk rubrikle çok yönlü olma açısından analizine göre; bir öğretmen adayı (4%) sosyobilimsel konuların çok yönlü olduğunu kavrayamamıştır. Öğretmen adaylarının üçü (13%) çok yönlü olma özelliğini kavramış ancak verilen perspektifleri değerlendirememişlerdir. Altı (25%) öğretmen adayı ise çok yönlü olma özelliğini kavramış ve verilen bir perspektifi değerlendirebilmiştir. On dört (58%) öğretmen adayı iki tane bilgi sunabilmiştir. Yedi (%26) öğretmen adayı sosyobilimsel konuların çok yönlü olduğunu kavrayıp verilen iki perspektifi değerlendirebilmiştir. Kalan yedi öğretmen adayı ise sosyobilimsel konuların çok yönlü olduğunu kavrayıp verilen üç perspektifi de analiz edebilmişlerdir ve ilk rubriğe göre en yüksek seviye olan 4. seviyede değerlendirilmişlerdir. Son görüşmelerin ilk rubrikle analizine göre ise; bir (4%) öğretmen adayı sosyobilimsel konuların çok yönlü olduğunu kavrayıp bir perspektif hakkında değerlendirme yapabilmiştir. Dört (17%) aday ise iki

perspektif için değerlendirme yapabilmiştir. On dokuz (79%) öğretmen adayı ise sosyobilimsel konuların çok yönlü olduğunu kavrayıp verilen üç perspektif için de değerlendirme yapabilmişlerdir.

Ön ve son görüşmeler ikinci rubriğe (depth rubrik) göre de analiz edilmiştir. Bu rubrikte sıfırdan üçe kadar seviyeler bulunmaktadır. Sıfır ilk rubrikte olduğu gibi sosyobilimsel konuların çok yönlü olduğunu kavrayamamaya, üç ise çok yönlü olduğunu kavrayıp, verilen perspektifleri değerlendirip, perspektiflerle ilgili detaylı açıklama ve dayanak göstermelerini değerlendirmektedir. Ön görüşmelerin ikinci rubrik kullanılarak sosyobilimsel konuların çok yönlü olma açısından analizine göre; Bir öğretmen adayı (4%) sosyobilimsel konuların çok yönlü olduğunu kavrayamamış, üçü ise kavrayabilmiş ancak verilen perspektifler ile ilgili değerlendirme yapamamıştır. On yedi (71%) bu konuların çok yönlü olduğunu kavrayabilmiş ve sayısına bakılmaksızın verilen perspektifler ile ilgili değerlendirme yapabilmişlerdir. Yani bu perspektifler için iddialar ve fikirler ortaya koyabilmişlerdir. Ön görüşmelerde sadece üç fen bilgisi öğretmen adayı sosyobilimsel konuların çok yönlü olduğunu kavramış, verilen perspektifler ile ilgili değerlendirme yapabilmiş ve aynı zamanda perspektiflerle ilgili detaylı açıklama ve dayanak gösterebilmişlerdir. Bu yüzden ikinci rubriğe göre en üst seviye olan 3. seviyede olduğu kararlaştırılmıştır. Son görüşmelerin ikinci rubrikle çok yönlü olma açısından analizine göre ise; 3 (13%) öğretmen adayı sosyobilimsel konuların çok yönlü olduğunu kavrayabilmiş ve verilen perspektiflerin en az biriyle ilgili değerlendirme yapabilmişlerdir. Kalan 21 öğretmen adayı ise 3. seviyede bir

muhakeme göstermişlerdir. Diğer bir deyişle sosyobilimsel konuların çok yönlü olduğunu kavramış, verilen perspektifler ile ilgili değerlendirme yapabilmiş ve aynı zamanda perspektiflerle ilgili detaylı açıklama ve dayanak gösterebilmişlerdir.

İki rubrikten elde edilen puanlar birleştirilmiş ve her öğretmen adayının sosyobilimsel konuların çok yönlü olduğunu kavradığını gösteren bir ön görüşme ve bir son görüşme puanı oluşmuştur. Bu puanlar üzerinden yapılan Wilcoxon Signed Rank testine göre fen bilgisi öğretmen adaylarının sosyobilimsel konuların çok yönlü olduğunu kavradığını gösteren muhakeme yeteneklerinde anlamlı bir artış gözlemlenmiştir.

Sosyobilimsel Konulara Göre Tasarlanmış Olan Dersin Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Muhakeme Yeteneklerine Katkısı

Öğretmen adaylarının sosyobilimsel muhakeme yeteneklerinin ön ve son görüşmelere göre geliştiği ilk araştırma sorusuyla ortaya çıkmıştır. İkinci araştırma sorusu ile de bu derste uygulanan birinci ve ikinci aşamadan sonra sosyobilimsel muhakemelerindeki gelişme ortaya çıkarılmıştır.

Birinci Aşamadan Sonra Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Muhakemelerindeki Değişim

Birinci ve ikinci aşamadan sonra, öğretmen adaylarını sosyobilimsel muhakemelerin değerlendirilmesi birinci ve ikinci rubriğin birleştirilmesiyle elde edilen 8 seviyeden oluşan sıralı ölçeğe göre değerlendirilmiştir. Buna göre, birinci

aşamadan sonra 24 fen bilgisi öğretmen adayının içinde 5 öğretmen adayı sosyobilimsel konuların kompleks olduğunu kavrayamamıştır. Ön görüşmelerde bu sayı altı idi. Ancak ön görüşmedeki sonuçlarla kıyaslandığında, öğretmen adaylarının birinci aşamadan sonra daha üst düzey seviyelerde muhakeme gösterdiği ortaya çıkmıştır. Dört öğretmen adayı ise sosyobilimsel konuların kompleks olduğunu kavramış ancak nedenler sunamamıştır. Dokuz öğretmen adayı bu konuların kompleks olduğunu kavramış ve iki neden ortaya koyabilmişlerdir. Sadece bir öğretmen adayı ortaya koyduğu nedenlerle ilgili detaylı bilgi verebilmiştir.

Sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavrama açısından birinci aşamadan sonra fen bilgisi öğretmen adayları ön görüşmeye göre gelişme göstermişlerdir. Bütün öğretmen adayları sosyobilimsel konuların sürekli araştırmaya dayalı olduğunu kavramış ve en az bir spesifik bilgi belirtmişlerdir. On öğretmen adayı iki spesifik bilgi, altı öğretmen adayı ise üç spesifik bilgi belirtmişlerdir. Sadece bir öğretmen adayı belirttiği bir spesifik bilgi ile ilgili detaylı açıklama yapmıştır. Ön görüşmede bunu yapabilen öğretmen adayı bulunmamaktadır. Ön görüşmeyle kıyaslandığında iki ve üç spesifik bilgi belirten öğretmen adayı sayılarında da artış olmuştur.

Sosyobilimsel konuların çok yönlü olduğunu kavramaları açısından, birinci aşamadan sonra öğretmen adaylarının muhakemelerinde gelişme gözlemlenmiştir. Bütün öğretmen adayları sosyobilimsel konuların çok yönlü olduğunu kavrayabilmiştir. Bunların içinde üç öğretmen adayı nükleer santral ile ilgili iki

yön, dokuz öğretmen adayı ise üç ya da daha fazla yön belirtmişlerdir. On bir öğretmen adayı ise nükleer santralin çok yönlü olduğunu kavramakla kalmamış, belirttikleri yönlerin en az biriyle ilgili detaylı bilgi ve açıklama yapabilmişlerdir.

Birinci aşamada öğretmen rehberliğinde yapılan sınıf tartışmaları açık uçlu sorular, bilgi akışı, tekrarlar ve açık tartışmalar içermektedir. İlki olan açık uçlu sorular öğretmen tarafından sorulan nükleer santralle ilgili çevre, politika, toplum ve ekonomi yönlerini vurgulayan sorulardır. İkinci olarak öğretmen öğretmen adaylarına farklı bilgi türlerini sunmuştur. Bunlar tarihsel bilgi, araştırma sonuçları, uzman görüşleri ve bilimsel bilgidir. Üçüncü olarak öğretmen sınıf tartışmalarından sonra nükleer santralle ilgili perspektiflerin, aktarılan bilgilerin tekrarını öğretmen adaylarıyla etkileşimli bir şekilde gerçekleştirmiştir. Sadece sınıf tartışmalarından sonra değil grup aktivitelerinden sonra da bu tarz tekrarlar görülmüştür. Karşılıklı yapılan bu tartışmalarda, örneğin, öğretmen adayı bir perspektif üzerinde dururken öğretmen sorduğu bir soruyla onu başka bir perspektif üzerinde düşünmeye de zorlamıştır. Bunlar öğretmen adaylarının sosyobilimsel konuların kompleks, sürekli araştırmaya dayalı ve çok yönlü olma özelliklerini kavramalarına ve muhakeme yeteneklerinin gelişmesine katkısı olmuştur. Son olarak öğretmen rehberliğindeki sınıf içi tartışmalarında açık tartışmalar dediğimiz sosyobilimsel konuların bahsedilen özelliklerinin açık bir şekilde tartışıldığı gözlemlenmiştir. Bu şekilde yapılan açık tartışmalar bu özelliklerin sadece nükleer santrale ait olmadığını tüm sosyobilimsel konularda ortak olan özellikler olduğunu öğretmen adaylarına benimsetmeye çalışmıştır. Açık bir şekilde sosyobilimsel konuların özelliklerin

tartıştırılması öğretmen adaylarının sosyobilimsel muhakeme yeteneklerine katkı sağlamıştır. Bu şekilde yapılan tartışmalar başka alanlarda da faydalı olduğu ortaya konmuştur. Örneğin bilimin doğası üzerine yapılan araştırmalar öğrencilerin bilimin doğasını daha iyi anladıklarını göstermiştir.

İkinci Aşamadan Sonra Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Muhakemelerindeki Değişim

İkinci aşamadan sonra fen bilgisi öğretmen adaylarının sosyobilimsel muhakeme yetenekleri tekrar değerlendirildi. Katılımcıların sosyobilimsel muhakemelerinde birinci aşamaya göre gelişme olmuştur.

Sosyobilimsel konuların kompleks olduğunu kavrama açısından sadece bir öğretmen sosyobilimsel konuların kompleks olmadığını ifade etmiştir. Bu sayı birinci aşamadan sonraki değerlendirmede beş idi. İkinci aşamadan sonra 12 öğretmen adayı sosyobilimsel konuların kompleks olduğunu kavramış ve en az bir neden belirtmiştir. On bir öğretmen adayı ise belirttiği nedenlerle ilgili detaylı açıklama ve gerekçe ortaya koymuştur.

Sosyobilimsel konuların sürekli araştırmaya dayalı olduğu açısından da fen bilgisi öğretmen adaylarının muhakemelerinde birinci aşamaya kıyasla gelişme gözlemlenmiştir. Bütün öğretmen adayları sosyobilimsel konuların tartışması ve çözümünde sürekli araştırma gerekeceğini kavramış ve en az bir spesifik bilgi ortaya koymuşlardır. Bunun yanı sıra on bir fen bilgisi öğretmen adayı ise belirttikleri bilgilerle ilgili detaylı açıklama ve gerekçe sunmuşlardır.

Sosyobilimsel konuların çok yönlü olduğunu kavramada da fen bilgisi öğretmen adayları birinci aşamaya göre gelişme göstermişlerdir. İkinci aşamadan sonra on dokuz öğretmen adayı sosyobilimsel konuların çok yönlü olduğunu kavramış ve en az bir perspektif için detaylı açıklama ve gerekçeler ifade etmişlerdir.

İkinci aşama nükleer santralle ilgili karar verme sürecini içeren öğretmen rehberliğinde gerçekleşen grup aktiviteleri içermektedir. Bu aktivite sırasında öğretmen adayları karar vermede sıkıntılar yaşamış, nükleer santralin iyi ve kötü yönlerini tartışmış, eldeki bilgileri değerlendirmiş ve daha fazla bilgi ihtiyacı hissetmiş, farklı yönlerden nükleer santrali incelemiş ve verdikleri karar farklı yönleri içermiştir. Yani öğretmen adaylarının bu deneyimleri onların sosyobilimsel konuların değişmez özelliklerini kavramalarına yardımcı olmuştur. Nitekim bu aktivite ile ilgili görüşlerinde de bu aktivite sayesinde bu konuların ne kadar kompleks ve karar verilmesi zor konular olduğunu, araştırma yapmaları gerektiğini ve eldeki bilgilerin yetersiz kalabileceğini, ve bir çok açıdan bu konuların incelenmesini gerektiğini belirtmişlerdir.

Sonuç olarak fen bilgisi öğretmen adaylarının sosyobilimsel muhakeme yeteneklerinde gelişme bulunmuştur ve sosyobilimsel konular üzerine tasarlanmış olan derste uygulanan farklı aktiviteler buna katkı sağlamıştır. Bu anlamda sosyobilimsel konular fen eğitimine dahil edilmelidir ve öğrencilerin sosyobilimsel muhakeme yeteneklerinin gelişmesi amaçlanmalıdır. Ayrıca sosyobilimsel konular öğretmen yetiştirme programlarına da dahil edilmelidir ve bu konuları öğretecek

olan öğretmenler bu konulardan haberdar olmalı ve kendileri de bu konular üzerine muhakeme edebilmelidirler.

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