INVESTIGATING PRE-SERVICE SCIENCE TEACHERS' INFORMAL REASONING, EPISTEMOLOGICAL BELIEFS AND METACOGNITIVE AWARENESS REGARDING SOCIOSCIENTIFIC ISSUES: A CASE FOR NUCLEAR POWER PLANT CONSTRUCTION

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Approval of the Graduate School of Social Sciences

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ABSTRACT

INVESTIGATING PRE-SERVICE SCIENCE TEACHERS' INFORMAL REASONING, EPISTEMOLOGICAL BELIEFS AND METACOGNITIVE AWARENESS REGARDING SOCIOSCIENTIFIC ISSUES: A CASE FOR NUCLEAR POWER PLANT CONSTRUCTION

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The aims of the present study were to investigate the relationship among pre-service science teachers' informal reasoning regarding nuclear power plant construction, epistemological beliefs and metacognitive awareness. Throughout 2010-2011 fall and spring semesters, a total of 674 pre-service science teachers participated in the study. Data were collected through Schommer's Epistemological Questionnaire, Metacognitive Awareness Inventory, and Open-ended Questionnaire Assessing Informal Reasoning regarding Nuclear Power Usage. MANOVA, correlational analysis, and stepwise multiple regression analyses were conducted. The analyses revealed that the differences between pre-service science teachers' epistemological beliefs within the two decision making groups were not statistically significant. Besides, results of the bivariate correlation revealed that there were statistically significant correlation between pre-service science teachers' total

argument construction and all the dimensions of SEQ except omniscient authority. Also, there was a significant correlation between pre-service science teachers' certain knowledge dimension of SEQ and their counterargument construction. Moreover, the differences between pre-service science teachers' metacognitive awareness within the two decision making groups were not statistically significant. Results of the bivariate correlation revealed that there was a significant correlation between pre-service science teachers' metacognitive awareness and informal reasoning outcomes. Finally, stepwise multiple regression analyses revealed that pre-service science teachers' information management strategy was the only significant predictor for their rebuttal construction. Declarative knowledge was the best predictor of pre-service science teachers' counterargument construction while the second best predictor was certain knowledge for their counterargument construction. Finally declarative knowledge was the only significant predictor for the amount of pre-service science teachers' reasoning modes.

Keywords: Socioscientific Issues, Informal Reasoning, Epistemological Beliefs, Metacognitive Awareness, Teacher Education

ÖZ

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ SOSYOBİLİMSEL KONULARA İLİŞKİN KRİTİK DÜŞÜNME YETENEKLERİNİN, EPİSTEMOLOJİK İNANÇLARININ, VE ÜSTBİLİŞSEL FARKINDALIKLARININ İNCELENMESİ: NÜKLEER ENERJİ SANTRALLERİ ÖRNEĞİ

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Bu çalışmada fen bilgisi öğretmen adaylarının sosyobilimsel konulara ilişkin kritik düşünme yetenekleri, epistemolojik inançları ve üstbiliş farkındalıkları arasındaki ilişkinin araştırılması amaçlanmıştır.

Çalışmaya 2010-2011 güz ve bahar dönemlerinde 674 fen bilgisi öğretmen adayı gönüllü olarak katılmışlardır. Veri toplama aracı olarak Schommer'in Epistemolojik İnançlar Anketi, Üstbilişsel Farkındalık Anketi, ve nükleer enerji konusunda kritik düşünme yeteneklerini ölçen ve açık uçlu sorulardan oluşan bir anket kullanılmıştır.

Çalışmanın amaçları doğrultusunda, çok yönlü varyans analizleri, korelasyon analizi, ve çoklu regrasyon analizleri yapılmıştır. Analiz sonuçlarına gore, öğretmen adaylarının epistemolojik inançları sezgisel karar veren ve kanıta dayalı karar veren

gruplar arasında bir değişiklik göstermemiştir. Ayrıca, korelasyon analizlerine göre, öğretmen adaylarının geliştirdikleri toplam argüman sayısıyla epistemolojik inançlar anketinin alt boyutları arasında anlamlı bir ilişki bulunmuştur. Bunun yanı sıra epistemolojik inançlar anketinin alt boyutu olan bilginin kesinliğine inanma ile öğretmen adaylarının karşı argüman geliştirmeleri arasında anlamlı ve negatif bir ilişki bulunmuştur. Öğretmen adaylarınn üstbilişsel farkındalıkları sezgisel karar veren grup ile kanıta dayalı karar veren grup arasında anlamlı bir fark göstermemiştir. Korelasyon analizi sonuçlarına göre, öğretmen adaylarının üstbilişsel farkındalıklarıyla sosyobilimsel konular hakkındaki kritik düşünme yetenekleri arasında anlamlı bir ilişki bulunmuştur. Çoklu regrasyon analizlerine gore ise, bilgi yönetme stratejisi alt boyutu öğretmen adaylarının karşı fikri çürütmek için geliştirdikleri argümanları tahmin etmedeki en önemli alt boyuttur. Öğretmen adaylarının karşı argüman geliştirmelerini tahmin etmedeki en önemli alt boyut bildirimsel bilgi, ikinci alt boyut ise bilimsel bilginin kesinliğine inanmadır. Son olarak, öğretmen adaylarının değişik yönlerden kritik düşünmelerini tahmin etmedeki en önemli alt boyut bildirimsel bilgidir.

Anahtar kelimeler: Sosyobilimsel Konular, Kritik Düşünme (Informal Reasoning), Epistemolojik İnançlar, Üstbilişsel Farkındalık, Öğretmen Eğitimi

To all my family

Turan, Tuğçe and E.Emre ÖZTÜRK

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LIST OF ABBREVIATIONS

AAAS: American Association for the Advancement of Science

CFI: Comparative Fit Index

CLEV: Checklist of Educational Values

DV: Dependent variable

GFI: Goodness of Fit

MAI: Metacognitive Awareness Inventory

MER: Measure of Epistemological Reflection

OECD: Organization for Economic Cooperation and Development

PISA: Programme for International Student Assessment

PST: Pre-service Science Teacher

RMSEA: Root Mean Square Error of Approximation

SEQ: Schommer's Epistemological Questionnaire

SRMR: Standardized Root Mean Square Residuals

SSI: Socioscientific issues

STS: Science, Technology and Society

STS(E): Science, Technology, Society and Environment

CHAPTER 1

INTRODUCTION

Scientific literacy which is a phrase representing what students are supposed to know and do in consequence of their science learning practices is accepted as one of the major goals of science education (Sadler & Zeidler, 2009). Several curriculum movements have been emerged to support the scientific literacy which involves personal decision-making about real-life situations related to science and influenced by different perspectives such as social, political, economic, and ethical (Sadler & Zeidler, 2009). Science-Technology-Society (STS) curriculum based education is the most known of these movements which has been started to be implemented by the late 1970s. STS movement intended to focus on students' understanding of the interaction among science, technology, and society (Zeidler, Sadler, Applebaum, & Callahan, 2009; Zeidler, Sadler, Simmons, & Howes, 2005) and use of decision-making skills about society-related issues including science and technology aspects (Yang & Anderson, 2003). However, STS education has been criticized for the lack of emphasis on students' psychological and epistemological growth and their moral and ethical development (e.g. Zeidler et al., 2005; Zeidler et al., 2009). Hence, a new framework named socioscientific issues (SSI) has emerged which enables students to discuss moral problems including scientific and social point of views and these point of views may sometimes conflict students' own beliefs (Zeidler et al., 2009). Most

recently SSI approach to teach controversial scientific concepts appears as an important part of science instructions and newly accepted definitions of scientific literacy also accepted the need for SSI inclusion in science courses to have scientifically literate future generations (Roth & Barton, 2004).

The definition of scientific literacy has been changed many times since it was first used by Hurd (1958). In earlier definition of scientific literacy there were fundamental ideas in science that should be learned. One of these ideas emphasized the learning science content as the major predictor of scientific literacy (e.g., American Association for the Advancement of Science (AAAS), 1993; Millar, 1997). For instance, the Organization for Economic Cooperation and Development (OECD) Programme for International Student Assessment (PISA) (1998) defined scientific literacy as "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity" (p. 60).

Above definition was accepted until the first use of the term scientific literacy by Hurd (1958) to the recent years of PISA studies. However, in time, what is understood from scientific literacy has been changed from the knowledge based perspective to having ability for being active citizens in society, developing reasoning, and using decision-making skills regarding socioscientific issues (Holbrook & Rannikmae, 2009). Thus, in light of this new understanding, the term scientific literacy includes multidimensional aspects. In the meantime OECD (2009)

has also changed the abovementioned definition of scientific literacy. According to the most recent definition of PISA, scientific literacy refers to an individual's:

- Scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues;

- Understanding of the characteristic features of science as a form of human knowledge and enquiry;

- Awareness of how science and technology shape our material, intellectual and cultural environments;

- Willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen (p. 3).

Different from the previous definitions, the inclusion of individuals' ability to draw conclusions about science-related issues and being a reflective citizen who engages in science-related issues can be seen in PISA (2009) definition. Later on, Holbrook and Rannikmae (2009) defined the scientific literacy in a way to involve more emphasis on individuals' decision-making and argument generation on socioscientific issues.

Specifically, Holbrook and Rannikmae (2009) defined the scientific literacy as:

> Developing an ability, to creatively utilize appropriate evidence-based scientific knowledge and skills, particularly with relevance for everyday life

and a career, in solving personally challenging yet meaningful scientific problems as well as making, responsible socio-scientific decisions, collective interaction skills, personal development and suitable communication approaches as well as the need to exhibit sound and persuasive reasoning in putting forward socio-scientific arguments (p. 286).

Above definitions of scientific literacy revealed that learning and teaching of SSI in science classrooms become one of the critical aspects of science instructions. New developments in scientific studies such as gene cloning, and emergence of different energy resources, also make the necessity of consideration of students' ethical and moral values in science classrooms. Moreover, for developing future generations' scientific literacy, inclusion of socioscientific concepts in science classrooms is crucial.

Teaching and learning SSI cannot be similar to teaching other scientific concepts. Researchers argued that informal reasoning which is the process of individuals' generation of negotiations, and drawing conclusions, is necessary in practicing socioscientific issues in science classrooms (Sadler & Zeidler, 2005). In the next section, SSI and informal reasoning are presented in terms of how they were operationalized in this study.

1.1. Socioscientific Issues and Informal Reasoning

Current major developments in science and technology have triggered the emergence of controversial aspects for some of the scientific issues such as gene cloning, global warming, and nuclear power plant construction. The controversial

approach is necessary because of the social, ethical, and moral considerations regarding these scientific issues. These issues are generally called as 'socioscientific issues' (Lee & Witz, 2009; Sadler, 2004). SSI comprise a variety of social dilemmas associated with science bridging science and society such as cloning, environmental problems, radioactive waste disposal, euthanasia, and genetically modified foods (Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006; Sadler & Zeidler, 2005). According to many associations such as AAAS, understanding the connections between science and society which is inherent among socioscientific issues are crucial (Zeidler, 2003). Since SSI are debatable problems and they are subject to many different viewpoints and solutions, when people encounter with these issues, they try to generate ideas, claims, and possible solutions to these problematic issues. According to Sadler and Zeidler (2005), discussing and resolving these complicated issues require use of informal reasoning which entails both cognitive and affective processes. Informal reasoning involves the analysis and evaluation of arguments which based on reasons and in the core of informal reasoning there is claim-support relationship (Cerbin, 1988). In informal reasoning, premises may change when the additional information is available (Sadler, 2004). On the other hand, noncontroversial scientific issues can be resolved by formal reasoning. In other words, formal reasoning includes well-defined problems which can be solved by the use of information provided, not more than this. "The evaluation of formal arguments involves determining whether the conclusions follow from the premises according to the rules of the system" (Cerbin, 1988, p. 4). The premises of formal reasoning are fixed and not changing (Sadler, 2004). For instance force is a scientific

concept and one can compute the value of force as following the premises of formal reasoning with the information provided. More specifically, force (F) can be computed by the formula mass multiplied by acceleration (F□m*a). This formula is enough for individuals to reach the solution, there is no need to much more information, discussion, or claim generation. On the contrary to formal reasoning, informal reasoning enables the generation of positions response to the complex issues which do not have certain solutions (Sadler, 2004). Parallel to this understanding, Zohar and Nemet (2002) defined the construct informal reasoning as follows:

> It [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 (p. 38).

Informal reasoning is a more suitable framework for the negotiation of contemporary SSI comparing to the formal reasoning since the negotiation process of SSI encompass ill-structured problems, different kinds of positions and decision alternatives rather than well-defined problems. More specifically, while dealing with SSI, individuals' informal reasoning ability has a major role (Sadler, 2004). Therefore, in this study, regarding an SSI, pre-service science teachers' (PST) discussion and argument construction by using the informal reasoning processes were investigated.

Research studies about the use of informal reasoning for SSI have increased rapidly in recent years. Some of the studies investigated the use of informal reasoning in the context of SSI by considering some other characteristics of learners. For instance, in some research studies, individuals' epistemological beliefs (e.g., Hofer, 2001; Liu, Lin, & Tsai, 2010; Sadler & Chambers, 2004; Schommer, 1994; Schommer-Aikins & Hutter, 2002; Schraw, Dunkle, & Bendixen, 1995; Wu & Tsai, 2010) and metacognition (e.g., Hofer, 2001; Hofer & Pintrich, 1997; Yang, 2005) were thought to be the factors related to the use of informal reasoning. Wu and Tsai (2010) reported that students' epistemological views towards science and scientific knowledge improved the effective use of informal reasoning. In addition, according to Kitchener (1983), different from well-defined problems, ill-defined problems require epistemic assumptions to be solved since they do not possess certain solutions and may possess more than one right answer. Similarly, Schommer-Aikins and Hutter (2002) argued that the more individuals believed in complex and tentative nature of knowledge, the more they are willing to change their thinking, holding multiple perspectives, and understanding the complex and tentative nature of controversial issues. Research studies conducted so far revealed the relationship between epistemological beliefs and informal reasoning regarding SSI. However, there are a few detailed research studies investigating the relationship between epistemological beliefs and informal reasoning regarding a specific SSI. Hence, in this study, nuclear energy usage namely nuclear power plant construction was chosen as an SSI in order to explore how PSTs use their informal reasoning skills in association with their epistemological beliefs.

Metacognition was also seen as one of the concepts related to informal reasoning regarding SSI. For instance, according to Yang (2005), "the performance of scientific thinking in the everyday context is shaped by the relevant domain knowledge and metacognitive ability" (p. 67). Monitoring one's own understanding of the complex problems, certainty of knowledge and the evaluation of evidence are all so crucial in critical thinking skills necessary to solve the controversial ill-structured problems individuals face in society (Hofer, 2001). In addition, Kuhn (1991) proposed that evaluation and judgement of alternative evidence requires metacognitive ability which is necessary to be reflective about one's own thinking. Hence research studies revealed the relationship between SSI and metacognition. "Metacognition refers to the ability to reflect upon, understand, and control one's learning (Schraw & Dennison, 1994, p. 460)" and research studies indicate that metacognitively aware learners are more strategic and their performance is higher than the metacognitively unaware learners (Garner & Alexander, 1989; Pressley & Ghatala, 1990). In the present study, learners' metacognition will be expressed through metacognitive awareness so; both metacognition and metacognitive awareness imply pre-service science teachers' awareness metacognitively. Similar to epistemological beliefs, there are a few research study investigating the relationship between metacognition and informal reasoning on a specific SSI. Hence, in this study, PSTs' metacognitive awareness and informal reasoning on nuclear energy usage will be explored. The research study conducted by Wu and Tsai (2010) was very insightful for the present study. Their study investigated the relationships among informal reasoning, epistemological beliefs and cognitive structures of high

school students and they strongly recommended also investigating the relationship between metacognition and informal reasoning. Thus, by taking this recommendation into consideration, in the present study, the relationship among PSTs' metacognitive awareness and informal reasoning regarding nuclear power construction was investigated.

The reason why nuclear energy usage was chosen is that nowadays, the first nuclear power plant construction has been accepted by the Turkish Parliament and there is a debate on whether it is right or wrong to build nuclear power plant in Turkey. In the past, there have been several attempts to construct nuclear power plant in Turkey. The first attempt of Turkey was 46 years ago in the 1960s and in 1955, an agreement was established between USA and Turkey for peaceful uses of nuclear energy (Akcay, 2009). After a few attempts till 1976, Mersin Akkuyu Project was chosen to build a nuclear power plant in Turkey (Erdogdu, 2007). In 1986, Chernobyl nuclear power plant accident was occurred and for the years between 1998 and 2000, the Akkuyu Project was stopped by the government. Although the process was started again in 1993, it was postponed to 2000 because of the economic crises (Akcay, 2009). Recently, Turkish government has decided to build the first nuclear power plant in Mersin Akkuyu and planning to build the second nuclear power plant in Sinop in the following years.

In the following parts how we operationalized epistemological beliefs and metacognition were explained.

1.2. Epistemological Beliefs

Epistemological beliefs refer to individuals' understanding of what knowledge is, what is its source and its degree of certainty and epistemology as a general term deals with the nature and justification of human knowledge (Hofer, 2001; Hofer & Pintrich, 1997). Research studies on epistemological beliefs started with Perry in 1968. Perry was the first person proposing that it is not the reflection of personality but a developmental process that affects the meaning making of college students. After Perry, studies about epistemology have shifted from traditional philosophical inquiries which assume true, universal, and absolute knowledge to cognitive oriented studies in time. Different from the traditional view, cognitive researchers focus on what individuals believe about the limit of information truthiness, the organization of information, the acquisition of knowledge, and the justification of knowledge claims (Schommer, 1994). There are two main positions characterizing much of the epistemological beliefs research. The first position suggests that personal epistemology develops in a fixed progression of stages which means unidimentional and individuals move through this specified sequence in their ideas about knowledge and knowing as their ability to make meaning evolves (Hofer, 2001). Five major "developmental model" have been empirically identified. The first developmental model was first proposed by Perry (1968). After Perry, research on "woman's ways of knowing" (Belenky, Clinchy, Goldberg, & Tarule, 1986), the epistemological reflection model (Baxter Magolda, 1992), reflective judgement model (King & Kitchener, 1994), and epistemological perspectives which underlies argumentative reasoning (Kuhn, 1991) have emerged. These models share a common

idea that the epistemological development begins with objectivist and dualistic view of knowledge, followed by a multiplistic view and finally knowledge is actively constructed by the knower, evolving and organized by justification (Hofer, 2001). The second position was pioneered by Schommer (1990, 1993, 2002) basing on Perry's initial work. Schommer (1990) suggests that personal epistemology is a belief system consisting of more or less independent dimensions and according to Schommer (1990) beliefs about the nature of knowledge are too complex to be identifiable only in one dimension, organized in stages and evolving in a systematic way. She proposed that every individual hold different beliefs about the nature of knowledge regarding the structure, certainty, and source of knowledge, and the control and speed of knowledge acquisition which means personal epistemology is multidimensional (Schommer, 1990). Based on the original survey that Perry was developed, Schommer developed The Epistemological Beliefs Questionnaire in which she hypothesized five dimensions: Simple Knowledge (knowledge is simple rather than complex), Omniscient Authority (knowledge is handed down by authority rather than derived from reason), Certain Knowledge (knowledge is certain rather than tentative), Quick Learning (learning is quick or not at all) and Innate Ability (the ability to learn is innate rather than acquired) (Schommer, 1990, p. 499). Empirical work generated four of the factors which are: Innate Ability, Simple Knowledge, Quick Learning, and Certain Knowledge (Schommer, 1990). Schommer studied with different age groups to validate the questionnaire (Schommer, 1990, 1993) and the questionnaire has been used by many researchers from many different countries (Kardash & Scholes, 1996; Lodewyk, 2007; Yilmaz-Tuzun & Topcu,

2008). According to these studies, epistemological beliefs differ regarding the age group and country. As can be understood, Schommer (1990) contribute to the literature on epistemological beliefs by developing the questionnaire which is widely used and proposing that epistemological beliefs consist of more or less independent beliefs, and they are multidimensional rather than unidimentional and developed in sequenced stages. The questionnaire Schommer developed made her one of the initiators of the quantitative research on epistemological beliefs. In this study, Schommer's hypothesized dimensions and questionnaire were used to determine PSTs' epistemological beliefs.

1.3. Metacognition

There have been many different attempts in the literature to define the construct of metacognition (e.g., Flavell, 1979; Paris & Winograd, 1990; Schraw, Crippen, & Hartley, 2006; Swanson, 1990). Metacognition generally refers to cognition of cognition and includes skills that help individuals to understand and monitor their own cognitive processes (Schraw, Crippen, & Hartley, 2006). The concept of metacognition was first introduced by Flavell (1976). According to Flavell (1976), metacognition is "one's knowledge concerning one's own cognitive and processes and products or anything related to them" (p. 232). Flavell's metacognition model includes interactions among four classes of factors which are needed cognitive enterprises to be occurred: metacognitive knowledge, metacognitive experiences, goals (or tasks), and actions (or strategies) (1979). Metacognitive knowledge consists primarily of knowledge or beliefs about what factors or variables act and interact in what ways to affect the course and outcome of

cognitive enterprises (Flavell, 1979, p. 907). According to Flavell (1979), metacognitive knowledge consists of three variables: person, task, and strategy. The person variable refers to "everything that you could come to believe about the nature of yourself and other people as cognitive processors" (Flavell, 1979, p. 907). It considers one's awareness of strengths and weaknesses as a learner. The second variable, task, refers to knowing what the learning task really is and recognition of the knowledge that different tasks have different goals hence need different cognitive strategies. Finally, the strategy variable includes knowledge about which strategies are needed and effective in achieving the goals.

Pintrich (2002) represented Flavell's general framework consisting of knowledge of strategy, task, and person by including students' knowledge of general strategies for learning and thinking (Strategic knowledge), students' knowledge of cognitive tasks as well as when and why to use these different strategies (Knowledge about cognitive tasks), and finally knowledge about the self (the person variable) in relation to both cognitive and motivational components of performance (Self knowledge) (p. 220). According to Pintrich (2002), these three general types of metacognitive knowledge are crucial because these knowledge types are positively related to student learning and development of metacognitive knowledge is needed.

Endorsing the work of Flavell (1979), Schraw (1998) proposed that metacognition involves mainly two distinct subcomponents which are knowledge of cognition (metacognitive knowledge) and regulation of cognition (metacognitive regulation). According to Schraw et al. (2006), knowledge of cognition implies what we know about our own cognition and includes three subcomponents which are

declarative knowledge, procedural knowledge and conditional knowledge. Declarative knowledge refers to knowledge about ourselves as learners and factors influencing our performance; procedural knowledge includes knowledge about strategies and procedures; and conditional knowledge refers to knowledge of the reason why individuals use a certain strategy (Schraw & Moshman, 1995). Regulation of cognition implies mental processes that help individuals plan, monitor, and evaluate their thinking and learning (Schraw & Moshman, 1995). It includes three subcomponents which are planning, monitoring, and evaluation. Planning refers to selecting the appropriate strategy which affects one's learning; monitoring includes the ability to do self-testing of learning; and evaluation refers to appraising the products and processes of one's own learning (Schraw & Moshman, 1995).

In 1994, different from the previous assessment instruments, Schraw and Dennison generated an easily administered metacognitive inventory to measure adults' metacognitive awareness. The inventory consists of 52-items which are classified into eight subcomponents (declarative knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation) under two main categories: knowledge of cognition and regulation of cognition. In the present study, Schraw and Moshman's classification of knowledge of cognition and regulation of cognition will be used while assessing metacognitive awareness.

Research studies conducted so far revealed the importance of metacognitive awareness. One explanation is that "metacognitive awareness allows individuals to plan, sequence, and monitor their learning in a way that directly improves

performance" (Schraw & Dennison, 1994, p. 460). According to Schraw and Dennison (1994), although researchers agreed the importance of the concept metacognitive awareness, assessing metacognitively aware learners quickly and reliably was one of the most difficult problems they faced. In previous studies, it was used some form of online-experimental testing, calibrating one's comprehension, and extensive verbal interviews (Schraw & Dennison, 1994). However, according to Schraw and Dennison (1994), the administration of these procedures is very obstructive in many applied settings since the administration requires high amount of time and effort. Hence, Schraw and Dennison (1994) developed MAI which is an easily administered as well as a reliable and valid inventory to assess individuals', more specifically adults', metacognitive awareness. On the grounds of aforementioned reasons, in order to assess pre-service science teachers' metacognitive awareness, MAI was used in the present study.

1.4. Research Questions

The study addressed the following research questions:

Research Question 1 (RQ1): Is there a significant mean difference in PSTs' epistemological beliefs within the evidence based and intuitive based decision making groups?

Research Question 2 (RQ2): What are the relationships among PSTs' informal reasoning regarding nuclear power usage and their epistemological beliefs?

Research Question 3 (RQ3): Is there a significant mean difference in PSTs' metacognitive awareness within the evidence based and intuitive based decision making groups?

Research Question 4 (RQ4): What are the relationships among PSTs' informal reasoning regarding nuclear power usage and their metacognitive awareness?

Research Question 5 (RQ5): What are significant predictors for PSTs' informal reasoning on nuclear power usage regarding epistemological beliefs and metacognitive awareness?

1.5. Significance of the Study

Exploring the relationships among PSTs' informal reasoning regarding an SSI which is nuclear power usage, epistemological beliefs and metacognitive awareness makes the study unique since there are a few studies investigating these relationships. The relationships among PSTs' informal reasoning and epistemological beliefs and their informal reasoning and metacognitive awareness was worth exploring because researchers claimed that individuals' epistemic views toward scientific knowledge improve their informal reasoning (Wu & Tsai, 2007). Besides, since SSI are ill-structured problems they require thinking from multidimensional perspectives. According to Schommer-Aikins and Hutter (2002) as the individuals believe in the tentative and complex structure of the scientific knowledge, they are more likely to think from different perspectives. Because of these claims, the present study tried to investigate the relationship between PSTs' informal reasoning regarding nuclear power plant construction and their

epistemological beliefs. Also, metacognition was accepted by some of the researchers that individuals' metacognition may be a factor in relation to their informal reasoning regarding SSI. Metacognitive ability is needed to judge the alternative evidences which is required for the resolution of ill-structured and open-ended SSI. According to Kuhn (1991), the metacognitive ability let individuals be reflective about their own thinking. Besides, according to Bendixen and Rule (2004), "An individual who is highly engaged metacognitively would be more aware of the need for resolution strategies and would closely monitor the effectiveness of those strategies" (p. 74). Hence, the rationale for the investigation of the relationship among PSTs' informal reasoning regarding SSI and metacognitive awareness may be the claim that as individuals become more metacognitively aware, they are getting more conscious about the resolution strategies on the controversial SSI.

In addition, the SSI that was chosen for the present study, nuclear power plant construction, is one of the hottest issues discussing in the society nowadays. Nuclear power plants were started to be criticized and people in the society started to generate arguments on both the negative and positive sides of nuclear power plant construction. Hence, addressing an issue on which the society awareness increased was valuable.

Moreover, most of the studies related to informal reasoning regarding SSI in the literature were conducted with elementary or high school students (e.g. Wu & Tsai, 2010, Yang, 2005) however, the sample of this study is pre-service science teachers who will teach the concept SSI in their future classes. With a better understanding derived from such research studies, teacher training programs may be

revised so that future teachers may have the capability to implement discussions of socioscientific issues in science classes which in turn let students develop scientific literacy.

The literature on informal reasoning regarding socioscientific issues consists of many studies from Europe and USA; also there are some research studies from nonwestern countries (e.g., Wu & Tsai, 2007; 2010). The present study will be one of the few studies conducted considering Turkish context. Conducting such a research study in Turkish context has significance since, as stated by Topcu (2010), the current teacher training programmes do not cover science related social issues although inclusion of SSI develop teachers' reasoning and discussion on controversial issues which automatically develop students' reasoning and discussion on SSI.

CHAPTER 2

LITERATURE REVIEW

In this chapter, a review of literature on scientific literacy and SSI, informal reasoning and SSI, epistemological beliefs, and metacognition is presented respectively.

2.1. Scientific Literacy and SSI

Raising learners to be scientifically literate individuals has become a well-recognized educational goal for science educators all over the world (Wu & Tsai, 2007). The phrase "scientific literacy" has been defined by many researchers and professional associations in science (e.g. AAAS, 1993; Holbrook & Rannikmae, 2009; Hurd, 1958; Millar, 1997; National Science Education Standards, 1996; OECD, 2006, 2009; Roth & Barton, 2004; Sadler & Zeidler, 2009; Shamos, 1995).

In the Handbook of Research on Science Education, Roberts (2007) reviewed the research studies about scientific literacy comprehensively. Roberts (2007) reviewed the research studies on scientific literacy in two different visions, namely Vision I and Vision II and defined these two visions as the following:

> Vision I gives meaning to scientific literacy by looking inward at the canon of orthodox natural science, that is, the products and processes of science itself. At the extreme, this approach envisions literacy (or, perhaps, thorough

knowledgeability) *within science*. Vision II derives its meaning from the character of situations with a scientific component, situations that students are likely to encounter as citizens. At the extreme, this vision can be called *literacy* (again, read *thorough knowledgeability*) *about science-related situations* in which considerations other than science have an important place at the table (p. 730).

What is understood from the visions of Roberts (2007) is that Vision I implies the aim of science education is to transfer scientific concepts and science education helps students to understand scientific products and processes. AAAS (1989, 1993) documents are those supporting the Vision I since they included series of scientific concepts that students should comprehend (Sadler & Zeidler, 2009).

However, Vision II is broader encompassing personal decision making about real life situations. These real life situations are those individuals encounter in their daily lives related to science also influenced by social, political, economical, and ethical perspectives. Hence, according to Vision I, for ones to be scientifically literate, they should know about the discipline "science". On the other hand, Vision II gives importance to the ability to utilize scientific ideas, processes, and reasoning to be a scientifically literate individual.

There were several curriculum movement attempts to develop scientific literacy in the light of Vision II in the past (Sadler & Zeidler, 2009). The Science-Technology-Society (STS) movement was the most widely known of these movements (Yang & Anderson, 2003). STS movement was aimed to educate

students about the interdependence among science, technology, and society (Sadler, 2004). In addition, STS education had an emphasis on the impact of science and technology on society (Sadler & Zeidler, 2005). Aikenhead (1994, as cited in Zeidler et al., 2005) review the main characteristics of STS teaching as the following: "STS science teaching conveys the image of socially constructed knowledge. Its' student-oriented approach emphasizes the basic facts, skills, and concepts of traditional science but does so by integrating that science content into social and technological contexts meaningful to students" (p. 59).

However, STS education started to be criticized for the lack of moral and ethical implications of the issues science, technology and society (Sadler & Zeidler, 2005). According to Zeidler et al. (2005), "STS education, as typically envisioned and practiced, does not seem to be embedded in a coherent developmental or sociological framework that explicitly considers the psychological and epistemological growth of the child, nor the development of character or virtue" (p. 358). Besides, STS education was criticized that many of the issues of STS education (e.g. nuclear power, global warming) are not exciting or related to students' everyday personal experiences (Shamos, 1995). Hence, STSE curriculum was emerged which was more issues-driven (Hodson, 1994, 2003; Pedretti, 2003). The STSE curriculum namely science-technology-society-environment education was constructed over the strategies of STS curriculum by advocating literacy based on ethical, individual, and social responsibility hence it may be shown as STS(E) (Zeidler, et al., 2005; Pedretti, 2003). However, STS(E) curriculum was also criticized by the researchers that it does not directly cover students' moral and ethical development, it lacks of a well-

developed theoretical basis and there is a claim that science educators do not recognize the difference between STS and STS(E) curriculum movements hence, STS(E) curriculum approaches has been marginalized in the curriculum (Zeidler, et al., 2005).

Despite the fact that STS(E) approaches was mainly aimed to increase students' interest in science by focusing on the interrelationship and interdependence of science, technology and society and also teaching of science and technology in the context of society, they did not involve the viewpoints of students' ethical and moral development (Sadler, 2004; Sadler & Zeidler, 2005; Zeidler et al., 2005). However, besides the focus on the interrelationships between science, technology and society, SSI approach emphasized on the social dimension of science content, students' personal experiences and belief systems, and individuals' intellectual development in morality and ethics (Topcu, 2010; Zeidler et al, 2005).

As aforementioned, STS(E) approaches was criticized for the lack of a theoretical basis however, the SSI movement constructed a theoretical framework consisting of moral and epistemological orientations and importance of emotions and character development (Zeidler & Keefer, 2003). As understood, STS(E) and SSI are related but SSI have some distinct characteristics than STS(E) approaches. More specifically, SSI is a broader term encompassing all the STS approaches but at the same time considering students' psychological, ethical and moral development (Zeidler, Walker, Ackett, & Simmons, 2002).

Since SSI has a crucial role to improve scientific literacy, they became important in science education (Kolstø, 2001; Sadler, 2004; Sadler & Zeidler, 2005). Socioscientific decision making is an integral component of scientific literacy which is the main goal of science education hence, according to Sadler and Zeidler (2005), it is necessary to investigate how individuals discuss and resolve SSI. They further maintained their idea that "explicating the processes and patterns students use as they confront controversial dilemmas in science will aid the development of appropriate socioscientific curricula and pedagogical strategies, thereby enhancing the promotion of scientific literacy" (Sadler & Zeidler, 2005, p. 113).

Recognition of the role of SSI in the improvement of scientific literacy can be understood from the recent definitions of scientific literacy released by both professional associations in science education and the research studies. The earlier opinion about the features of a scientifically literate individual was that there are fundamental ideas in science to be learned and the science content was the main indication of becoming a scientifically literate individual (e.g., AAAS, 1993; Millar, 1997). However, recent definitions of scientific literacy assert that in order for a citizen to be a scientifically literate, s/he should have the ability to negotiate on and find solutions about SSI as stated in the last released report of OECD (2009): "Scientifically literate individuals have the ability to draw conclusions about science-related issues and to be a reflective citizens who engages in science-related issues" (p. 128). In the same way, according to Christensen "scientific literacy is about preparing future citizens to make personal and collective decisions on socioscientific issues" (2001, p. 142). Hence, recent definitions of scientific literacy verified the

importance of the implementation of SSI into science classes in order to raise scientifically literate citizens who have the ability to discuss and draw conclusions in the context of SSI.

2.2. Informal Reasoning and SSI

Advancements in science and technology evoked the emergence of social dilemmas which are often called as 'socioscientific issues' (Sadler, 2004). SSI are those that are 'based on scientific concepts or problems, controversial in nature, discussed in public outlets and frequently subject to political and social influences' (Sadler & Zeidler, 2005, p. 113). SSI are ill-structured and open-ended problems which do not possess clear-cut solutions (Sadler, 2004; Sadler & Zeidler, 2005). In addition, these issues consists of scientific claims and arguments, political, ethical and epistemological perspectives (Kolstø, Bungum, Arnesen, Isnes, Kristensen, Mathiassen, Mestad, Quale, Vedvik-Tonning, & Ulvik, 2006). Besides, SSI are those individuals may easily confront in their daily lives such as genetic engineering (Walker & Zeidler, 2007; Zohar & Nemet, 2002), environmental issues (Kortland, 1996; Osborne, Erduran, & Simon, 2004; Patronis, Potari, & Spiliotopoulou, 1999), nuclear power usage (Yang & Anderson, 2003; Wu & Tsai, 2007; Wu & Tsai, 2010), and effects of mobile phone use (Kolstø, 2006; Lee, 2007).

The discussion and resolution of SSI characterized generally by the process of informal reasoning (Sadler, 2004; Sadler & Zeidler, 2005). Informal reasoning is used to solve ill-structured, open-ended problems that lack a definite correct answer (Kuhn, 1991). In addition, this type of reasoning involves cognitive and affective

processes which contribute to sort out controversial problems (Dawson & Venville, 2009; Sadler & Zeidler, 2005; Voss, 1991). According to Perkins (1985), informal reasoning includes "considering a claim and seeking reasons with a nonformal bearing on the claim, pro or con, in an attempt to resolve the truth of the claim and stands in contrast to formal reasoning" (p. 562).

Reasoning generally defined by the researchers as the process of the evaluation of arguments and drawing conclusions (Evans, 2002). The term reasoning was also defined by Galotti (1989, as cited in Amsterlaw, 2006) as "mental activity that consists of transforming given information in order to reach conclusions" (p. 335). There is a general perception in science that reasoning refers to formal reasoning which is constituted of the rules of logic and mathematics (Sadler, 2004). In literature, formal reasoning was mostly fall into two domains: deductive reasoning and statistical inference (Evans & Thompson, 2004). In both deductive reasoning and statistical inference, individuals encounter well-defined problems and in order to solve these kinds of problems, individuals need to use only the information provided in the premises, not adding any other information (Evans & Thompson, 2004). In deductive reasoning, individuals are given some premises and draw conclusions that necessarily follow while in the statistical inference, individuals are expected to make statistical inference on well-defined problems and provided the necessary probabilities and frequency distributions, finally their answers were assessed for the correctness (Evans & Thompson, 2004).

There is a concern in the literature that the processes that is followed to solve the problems in formal reasoning may differ from those necessary to solve the

problems of informal reasoning (Sadler, 2004; Evans & Thompson, 2004) and according to Perkins (1985) the ways of constructing and weighing lines of argument in informal reasoning are not required by formal arguments. Formal reasoning is limited to follow an inferential process which is used to come to a conclusion from a fixed set of premises however, informal reasoning deals with the complex issues which are open-ended and includes the process of generation and evaluation of different positions from different perspectives (Sadler, 2004). According to T. S. Kuhn (1962), formal reasoning may make contribution to scientific discovery however; it is not the only way to produce progress. In order to make clear the distinction between formal reasoning and informal reasoning, Perkins (1985) stated differences as the following: Firstly, in formal reasoning, arguments are well-formed and deductive, however in informal reasoning; arguments may be constructed on both sides of the case. Also, in formal reasoning, premises are given and strict, but in informal reasoning, premises may be changed according to reasoners' critical thinking. Hence, since SSI are ill-structured, open-ended and lack clear-cut solutions, the negotiation and resolution of these controversial issues are characterized by the process of informal reasoning.

Many of research studies illustrated the aspects of informal reasoning within the context of SSI (Sadler & Zeidler, 2005) and in the review of Sadler (2004), it was focused some certain themes such as; the expression of informal reasoning through argumentation, relationships between nature of science conceptualizations and socioscientific informal reasoning, patterns of data interpretation and information evaluation, and the influence of conceptual understanding of material related to a SSI

and informal reasoning (Sadler & Zeidler, 2005). Besides, research studies investigated informal reasoning on SSI by following different ways of assessments in other words they represent individuals' informal reasoning in different types. Namely, some studies assessed individuals' informal reasoning as 'patterns' while the others as 'modes'. For instance, in their study, Yang and Anderson (2003) investigated high school students' preference and reasoning modes about nuclear energy use and how they deal with the social and scientific aspects of this complex issue. They classified participants' reasoning modes into three: scientifically oriented, socially oriented, and equally disposed reasoning where scientifically oriented students were inclined to reason by the help of scientific information, socially oriented students were tended to use social factors rather than scientific evidence while reasoning and equally disposed students used rather diverse source and able to use different perspectives. In addition, Wu and Tsai (2007, 2010) investigated high school students' informal reasoning on nuclear energy use by using an integrated framework developed by the same researchers. Reasoning modes was one of the main three criteria used for the analysis of informal reasoning. They categorized high school students' reasoning modes on nuclear energy use as: social-oriented arguments, economic-oriented arguments, ecology-oriented arguments, and science-oriented or technology-oriented arguments. Social-oriented arguments imply individuals' tend to reason from social-oriented aspects, economic-oriented arguments mean an individuals' thinking with economic considerations, ecology-oriented arguments are those generated by the individuals who reason with ecology-oriented care and science or technology-oriented arguments imply that individuals

reasoned from science –or technology- oriented perspectives and have the ability to reflect what they learned in science classes while reasoning (Wu & Tsai, 2007, 2010). In parallel with this study, Patronis et al. (1999) explored 14-year-old students' arguments about an actual problem, design of a road in their area. In this study, students' arguments were categorized as social, ecological, economic, and practical modes and students were faced to some dilemmas such as: development versus conservation of natural environment, society versus nature, money versus human values, and personal happiness versus benefit for all. On the other hand, in their study investigating college students' discussion and solution of genetic engineering conflicts, Sadler and Zeidler (2005) investigated informal reasoning in the context of genetic engineering in terms of patterns and stated three informal reasoning patterns: rationalistic, emotive, and intuitive. Rationalistic informal reasoning involves reason-based considerations; emotive informal reasoning involves care-based considerations, and finally intuitive informal reasoning involves sudden reactions to the scenario given in the study. As seen in the literature, there are different studies investigating informal reasoning in the context of SSI by using different frameworks. In the present study, the framework that was developed by Wu and Tsai (2010) was used in which reasoning modes was classified as: social-oriented arguments, economic-oriented arguments, ecology-oriented arguments, and science-oriented or technology-oriented arguments.

2.3. Epistemological Beliefs

Epistemology, as a general term, is a branch of philosophy and defined as "… a philosophical enterprise which is concerned with the origin, nature, limits,

methods, and justification of human knowledge" (Hofer, 2002, p. 4). In the field of epistemology (the nature and justification of human knowledge), major concerns are to investigate what is knowledge and how is it acquired, what people know, and how do we know what we know (Hofer, 2002).

Personal epistemology which addresses individual conceptions of knowledge and knowing is the focus of this study. Personal epistemology addresses "students' thinking and beliefs about knowledge and knowing, and typically includes some or all of the following elements: beliefs about the definition of knowledge, how knowledge is constructed, how knowledge is evaluated, where knowledge resides, and how knowing occurs" (Hofer, 2001, p. 355). In the field of personal epistemology, there are different ways to conceptualize individual thinking about epistemological concerns. The first line of work is developmental in nature which refers to the idea that individuals move through a sequence of development in their beliefs about knowledge and knowing. In this line of work, one group of researchers interested in how individuals interpret their own educational experiences (Baxter Magolda, 1992; Belenky et al., 1986; Perry, 1968, 1970) while the second group of researchers interested in the way epistemological assumptions affect the thinking and reasoning of individuals, especially focusing on reflective judgement (King & Kitchener, 1994; Kitchener & King, 1981; Kitchener, King, Wood, & Davison, 1989; Kitchener, Lynch, Fischer, & Wood, 1993) and argumentative reasoning (Kuhn, 1991, 1993). On the other hand, the second line of work suggests that personal epistemology is a system of more-or-less independent beliefs (Schommer, 1990). In

the following parts, the theories and models of personal epistemology within the historical framework will be presented.

2.3.1. Perry's Scheme of Intellectual and Ethical Development

Historically, research studies on personal epistemology have started with Perry (1968) by whom the researchers of this field inspired of and developed several approaches and models. Perry's scheme of intellectual and ethical development which is a longitudinal and phenomenological study started in late 1950s at Harvard's Bureau of Study Counsel. The scheme was based on a series of open-ended interviews conducted with undergraduate students in Harvard College in which students were asked their experiences during the four year of liberal art undergraduate education (Perry, 1968, 1970). In order to select the participants for initial interviews, Perry developed an instrument called Checklist of Educational Values (CLEV). One of the questions of CLEV which may be found in the epistemological instruments developed later (Schommer, 1990) was that "The best thing about science courses is that most problems have only one right answer". These interviews were administered to 31 first-year students (27 men, 4 women) in 1954-1955 years. Based on these interviews Perry and his colleagues developed a scheme of intellectual and ethical development which included a sequence of nine positions and in order to validate the scheme, it was administered to a randomly selected group of 109 first-year students (85 men, 24 women) in 1959-1960 following their four years of college. Only two women included in the results of the study but the rest of them were eliminated (Hofer & Pintrich, 1997). Perry (1968) summarized his findings as:

> Within its own strictest limits, the study demonstrates the possibility of assessing, in developmental terms, abstract structural aspects of knowing and valuing in intelligent late-adolescents. Substantively, the study confirms the validity of one scheme of such development, showing it to be reliably evident as a theme common to all students' reports to be sampled (p. 5).

The scheme of intellectual and ethical development was constituted of nine distinct stages, as Perry called "positions", which were clustered into four sequential categories: dualism, multiplicity, relativism, and commitment within relativism (Hofer & Pintrich, 1997).

Dualism: Including Positions 1 and 2, dualisms refers to individuals who view knowledge as either right or wrong and believe that there is a completely unquestioned view of truth with no tolerance for different points of view.

Multiplicity: Including Position 3 and 4, different from dualism, multiplicity involves the recognition of diversity and uncertainty and refers to individuals who believe that all views are equally valid and each person has a right to his or her own opinion.

Relativism: Including Position 5 and 6, relativism refers to individuals who shifted from a dualistic view of the world to a view of contextual relativism and the major shift is in the perception of self as an active maker of meaning. At this position, individuals perceive knowledge as relative, contingent, and contextual and begin to realize the need to choose and affirm one's own commitments.

Commitment within relativism: Including Position 7 through 9, commitment within relativism reflect a focus on responsibility, engagement, and the forging of commitment within relativism. Individuals in that category make and affirm commitments to values, careers, relationships, and personal identity (Hofer & Pintrich, 1997).

Perry (1968) was the first person who proposed that how college students made meaning of their educational experiences was not a reflection of their personality but a progressive developmental process (Hofer & Pintrich, 1997). His scheme including the dualistic, multiplistic, relativistic point of views was an important contribution to the epistemology literature. Also, according to Perry (1968) teachers have a role to be an authority in development of students' personal epistemology and reasoning about knowledge.

His study also possessed some limitations. As Perry stated (1968, 1970), the limitations are those; participants were students from a single college, the sample was comprised of white, elite, male college students educated at Harvard during 1950s, and the investigators who developed the scheme was also the interviewers in the study. Although Perry did not do further research in the field of epistemology, his work was the first study investigating college students' understanding and approaches to learning and laid the ground for the following research studies on personal epistemology.

2.3.2. Women's Ways of Knowing

The second developmental model of personal epistemology was proposed by Belenky et al. (1986). Perry's study was started to be criticized in the late 1970s for the limitation of generalizability to the general population of college students since the sample of his study was elite male students in Harvard. Hence, Belenky et al. (1986) investigated women's ways of knowing and describe women's perspectives of truth, knowledge, and authority. In their own words, Belenky et al. (1986) described their study as: "*Our work focuses on what else women might have to say about the development of their minds and on alternative routes that are sketchy or missing in Perry's work*" (p. 9). Belenky et al. (1986) interviewed with 135 women who are living ordinary lives and are from different ages, class and ethnic backgrounds, and educational histories. Of the 135 women, 90 of them were students enrolled in academic institutions while the other 45 women were from family agencies supporting women in parenting their children. By this way, researchers aimed to explore how women's ways of knowing was shaped by academic institutions and maternal practice. The model Belenky et al. (1986) proposed was revealed a set of epistemological categories organized around the metaphor of voice. These categories are; silence, received knowledge (voice of others), subjective knowledge (the inner voice), procedural knowledge (the voice of reason), and constructed knowledge (integrating the voice). Silence refers to "a position in which women experience themselves as mindless and voiceless and subject to the whims of external authority"; received knowledge refers to "a perspective from which women conceive of themselves as capable of receiving, even reproducing, knowledge from

the all-knowing external authorities but not capable of creating knowledge on their own"; subjective knowledge refers to "a perspective from which truth and knowledge are conceived of as personal, private, and subjectively known or intuited"; procedural knowledge refers to "a position in which women are invested in learning and applying objective procedures for obtaining and communicating knowledge"; and finally constructed knowledge refers to "a position in which women view all knowledge as contextual, experience themselves as creators of knowledge, and value both subjective and objective strategies for knowing" (Belenky et al., 1986, p. 15).

The study of Belenky et al. (1986) widened the perspectives of Perry by investigating women's ways of knowing. According to Hofer and Pintrich (1997), one of the most important distinctions between Perry's work and the study of Belenky et al. is that Perry's positions were descriptive of the nature of knowledge and truth while the latter emphasized on the source of knowledge and truth. Although Belenky et al. was criticized for studying on a single women group, their work revealed important key points about women epistemology which was developmental in nature as in Perry's study.

2.3.3. Epistemological Reflection Model

The third developmental model of personal epistemology was proposed by Baxter Magolda in 1986, namely Epistemological Reflection Model (Baxter Magolda, 1992, 2004). Different from Perry and Belenky et al., Baxter Magolda studied with individuals from both gender. On the other hand, similar to the works of Perry and Belenky et al., Baxter Magolda described stages of epistemological

development which proposed changes in terms of complexity and reflective thinking (Brownlee, Purdie, & Boulton-Lewis, 2001). In 1986, Baxter Magolda started to a 5-year longitudinal study in which she conducted annual open-ended interviews and administrated Measure of Epistemological Reflection (MER) to 101 randomly selected students (51 females, 50 males) both from undergraduate and graduate level in order to validate it. Analysis of these data led Baxter Magolda to develop Epistemological Reflection Model (Hofer & Pintrich, 1997). Epistemological Reflection Model included four different "ways of knowing": absolute, transitional, independent, and contextual. Absolute knowers "view knowledge as certain and believe that authorities have all the answers"; transitional knowers "discover that authorities are not all-knowing and begin to accept the uncertainty of knowledge"; independent knowers question authority as the only source of knowledge and begin to hold their own opinions as equally valid"; contextual knowers "are capable of constructing an individual perspective by judging evidence in context" (Hofer & Pintrich, 1997, p. 98).

The work of Baxter Magolda has importance since she investigated gender-related patterns of epistemological development by including both males and females in the sample and conducted a longitudinal study exploring the developmental patterns. The patterns for absolute knowing was ranged from receiving (used more often by women) to mastery (used more often by men), for transitional knowing students tend to make a more interpersonal (common among women) or impersonal (common among men) approach, for independent knowing from interindividual (more prevalent among women) to individual (more prevalent among men) and

finally gender patterns in the contextual knowing was converged (Buehl, 2003). Although in her study, the initial aim of Baxter Magolda was to investigate how epistemological assumptions influence interpretations of educational experiences, a number of beliefs that were not epistemological was also addressed in the model such as beliefs about the role of learner, peers, instructors, and beliefs about evaluation which was misleading for the model (Hofer & Pintrich, 1997; Buehl, 2003).

2.3.4. Reflective Judgment Model

The fourth model of personal epistemology was Reflective Judgment Model developed by King and Kitchener (1994) based on the work of Perry (1970) and Dewey (1938)'s reflective thinking (Hofer & Pintrich, 1997). The model was derived from the results of a longitudinal study lasted 15 years. King and Kitchener (1994) conducted interviews with individuals from high school students to middle-aged adults in which the participants were asked to express and justify their viewpoints and responses to four ill-structured problems which are about how the pyramids were built, the safety of chemical additives in food, the objectivity of news reporting, and the issue of creation and evolution (Hofer & Pintrich, 1997). Reflective Judgment Model is a seven-stage developmental model of reflective thinking in which each step shows different epistemological perspectives (King & Kitchener, 1994, 2004). In order to define these perspectives, the researchers used Kitchener's (1983) definition of epistemic cognition which is different from cognition and metacognition and referring to "individuals' assumptions about knowledge and how it is gained (King & Kitchener, 2004, p. 6)". Reflective Judgment Model aimed to

describe views individuals hold about knowledge and justification and the relationship between their epistemological assumptions and the way they make reflective judgments about controversial in other words ill-structured problems (King & Kitchener, 1994, 2004).

As aforementioned, the model includes seven developmental stages classified into three levels: Pre-reflective thinking (Stages 1-3), quasi-reflective thinking (Stages 4-5), and reflective thinking (Stages 6-7).

Pre-reflective judgement refers to individuals who view knowledge as certain and gained by authority as well as they believe that all questions have a single correct answer and there is no any distinction between well-defined and ill-defined problems, that is, all problems are well-structured (King & Kitchener, 1994, 2004).

Quasi-reflective judgement refers to individuals who recognized the uncertainty in the knowing process and use evidence and provide different perspectives on controversial issues in reasoning although they are not sure about the link between how evidence is gained and a conclusion is made (King & Kitchener, 1994, 2004).

Reflective thinking refers to individuals who can easily use evidence and reason to support their judgments, aware of the uncertainty in the knowing process, at the same time, open to reevaluate their claims and conclusions (King & Kitchener, 1994, 2004).

King and Kitchener proposed parallel conclusions with Perry's work that there are some certain developmental stages starting from the view assuming

knowledge is certain and given by authority to the view assuming the knowledge as uncertain and using evidence in their knowledge claims while reasoning on controversial problems. However, the proposed model was criticized for its limitations such as the problems that were used while developing the model were not based on school knowledge (Buehl, 2003), and the researchers' primary aim was not to develop a model of personal epistemologies instead, researchers interpreted the epistemic assumptions from participants' responses to the interviews (Hofer & Pintrich, 1997).

2.3.5. Argumentative Reasoning

The last model of the idea that personal epistemology is developmental in nature was proposed by Kuhn (1991). Kuhn (1991) addressed the epistemological nature of solving ill-structured problems and worked on informal reasoning as an attempt to explore how individuals responds about everyday situations although her initial attempt was to investigate argumentative thinking (Hofer, 2001; Hofer & Pintrich, 1997). Kuhn conducted interviews with participants who were from four age groups: teens, 20s, 40s, and 60s and this broader sample makes Kuhn's work different than the previous work (Hofer & Pintrich, 1997). Through the interview, Kuhn (1991) asked questions about three current urban social problems which are: (a) what causes prisoners to return to crime after they're released?, (b) What causes children to fail in school?, (c) What causes unemployment? Participants were expected to justify their position as well as propose an opposite view with providing the rebuttal to that position.

According to Kuhn's model, there are three categories of epistemological views; absolutist, multiplist, and evaluative which are in parallel with the models proposed by Perry, Baxter Magolda, and Belenky, et al. According to those holding the absolutist view, knowledge is certain and absolute, conceive that facts and expertise are the basis for knowing, and they express high certainty about their beliefs. On the other hand, multiplists are doubtful about expertise and do not believe the possibility of expert certainty claiming that all views has the same legitimacy and ones' view may be as valid as an expert's view. Finally, those holding the evaluative epistemological view also do not accept the certainty of knowledge but according to them, they are less certain than the experts and think that viewpoints can be compared and evaluated (Hofer & Pintrich, 1997).

Kuhn found no significant gender or age differences, but found a relation between educational background and epistemological level, as the educational level increases, participants are more likely to be in the evaluative category and less likely to be an absolutist. Kuhn, later examined the relation between epistemologies and argument skills and three argument skills were emerged: generation of genuine evidence, generation of alternative theories, generation of any form of counterargument (Hofer & Pintrich, 1997) and found that those holding the evaluative view are more likely to generate counterargument and alternative theory generation which let Kuhn to conclude that "it is primarily the emergence of the evaluative epistemology that is related to argumentative skill development" (Kuhn, 1991, p. 195).

Kuhn's work was important since it focused on ill-structured problems from daily life and the sample of the study was broad. However, it was criticized that she offered little information about the validation of the scheme, also according to Buehl and Alexander (2001), problems used in the interview were nonacademic and it was related more to the general knowledge beliefs rather than the academic knowledge beliefs. Epistemological development models mentioned so far were shown in Table 2.1.

Table 2.1.

Models of Epistemological Development in Late Adolescents and Adulthood

Intellectual and ethical development (Perry)	Women's ways of knowing (Belenky et al.)	Epistemological reflection (Baxter Magolda)	Reflective judgment (King and Kitchener)	Argumentative reasoning (Kuhn)
Positions	*Epistemological perspectives*	*Ways of knowing*	*Reflective judgment stages*	*Epistemological views*
Dualism	Silence Received knowledge	Absolute knowing	Pre-reflective thinking	Absolutist
Multiplicity	Subjective knowledge	Transitional knowing		Multiplists
Relativism	Procedural knowledge (a)Connected knowing (b)Separate knowing	Independent knowing	Quasi-reflective thinking	Evaluatist
Commitment within relativism	Constructed knowledge	Contextual knowing	Reflective thinking	

Note: Stages and positions are aligned to indicate similarity across the five models. Adapted from "The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning," by B. K. Hofer and P. R. Pintrich, 1997, *Review of Educational Research, 67*(1), p. 92.

2.3.6. Epistemology as a System of Independent Beliefs

The models discussed so far conceived the idea that personal epistemology develops in patterns and are derived from samples including adult and university students from both gender. Epistemological development starts with a dualistic, objectivist view which is followed by a multiplistic view as individuals becomes aware of and accept the uncertainty. In the final stage individuals have the ability to construct knowledge and knowing is coordinated by justification (Hofer & Pintrich, 1997) and according to this view point, personal epistemology of individuals is unidimentional.

Different from these models, Schommer (1989, 1990, 1994) proposed a second approach about personal epistemology again, drawing on Perry's work. However, Schommer's approach was not organized into positions or stages, or follows some certain patterns, but according to this recent approach epistemological beliefs are conceptualized as a system of more or less independent beliefs. By system of beliefs, it was meant that "there is more than one belief to consider in personal epistemology" (Schommer-Aikins, 2002, p. 104). By more or less independent beliefs, Schommer meant "it cannot be assumed that beliefs mature in synchrony" (Schommer-Aikins, 2002, p. 104).

Schommer's study was different from the previous work that the personal epistemology approach was multidimensional rather than unidimentional and Schommer's research was more quantitative and analytical. In her research study, Schommer (1989, 1990) proposed that epistemological beliefs system is composed of

five more or less independent beliefs and included beliefs about; (a) the stability of knowledge, ranging from tentative to unchanging; (b) the structure of knowledge, ranging from isolated bits to integrated concepts; (c) the source of knowledge, ranging from handed down by authority to gleaned from observation and reason, (d) the speed of knowledge acquisition, ranging from quick-all-or-none learning to gradual learning, and (e) the control of knowledge acquisition, ranging from fixed at birth to life-long improvement. In order to assess these beliefs, Schommer (1990) developed an epistemological questionnaire derived from a research study including a sample of 117 junior college students and 149 university students. Nearly all the participants were either freshman or sophomores and there were approximately equal numbers of men and women participated in the study (Schommer, 1990). The questionnaire included 63 Likert-type items (28 negative and 35 positive items) ranging from 1 (strongly disagree) to 5 (strongly agree). The 63 items of the questionnaire were grouped into 12 different subsets. The questionnaire was constructed into five hypothesized dimensions: (1) Simple Knowledge, derived from "structure of knowledge", referring to "knowledge is simple rather than complex", (2) Omniscient Authority, derived from "source of knowledge" referring to "knowledge is handed down by authority rather than derived from reason", (3) "Certain Knowledge", derived from "certainty of knowledge" referring to "knowledge is certain rather than tentative", (4) Innate Ability, derived from "control of knowledge" referring to "the ability to learn is innate rather than acquired", (5) Quick Learning, derived from "speed of learning" referring to "learning is quick or not at all" (Schommer, 1990, p. 499). Explanatory factor analysis results revealed

four of these five hypothesized beliefs which are Innate Ability, Simple Knowledge, Quick Learning, and Certain Knowledge (Schommer, 1990). In 1994, Schommer developed a theoretical framework which can be summarized as:

1) Personal epistemology may be conceptualized as a system of beliefs that is personal epistemology is composed of more than one belief.
2) Beliefs within the system are more or less independent, that is, it cannot be assumed that beliefs will be maturing in synchrony.
3) Epistemological beliefs are better characterized as frequency distributions rather than dichotomies or continuums.
4) Epistemological beliefs have both indirect and direct effects.
5) Whether epistemological beliefs are domain general or domain independent will vary over time for any particular individual.
6) Epistemological belief development and change is influenced by experience. These experiences include engaging in problem solving and learning from family, friends, formal education, and life experiences (Schommer-Aikins, 2002, p. 106).

After the study of Schommer (1990), researchers conducted different research studies on personal epistemology using Schommer's questionnaire. The-four factor structure was replicated also by Schommer, Crouse, & Rhodes (1992) with college students and Schommer (1993) with high school students and by other researchers such as Kardash and Scholes (1996), Yilmaz-Tuzun and Topcu (2008) and Schraw, Dunkle, and Bendixen (1995). These studies validated Schommer's Epistemological Beliefs Questionnaire. Other researchers (e.g., Jehng, Johnson, & Anderson, 1993) revised the questionnaire and the factor analysis of these studies revealed five-factor

models. These research studies revealed different factor structures in different names. For instance, Yilmaz-Tuzun and Topcu (2008) conducted their study in Turkish context with PSTs in five public universities in order to explore the relationship between pre-service science teachers' epistemological beliefs, epistemological world views, and self efficacy beliefs. The factor analysis of SEQ revealed four factors which are Innate Ability, Simple Knowledge, Certain Knowledge, and Omniscient Authority in their study. The emergence of Omniscient Authority factor may due to the cultural difference which may supported the view of multidimensionality of personal epistemology as Schommer proposed. Moreover, the conducted studies linked epistemological beliefs to unique aspects of learning (Schommer-Aikins, 2002). For instance, beliefs in simple and certain knowledge related to students' problem solving of ill-structured content (Schraw et al., 1995); belief in quick learning predicted problem solving in well-structured content (Schraw et al., 1995). Also, according to Pajares (1992) epistemological beliefs plays important role in teachers' instructional beliefs and according to Winne (1995), epistemological beliefs affect students' self-regulated learning for instance, epistemological beliefs affect students' choices of cognitive strategies for studying.

There are some criticisms in the literature about Schommer's proposed model on personal epistemology. For instance, Hofer and Pintrich (1997) stated some concerns about the construct validity of the two factors in Schommer's questionnaire. Hofer and Pintrich (1997) thought that the two factors Fixed Ability and Quick Learning are not epistemological dimensions but more about beliefs about intelligence. In addition to this, according to Hofer and Pintrich (1997), these two

dimensions are not focusing on the nature of knowledge and knowing but more on the nature of learning. On the other hand, Schommer's work on personal epistemology possesses major importance in the literature on epistemological beliefs. A paper and pencil measurement instrument on epistemological beliefs that she developed made her the initiator of quantitative research in this area and has given researchers chance to do empirical investigation. In addition, Schommer's work was different from the previous works in terms of the idea that the epistemological beliefs were conceptualized as a system that are more or less independent rather than following certain developmental stages. Existing models of epistemological models and their details can be seen in Table 2.2.

2.4. Metacognition

The term metacognition, introduced by Flavell a quarter of a century ago, has become one of the most significant and notable constructs in cognitive and educational psychology (Hartman, 2001). Metacognition refers to "one's knowledge concerning one's own cognitive processes and products or anything related to them, e.g., the learning-relevant properties of information or data" (Flavell, 1976, p. 232). It is broadly defined as one's awareness and control on his/her learning in other words, thinking about one's own thinking (Gourgey, 2001; Hartman, 2001).

Research studies indicated the distinction between cognition and metacognition. According to Garner (1987, as cited in Schraw, 1998), cognitive skills are necessary to perform a task while metacognitive skills are needed to realize

Table 2.2.

Components from Existing Models of Epistemological Beliefs and Thinking

	Core dimensions of epistemological theories		Peripheral beliefs about learning, instruction, and intelligence	
Researcher(s)	Nature of knowledge	Nature of knowing	Nature of learning and instruction	Nature of intelligence
Perry	Certainty of knowledge: Absolute ↔ Contextual relativism	Source of knowledge: Authorities ↔ Self		
Belenky et al.		Source of knowledge: Received ↔ Constructed Outside the self ↔ Self as maker of meaning		
Baxter Magolda	Certainty of knowledge: Absolute ↔ Contextual	Source of knowledge: Reliance on authority ↔ Self Justification for knowing: Received or mastery ↔ Evidence judged in context	Role of learner Evaluation of learning Role of peers Role of instructor	

Table 2.2. (Continued)

Researcher(s)	Core dimensions of epistemological theories		Peripheral beliefs about learning, instruction, and intelligence	
	Nature of knowledge	Nature of knowing	Nature of learning and instruction	Nature of intelligence
King & Kitchener	Certainty of knowledge: Certain, right/wrong ↔ Uncertain, contextual Simplicity of knowledge: Simple ↔ Complex	Justification for knowing: Knowledge requires no justification ↔ Knowledge is constructed, and judgments are critically reevaluated Source of knowledge: Reliance on authority ↔ Knower as constructor of meaning		
Kuhn	Certainty of knowledge: Absolute, right/wrong answers ↔ knowledge evaluated on relative merits	Justification for knowing: Acceptance of facts, unexamined expertise ↔ evaluation of expertise Source of knowledge: Experts ↔ Experts critically evaluated		

Table 2.2. (Continued)

Researcher(s)	Core dimensions of epistemological theories		Peripheral beliefs about learning, instruction, and intelligence	
	Nature of knowledge	Nature of knowing	Nature of learning and instruction	Nature of intelligence
Schommer	Certainty of knowledge: Absolute ↔ Tentative and evolving Simplicity of knowledge: Isolated, unambiguous bits ↔ Interrelated concepts	Source of knowledge: Handed down from authority ↔ Derived from reason	Quick learning	Innate ability

Note: Adapted from "The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning," by B. K. Hofer and P. R. Pintrich, 1997, *Review of Educational Research, 37*(1), p. 113-115.

how the task was performed. Also, as Gourgey (2001) stated, "whereas cognitive strategies enable one to make progress -to build knowledge- metacognitive strategies enable one to monitor and improve one's progress to evaluate understanding and apply knowledge to new situations" (p. 18). Metacognition is crucial since it influences many aspects such as acquisition, comprehension, retention, and application of what is learned, learning efficiency, critical thinking, and problem solving (Hartman, 2001; Schraw & Dennison, 1994), oral communication of information, writing, language acquisition, attention, memory, social cognition, and different kinds of self-control and self-instruction (Flavell, 1979). In addition, metacognitive awareness allows individuals to control or self-regulation on their thinking and learning processes (Hartman, 2001).

The first framework of metacognition was proposed by Flavell (1979). Flavell tried to find out the answers of "What might there be for a child or adolescent to learn in this area? That is, what adultlike knowledge and behavior might constitute the developmental target here, toward which the child gradually progresses?" (1979, p. 906). According to Flavell (1979), cognitive monitoring arises from the actions of and interactions among four constructs: metacognitive knowledge, metacognitive experiences, goals (or tasks), and actions (or strategies). Flavell (1979) defined metacognitive knowledge as "it consists primarily of knowledge or beliefs about what factors or variables act and interact in what ways to affect the course and outcome of cognitive enterprises" (p. 907). The metacognitive knowledge consists of three categories of knowledge: person, task, and strategy. The person category, which is similar to Schraw and Moshman's (1995) definition of declarative

knowledge (Sungur & Senler, 2009) involves one's knowledge about how individuals learn and process information, the nature of self such as strengths and weaknesses and believe about other people as cognitive processors (Flavell, 1979). It was subcategorized by Flavell into intraindividual differences, interindividual differences, and universals of cognition. The task category concerns about different cognitive strategies and goals that different tasks requires and possesses. Here, the metacognitive knowledge is to recognize which information is best suitable to manage the cognitive enterprise and accomplish its goal. The strategy category includes the knowledge about which strategies are effective to accomplish the goals and under which conditions. According to Flavell (1979), metacognitive knowledge has crucial effect on the cognitive enterprise of children and adults by leading individuals to select, evaluate, revise, and leaving cognitive tasks, goals, and strategies as well as metacognitive experiences including self, tasks, goals, and strategies. The last construct of Flavell's model of metacognition, metacognitive experiences, include the use of metacognitive strategies which are "sequential processes that one uses to control cognitive activities, and to ensure that a cognitive goal (e.g., understanding a text) has been met" (Livingston, 1997, p. 2). These processes assist to regulate one's learning, including planning and monitoring cognitive activities, and the evaluation of these activities (Livingston, 1997).

According to Flavell (1979), metacognitive knowledge and metacognitive strategies are overlapping concepts. Also, metacognitive experiences have a crucial importance on metacognitive knowledge, cognitive tasks, and cognitive strategies. The reasons behind this are first of all, metacognitive experiences help someone to

set new goals and revise the old ones; secondly, metacognitive experiences may influence metacognitive knowledge base by addition, deletion, or revision; and lastly, metacognitive experiences may enable strategies for both cognitive and metacognitive goals (Flavell, 1979).

Flavell's work as the initiator of the models of metacognition in which the concept 'metacognition' was introduced first including metacognitive knowledge and metacognitive experiences as the two main components has a crucial importance in metacognition literature. Flavell's contribution was followed by numerous others, sometimes declaring different understandings of processes and mechanisms of metacognition such as Brown (1978), Paris and Winograd (1990), Pintrich (2002), Schraw and Dennison (1994), Schraw and Moshman (1995).

The work of Brown (1978) was theoretically different but complimentary with the work of Flavell. Flavell's research was basically on students' metacognitive knowledge about cognitive strategies. Taking a different position, Brown (1978) emphasized more on cognitive abilities. Brown (1978) suggested two components of metacognition which are knowledge of cognition and regulation of cognition. According to her work (1978), knowledge of cognition included declarative knowledge, procedural knowledge, and conditional knowledge where the regulation of cognition component included constructs such as planning behaviors, monitoring behaviors, and checking the outcomes.

The work of Paris and Winograd (1990) conceptualize the metacognition from a different perspective. The researchers stated in their study that, Flavell

emphasized on the metacognitive knowledge including person, task, and strategy variables, and metacognitive experiences while Brown (1978) review the Flavell's work but especially focused on the aspects of executive cognition including planning, monitoring and revising one's thinking and many researchers collate these two perspectives and emphasize on the knowledge of cognitive processes and the control of metacognition. According to these researchers, "… this familiar dichotomy of the mind is consistent with information processing accounts of declarative and procedural knowledge" (p. 17) and apprehend the two important features of metacognition: self-appraisal and self-management of cognition (1990). Self-appraisal of cognition refers to the reflections about individuals' knowledge states and abilities during the learning process (Georghiades, 2004; Paris & Winograd, 1990). This type of metacognition tries to answers the questions such as "Do I know the capital of Idaho?" or "Can I memorize a list of 20 words in 10 minutes?" (Paris & Winograd, 1990, p. 17). On the other hand, self-management, in other words "metacognition in action", comprises "how metacognition helps to orchestrate cognitive aspects of problem solving" (Paris & Winograd, 1990, p. 18). The ability of students' making good plans, using different strategies, and monitor and assess their performance may be given as examples (Baker & Brown, 1984; Paris & Winograd, 1990) to self-management.

Besides, Pintrich (2002), basing his study on Flavell's pioneering work, postulated three types of metacognitive knowledge: strategic knowledge, knowledge about cognitive tasks, and self-knowledge. Strategic knowledge refers to "knowledge of general strategies for learning, thinking, and problem solving" (p. 220) and these

strategies can be used for a wide range of tasks and disciplines rather than specific strategies from the domains or disciplines (Pintrich, 2002). According to Pintrich (2002), in addition to these general learning strategies, students may have knowledge of different metacognitive strategies, in order to use for planning, monitoring, and regulating their learning and thinking. Moreover, there are general strategies for problem solving and thinking which can be used to solve problems, especially ill-defined problems where there are no any clear-cut solution. In addition to knowledge about strategies, according to Pintrich (2002), individuals have the knowledge about cognitive tasks. Knowledge of tasks comprises "knowledge that different tasks can be more or less difficult and may require different cognitive strategies" (Pintrich, 2002, p. 221). The importance of the knowledge about cognitive tasks is knowing when and why to use these strategies appropriately. Finally, self-knowledge includes knowledge about one's strengths and weaknesses and this self-awareness may enable learners to use different kinds of strategies in different kinds of situations (Pintrich, 2002). Metacognitive knowledge of these different types may enhance learners' performance and learning, and should be taught explicitly in the classroom (Bransford, Brown, & Cocking, 1999; Pintrich 2002). In the work conducted by Hofer, Yu, and Pintrich (1998) and Pintrich, McKeachie, and Lin (1987) with college students, it was revealed that many of the college students possess very little metacognitive knowledge which showed the need for a better, explicit teaching of metacognitive knowledge in K-12 settings.

Although there is still debate on both the definition and classification of metacognition, there is a general consensus that metacognition comprises two main

components: knowledge of cognition and regulation of cognition (Schraw, 1998). The knowledge of cognition component includes three subcomponents which are declarative knowledge, procedural knowledge, and conditional knowledge (Schraw, 1998; Schraw, Crippen, & Hartley, 2006; Schraw & Dennison, 1994; Schraw & Moshman, 1995). Schraw and Moshman (1995) proposed a framework about the two general components of metacognition: knowledge of cognition and regulation of cognition. According to their framework, knowledge of cognition refers to "what individuals know about their own cognition or about cognition in general" (p. 352) which includes declarative, procedural and conditional knowledge. In the present study, the classification of the knowledge of cognition component in Schraw and Moshman (1995)'s framework will be utilized. According to Schraw and Moshman (1995)'s framework, declarative knowledge refers to one's knowledge about self as a learner and about the factors influencing one's performance. Procedural knowledge includes the knowledge about procedural skills and how to use strategies and finally conditional knowledge refers to the knowledge of why and when to use a strategy. On the other hand, regulation of cognition refers to "metacognitive activities that help to control one's thinking or learning" (Schraw & Moshman, 1995, p. 354). Although there are a number of regulatory skills in the literature, three skills are included in all the classifications which are planning, monitoring, and evaluation (Jacobs & Paris, 1987; Schraw, 1998; Schraw et al., 2006; Schraw & Moshman, 1995). Planning involves "the selection of appropriate strategies and the allocation of resources that affect performance" (Schraw & Moshman, 1995, p. 354). Making predictions before reading, strategy sequencing, and adjustment of time before

beginning a task may be given as examples of planning (Schraw, 1998). Monitoring refers to one's "on-line awareness of comprehension and task performance" (Schraw & Moshman, 1995, p. 355). One's ability to self-test periodically may be given as an example to monitoring. Finally, the evaluation subcomponent of the regulation of cognition involves the evaluation of the products and processes of one's own learning and as an example, re-evaluating one's goals and conclusions can be given (Schraw & Moshman, 1995).

Schraw and Dennison (1994) were the other researchers who conducted research studies on metacognition in which the researchers constructed an inventory to measure adults' metacognitive awareness. They categorized metacognition into two as knowledge about metacognition and regulation of cognition as in the other research studies conducted so far. The knowledge about cognition component involves three subcomponents which are declarative knowledge, procedural knowledge, and conditional knowledge. On the other hand, they included five subcomponents of the regulation of cognition which were discussed extensively in the literature (Artzt & Armour-Thomas, 1992; Baker, 1989, as cited in Schraw & Dennison, 1994): planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation. The definition of the knowledge of cognition subcomponents are in parallel with the definitions in the literature where planning includes "planning, goal setting, and allocating resources prior to learning"; information management involves "skills and strategy sequences used on-line to process information more efficiently such as organizing, elaborating, summarizing, and selective focusing"; monitoring refers to "assessment of one's learning or

strategy use"; debugging refers to "strategies used to correct comprehension and performance errors"; and finally evaluation includes "the analysis of performance and strategy effectiveness after a learning episode" (Schraw & Dennison, 1994, pp. 474-475). In the present study, these classifications of the regulation of cognition will be used.

Recent studies revealed that metacognitively aware learners use more strategies and show higher performance than the unaware learners (Garner & Alexander, 1989; Pressley & Ghatala, 1990). According to Schraw and Dennison (1994), one reason for this opinion is that metacognitive awareness enables individuals plan, sequence, and monitor their learning which develops their performance. In the study of Swanson (1990), it was found that when solving fluid combination and pendulum problems, metacognitively aware six grade students perform better and used more strategies comparing to the unaware students. Individuals' differences in performance and strategy use are in an intimate relationship with their metacognitive awareness (Schraw & Dennison, 1994). This finding proposes that metacognitive knowledge plays crucial role in cognitive performance of students since it increases strategy use (Schraw & Dennison, 1994). Metacognitive knowledge of strategies, tasks, as well as self-knowledge enhance students learning and performance in the classroom in the way that students who know about different kinds of strategies, they are more likely to use them and in terms of self-knowledge, students who know about their strengths and weaknesses more likely to adjust their thinking and learning for different tasks (Pintrich, 2002). Similarly, Georghiades (2000) supported the idea that metacognitive instruction play

important roles in facilitating learners' thinking, learning, and academic success as in the following:

> One can argue that positive impact of successful metacognitive instruction can be extended to students' abilities to both transfer and to retain conceptions for a longer time. The equation is as follows: by being reflective, revisiting the learning process, making comparisons between prior and current conceptions, and being aware of and analyzing difficulties, learners gradually maintain deeper understanding of the learned material (p. 128).

In this process, teachers play important roles in students' understanding of the distinction between cognition and metacognition and gaining of metacognitive awareness (Schraw, 1998). Teachers are models for metacognitive skills for their students that is, the more explicit this modeling, the more likely their student develop metacognitive skills, hence they should model their own metacognition for their students such as describing their own thought processes (Schraw, 1988). Also, teachers should pay attention and spend time on group discussion and reflection for their students to increase their metacognitive awareness. However, according to Georghiades (2004), science teachers are mostly unaware of the notion of metacognition. Also, according to Veenman, Van Hout-Wolters, and Afflerbach (2006), teachers lack enough knowledge about metacognition.

One can easily recognize when examine the metacognition literature that most research on understanding of metacognition focuses on classroom settings (Lee, Teo, & Bergin, 2009; Schraw & Dennison, 1994; Sperling, Howard, Miller, &

Murphy, 2002) and there is not much known about the influence of metacognition on individuals' informal reasoning on SSI which are ill-structured and controversial in nature. As aforementioned metacognition has an important role in individuals' problem solving and research indicated that the solution of well-defined and ill-defined problems require different cognitive processes in a way that everyday problem solving requires more complex cognitive processes than solving well-structured problems (Johnson-Laird, 1982; Lin, 2001; Watson & Johnson-Laird, 1972). Taking all these into consideration, the present study will fill the gap in the metacognition literature by exploring the relationship between PSTs' metacognitive awareness and informal reasoning on SSI.

CHAPTER 3

METHOD

This part of the proposal is comprised of information about the research design, sample, data collection instruments and procedure, data analysis, internal validity threats and assumptions and limitations of the study.

3.1. Research Design

In this study it was aimed to explore the relationships among PSTs' informal reasoning regarding SSI (nuclear power usage), epistemological beliefs, and metacognitive awareness. For this purpose, a correlational research approach was used in the study. The main goal of correlational research is to identify relationships among two or more variables without influencing them (Fraenkel & Wallen, 2006). Collected data concerning dimensions of the questionnaires were used for inferential purposes and relationships among the dimensions were investigated. In order to assess PSTs' epistemological beliefs and metacognitive awareness, quantitative data were collected through a Likert-type questionnaire. In addition, an open-ended questionnaire developed in 2007 and later revised by Wu and Tsai (2010) were used to gather data about PSTs' informal reasoning regarding nuclear power usage and the data were assessed by using an integrated analyzed framework developed in 2007 and later revised by Wu and Tsai (2010). Hence, with qualitative and quantitative data, quantitative analyses were conducted to explore the relationships among PSTs' informal reasoning regarding SSI (nuclear power usage), epistemological beliefs, and

metacognitive awareness. By utilizing an integrated analyzed framework developed by Wu and Tsai (2010), the responses to the open-ended questionnaire assessing informal reasoning were analyzed first qualitatively and then in order to provide distinct insights into participants' informal reasoning regarding nuclear power usage, statistical analyses were conducted.

3.2. Sample

The sample of the study comprised of PSTs enrolled in three public universities in Ankara. Thus, the target population was all PSTs enrolled in Faculties of Education in three public universities. The target population of the study constituted 943 pre-service science teachers. Of these teachers, 674 PSTs were reached as the sample of this study. Thus, the sample of the study constitutes 64 % of the target population. Of the participants, 156 of them were males and 518 of them were females from each grade level including sophomore, freshmen, junior and senior. By selecting the participants from each grade level, it was aimed to lay out the profile of the PSTs.

3.3. Instrumentation

Three instruments were utilized in the present study. These were 1) Open-ended Questionnaire Assessing Informal Reasoning Regarding Nuclear Power Usage developed by Wu and Tsai (2007), and revised by the same researchers in 2010, 2) Schommer's Epistemological Questionnaire (SEQ) developed by Schommer (1990), and 3) The Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison (1994). The first questionnaire comprises of open-ended questions while

the other two questionnaires include close-ended Likert-type questions that entail self-reported responses of participants. In the following three sections, the more detailed information about these instruments was presented.

3.3.1. Open-ended Questionnaire Assessing Informal Reasoning Regarding Nuclear Power Usage

Wu and Tsai (2007) developed and open-ended questionnaire including four questions for assessing students' possible position change on the building of the fourth nuclear power plant in Taiwan, evaluating students' ability to generate supportive arguments for their positions, assessing students' ability for counterargument construction, evaluating students' ability for rebuttal construction respectively. To assess the reliability of qualitative analyses, two researchers were asked to analyze 16 students' responses and all the inter-coder agreements of these analyses were greater than 0.80 (Wu & Tsai, 2010). Then Wu and Tsai (2010) mildly modified this open-ended questionnaire and used to collect data to evaluate students' informal reasoning on nuclear energy usage. The revised open-ended questionnaire included seven questions for assessing the participants' decision-making modes (Question 1), assessing initial supportive argument or counterargument construction (Question 2), evaluating initial supportive argument or counterargument construction (Question 3), assessing students' personal position on the building of a nuclear power plant (Question 4), evaluating students' ability to generate supportive arguments for their positions (Question 5), assessing the ability for counterargument construction (Question 6), evaluating the ability for rebuttal construction (Question 7). Likewise the first pilot study, apart from the two researchers, another researcher was asked to

analyze 15 students' responses to assess the reliability and all the inter-coder agreements for the analyses were greater than 0.80. In the present study, the revised form of the open-ended questionnaire (Wu & Tsai, 2010) was used to collect data regarding PSTs' informal reasoning on nuclear energy usage and inter-coder reliability between the two researchers of the study was computed as 0.85. The open-ended questionnaire was translated into Turkish by the researcher first, then the translation was checked by an expert on informal reasoning regarding SSI, and the agreement was established between the researcher and the expert after the necessary revisions were made. Then, translation was revised and finalized by an expert on translation from English to Turkish. The finalized Turkish version of the open-ended questionnaire that was first develop for assessing participants' informal reasoning on the construction of fourth nuclear power plant in Taiwan was used to assess PSTs' informal reasoning on the construction of first nuclear power plant in Turkey in the present study.

3.3.1.1. The Integrated Framework

In a pilot study, Wu and Tsai (2007) developed an integrated framework to obtain more information about learners' informal reasoning on socioscientific issues consisting of both qualitative and quantitative indicators. This framework included argumentation and decision-making on a socioscientific issue which is nuclear power usage in this study and developed by reviewing the previous studies related to analysis methods. Then, in 2010, the framework was slightly modified by the same researchers. The integrated framework which displayed in Figure 3.1 was used to examine the answers PSTs gave to the open-ended questionnaire questions.

3.3.1.1.1. Qualitative Indicators

The framework that was utilized for assessing PSTs' informal reasoning regarding nuclear power usage included three qualitative indicators which were decision making mode, reasoning quality, and reasoning mode.

3.3.1.1.1.1. Decision making mode

The aim is to assess participants' tendency of decision-making. In the present study, pre-service science teachers' decision making modes were divided into two categories as intuitive or evidence-based decision making.

3.3.1.1.1.2. Reasoning Quality

This indicator was utilized to assess the quality of informal reasoning. It assesses participants' abilities and skills to generate arguments for three purposes; supportive argument construction, counterposition construction, and rebuttal construction. Kuhn (1993) stated that rebuttals are crucial to complete the structure of an argument since they integrate argument and counterargument. Therefore, Wu and Tsai (2010) accepted participants' rebuttal construction as the indicator of their informal reasoning quality. More rebuttals were constructed by the participants, better reasoning quality the participant has.

In the literature, researchers claimed that one of the indicators of high quality reasoning is the counterargument construction (Means & Voss, 1996; Sadler & Zeidler, 2004). Also, according to Wu and Tsai (2007), individuals' usage of different reasoning modes may be helpful for them to generate more arguments, hence more counterarguments which in turn influence the construction of rebuttals.

Thus, PSTs' rebuttal construction, counterargument construction and usage of different reasoning modes were seen as the indicators of higher reasoning quality in the present study. That means, as the PSTs generated more rebuttals, counterarguments and used different reasoning modes, they were accepted to have higher reasoning quality.

3.3.1.1.1.3. Reasoning Mode

Participants' arguments may be generated from different perspectives. These perspectives were categorized as; social-oriented, ecology-oriented, economic-oriented, and science- or technology- oriented.

3.3.1.1.2. Quantitative Measures

Quantitative measures were also utilized to represent participants' informal reasoning regarding nuclear power usage which explained in the following part.

3.3.1.1.2.1. Number of Social-oriented Arguments

This measure refers to the amount of social-oriented arguments constructed by participants. An example for social-oriented argument is: "I disagree with the building of nuclear power plant in Turkey because it is risky for human health to live near to the nuclear waste storage." The more participants generate social-oriented arguments, the more they reason from social-oriented aspects. (Obtained by analyzing participants' responses on Questions 5-7 of the questionnaire.)

3.3.1.1.2.2. Number of Ecology-oriented Arguments

This measure refers to the amount of ecology-oriented arguments constructed by participants. An example is: “I disagree with the building of nuclear power plant in Turkey because the living things such as plants and animals near the nuclear power plant may be damaged.” The more participants generate ecology-oriented arguments, the more they reason from ecology-oriented aspects. (Obtained by analyzing participants’ responses on Questions 5-7 of the questionnaire.)

3.3.1.1.2.3. Number of Economic-oriented Arguments

Number of economic-oriented arguments implies the sum of economic-oriented arguments constructed by a participant. An example is: “I agree with the building of nuclear power plant in Turkey because it can provide sufficient electric power for the development of industry in Turkey.” The more economic-oriented arguments constructed the more participants tend to think economic considerations. (Obtained by analyzing participants’ responses on Questions 5-7 of the questionnaire.)

3.3.1.1.2.4. Number of Science or Technology-oriented Arguments

This measure refers to the sum of science-oriented and technology-oriented arguments constructed by participants. An example is: “I agree with the building of nuclear power plant in Turkey because the use of nuclear power is safe.” The more science- or technology-oriented arguments proposed by the participants the more they tend to reason from science-or technology oriented perspectives and this may be an indication that the participants can apply scientific knowledge they possess.

(Obtained by analyzing participants' responses on Questions 5-7 of the questionnaire.)

3.3.1.1.2.5. Total Number of Reasoning Modes

This measure refers to participants' total number of reasoning modes utilized in their informal reasoning. Aforementioned, there are four reasoning modes in total. As the number of reasoning mode utilized by the participant increases, the participant reason from multiple perspectives. For instance, if a participant generates one social-oriented argument and two ecology-oriented arguments, this participant is accepted as utilizing two reasoning modes. (Obtained by analyzing participants' responses on Questions 5-7 of the questionnaire.)

3.3.1.1.2.6. Number of Initial Supportive Arguments

This refers to the amount of supportive arguments constructed by the participants before they make personal position on nuclear power usage. Obtained by analyzing participants' responses on Questions 2 and 3 of the questionnaire.)

3.3.1.1.2.7. Number of Initial Counterarguments

This measure implies the amount of counterarguments participants propose before they make personal position on nuclear power usage. (Obtained by analyzing participants' responses on Questions 2 and 3 of the questionnaire.)

3.3.1.1.2.8. Number of Supportive Arguments

It is the amount of supportive arguments participants generated. The more participants propose supportive arguments, the more they were able to generate supportive evidences for their positions. (Obtained by analyzing participants' responses on Question 5 of the questionnaire.)

3.3.1.1.2.9. Number of Counterarguments

This measure refers to the amount of counterarguments a participant proposes. It assessed participants' ability to reason from the counterposition. (Obtained by analyzing participants' responses on Question 6 of the questionnaire.)

3.3.1.1.2.10. Number of Rebuttals

The amount of rebuttals a participant generated. The more a participant constructs rebuttals, the more he/she was able to justify for his/her position. (Obtained by analyzing participants' responses on Question 7 of the questionnaire.)

3.3.1.1.2.11. Total Number of Arguments

This measure refers to the total amount of the three kinds of arguments which are supportive arguments, counterarguments, and rebuttals. This measure was utilized to evaluate the participants' ability to generate arguments regarding an SSI. (Obtained by analyzing participants' responses on Questions 5-7 of the questionnaire.)

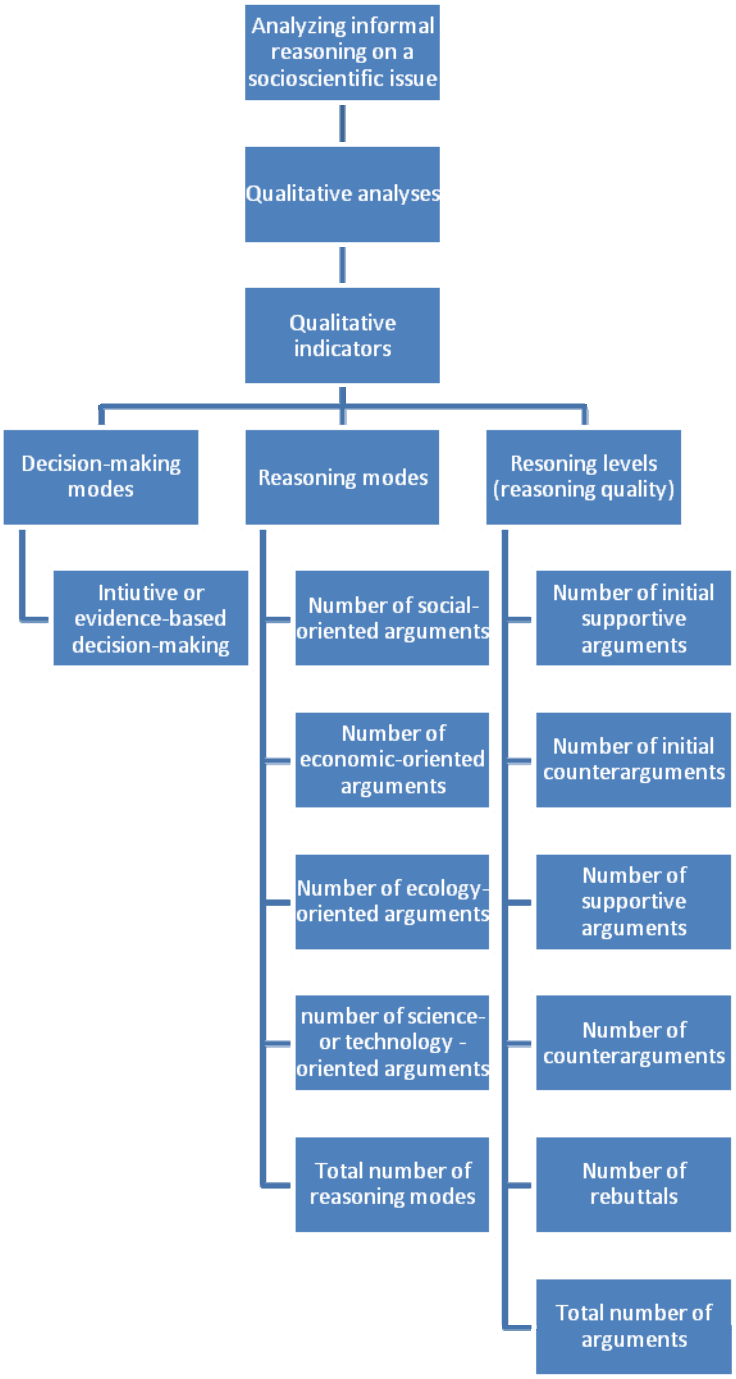

Figure 3.1 An integrated framework for analyzing informal reasoning on nuclear power usage. Adapted from "High School Students' Informal Reasoning Regarding a Socioscientific Issue, with Relation to Epistemological Beliefs and Cognitive Structures," by Y. T. Wu and C. C. Tsai, 2010, *International Journal of Science Education, 29*, p. 13.

3.3.2. Schommer's Epistemological Questionnaire (SEQ)

SEQ, which was the first quantitative measurement tool for epistemological beliefs, developed to measure college students' epistemological beliefs by Schommer (1990). SEQ includes 63 items in Likert format. Participants responded to each item on a scale ranging from strongly disagree to strongly agree. It was scored strongly disagree as 1 and strongly agree as 5 and overall of items was an indication of less developed epistemological beliefs. Due to the reverse scoring, participants who got higher scores from the questionnaire were seen as having less developed epistemological beliefs. There are 5 hypothetical dimensions and 12 subsets within these dimensions in the questionnaire. These 5 hypothetical dimensions and 12 subset dimensions can be seen in Table 3.1.

SEQ was translated into Turkish language and validated by Topcu and Yilmaz-Tuzun (2006) and the translation was examined by a bilingual expert in the field of epistemology in USA. Once the translation completed, SEQ was pilot tested with 94 pre-service science teachers and the researchers conducted factor analysis and results showed consistency with Schommer's early findings (Topcu & Yilmaz-Tuzun, 2006). Schommer (1993) reported the inter-item reliabilities for the items composing each factor ranging from .51 to .78 and in another research study conducted with pre-service science teachers, Yilmaz-Tuzun and Topcu (2008) reported the inter-item reliabilities ranged from .20 to .60.

Table 3.1.

Hypothetical Dimensions and Sub-dimensions of SEQ

Hypothetical dimension	Subset dimension	Number of items
Simple Knowledge	Seek single answers	11
	Avoid integration	8
Certain Knowledge	Avoid ambiguity	5
	Knowledge is certain	6
Omniscient Authority	Do not criticize authority	6
	Depend on authority	4
	Cannot learn how to learn	5
Innate Ability	Success is unrelated to hard work	4
	Ability to learn is innate	4
	Learning is quick	5
Quick Learning	Learn first time	3
	Concentrated effort is a waste of time	2

Note. Adapted from "Effects of beliefs about the nature of knowledge on comprehension," by M.A. Schommer, 1990, *Journal of Educational Psychology, 82,* p.500.

3.3.2.1. Factor Structure of SEQ

Factor structure of the SEQ which revealed the epistemological beliefs that are hold by PSTs was determined. Exploratory factor analysis was used to define the factor structure of the SEQ. In this analysis, the 12 subsets scores were computed with the mean scores of the subset items and these 12 subsets of items were used as

variables in factor analysis. Before doing the analyses, the assumptions for the principle component analyses were checked. The assumptions are:

1. Sample size: According to Tabachnick and Fidell (2007) there should be at least 300 subjects in the sample to perform factor analysis. Also, for each of the variables, there should be at least five cases (Pallant, 2007). The present study met this assumption with a number of 674 cases to 63 items in SEQ.

2. Factorability of the correlation matrix: For a suitable factor analysis, there should be at least some correlations of r=.3 or greater and if the correlation coefficients .3 and above do not find in the matrix, it should be reconsidered to use factor analyses (Pallant, 2007). In addition, Barlett's test of Sphericity should be statistically significant at $p < .05$ and the Kaiser-Meyer-Olkin value should be .6 or above (Pallant, 2007). When correlational matrix results were examined in this study, it was revealed that the correlation coefficients are .3 and above. Also, Barlett's test of Sphericity was statistically significant at $p < .05$ with the p value .00. Finally, Kaiser-Meyer-Olkin value was .88 which is above .6. Thus, the assumption of the factorability of the correlation matrix was met in the present study.

3. Linearity: Since the factor analysis is based on correlation, it is assumed that the relationship between the variables is linear (Pallant, 2007). According to Pallant (2007), if the sample size and the ratio of cases to variables are adequate, linearity of the sample is met. As discussed in the first assumption,

the sample size and the ratio of cases to variables in this study were adequate hence, the linearity assumption was met.

4. Outliers among cases: Since the factor analysis may be sensitive to outliers, before conducting the analyses the outliers were checked and removed from the data. Thus, this assumption was also met.

After checking the assumptions, principle factoring extraction analyses was conducted. With orthogonal varimax rotation, the analyses were conducted however it was revealed very low inter-item reliabilities for some factors. Hence, some items that caused the low reliability were omitted from the analyses. The omitted items were 11, 23, 29, 30, and 40. After removing these items the principle factoring extraction analyses were performed again and the results revealed four factors that account for 63.34 % of the variance. For naming the generated factors, the same procedure with Schommer (1990) was followed. Schommer gave descriptive titles to each factor according to the high loading subsets of items, the subsets having factor loadings higher than .50. In this study, Factor 1 was named “Innate Ability”, which includes the subset dimensions of “Ability to learn is innate” and “Success is unrelated to hard work”. Factor 2 was named “Omniscient Authority”, which includes the subset dimension of “Depend on authority”. Factor 3 was named “Certain Knowledge” which includes the subset dimension of “Knowledge is certain”. Factor 4 was named “Quick Learning” which includes the subset dimension of “Learn the first time”. Factor structure and variances associated with factors and their eigenvalues are presented in Table 3.2.

Inter-item reliabilities between items of each factor were ranged from .32 to .48. Those were lower than Schommer's reliability findings which ranged from .51 to .78. Yilmaz-Tuzun and Topcu (2008) who used SEQ in Turkish context also reported low inter-item reliabilities ranged from .20 to .60. According to Yilmaz-Tuzun and Topcu (2008), the reason of finding lower reliability may be due to two reasons. First, some of the subsets could not load into their hypothesized dimensions instead, they loaded highly to the other factors. That revealed that the participants in Turkish context did not successfully differentiate the subset items since they have similar meanings. Second, the lower reliability may be caused by the translation. With the Turkish version, Turkish students might not understand the items in a way the original questionnaire indicated (Yilmaz-Tuzun & Topcu, 2008). Similar arguments are also true for this study that the lower reliabilities might be caused because of the two reasons mentioned.

Moreover, since the number of the subsets was lower than the hypothesized number, the items correlated were decreased. For instance, for one of the subset in this study, the number of items correlated was two. According to Pallant (2007) when there are factors comprised of 10 or less items, it was possible to obtain low correlations.

Table 3.2.

Factor Loadings of Principal Component Factor Analysis with Varimax Rotation of SEQ

	Factor loading			
Subsets	1	2	3	4
Ability to learn is innate	**.797**	.167	.104	.005
Learning is quick	.734	-.039	.234	.121
Concentrated effort is a waste of time	.642	-.216	.085	.301
Success is unrelated to hard work	**.546**	-.497	.110	.106
Do not criticize authority	.503	-.375	.459	.115
Depend on authority	-.051	**.723**	-.298	.000
Avoid ambiguity	.103	.649	.375	.096
Cannot learn how to learn	.349	-.595	.425	.266
Seek single answers	-.075	.595	.065	-.445
Knowledge is certain	.136	.064	**.823**	.031
Avoid integration	.421	-.285	.524	.120
Learn the first time	.204	-.033	.122	**.888**
Eigenvalue	4.26	1.63	0.92	0.78
% of variances	35.51	13.64	7.69	6.49

Note: Factor loadings □ .50 are in boldface.

Schommer carried out many research studies with different groups and methods. In these studies, three to four different factor structures were obtained and it was concluded that with different samples, different factor structures may be found. For instance, in one of her study, Schommer hypothesized five factor

structures which are Quick learning, Certain knowledge, Simple knowledge, Innate ability and Omniscient authority however, empirical study revealed four of these factors which are Quick learning, Certain knowledge, Simple knowledge and Innate ability. Schommer could not find the Omniscient authority factor. In the present study, it was found four factors that are Innate ability, Omniscient authority, Certain Knowledge, and Quick learning. Hence, there are consistency between findings of Schommer and the present study. However, the Omniscient authority factor attracts our attention that in the studies carried out in Turkish context including the present study, the Omniscient authority factor appears as one of the factors of epistemological beliefs (e.g. Topcu & Yilmaz-Tuzun, 2006; Yilmaz-Tuzun & Topcu, 2008; Ozturk, 2009) where the studies conducted other cultures did not found this factor (e.g. Schommer, 1990; Kardash & Scholes, 1996). According to Yilmaz-Tuzun and Topcu (2008), this different may be caused by the cultural differences. According to these researchers, PSTs' previous learning experiences might influence their professional development in their university years. What they meant was that the traditional teaching strategies applied in the previous science curriculum may influence the viewpoints of individuals in a way that they perceive the scientists as the source of knowledge and the teachers as the person who deliver this body of knowledge. Hence it is difficult for them to distinguish between depending on authority or to be reflective on the scientific knowledge critically. This unique situation may be the cause of the existence of Omniscient authority factor in research studies conducted in Turkish culture.

To sum up, the factor structure of the SEQ was examined by using the principle factoring extraction analyses which generated four factors for this sample. These four factors are: Innate Ability, Omniscient Authority, Certain Knowledge, and Quick Learning. These findings support the idea of Schommer that PSTs have multidimensional epistemological beliefs. In the present study, PSTs develop a set of more or less independent epistemological beliefs by having four factors instead of having just one single belief structure.

3.3.3. The Metacognitive Awareness Inventory (MAI)

The Metacognitive Awareness Inventory was developed by Schraw and Dennison (1994) to assess adults' metacognitive awareness. MAI is a self-report inventory which includes 52 items in a 5-point Likert format. Items are classified into eight subcomponents under two broader categories: The Knowledge of Cognition Scale and The Regulation of Cognition Scale. The Knowledge of Cognition Scale measures "an awareness of one's strengths and weaknesses, knowledge about strategies and why and when to use those strategies (p. 471)" and The Regulation of Cognition Scale measures knowledge about planning, implementing, monitoring, and evaluating strategy use (p. 471)" (Schraw & Dennison, 1994).

The Knowledge of Cognition Scale includes three subcomponents: declarative knowledge (8 items), procedural knowledge (4 items), and conditional knowledge (5 items). Declarative knowledge implies knowledge about one's skills, intellectual resources, and abilities as a learner (e.g., "I am a good judge of how well

I understand something"). Procedural knowledge involves knowledge about how to implement learning procedures (e.g., "I find myself using helpful learning strategies automatically"). Finally, conditional knowledge refers to knowledge about when and why to use learning procedures (e.g., "I know when each strategy I use will be most effective"; Schraw & Dennison, 1994). The Regulation of Cognition Scale includes five subcomponents: planning (7 items), information management (10 items), monitoring (7 items), debugging (5 items), and evaluation (6 items). Planning involves planning, goal setting, and time programming before learning (e.g., "I think about what I really need to learn before I begin a task"). Information management refers to using skills and strategies to process information in an effective way (e.g., "I slow down when I encounter important information"). Monitoring implies the assessment of one's learning and strategy use (e.g., "I ask myself periodically if I am meeting my goals"). Debugging involves strategies used to correct comprehension and performance errors (e.g., "I reevaluate my assumptions when I get confused"). Finally, evaluation refers to the analysis of performance and strategy effectiveness after a learning episode (e.g., "I know how well I did once I finish a test"; Schraw & Dennison, 1994).

Schraw and Dennison (1994) reported the internal consistency of these scales ranging from .88 to .93. MAI was translated into Turkish language and validated by Sungur and Senler (2009) and in the same study, Sungur and Senler (2009) found sufficiently high Cronbach's alpha coefficients for all of the subscales, namely, declarative knowledge (α= .79), procedural knowledge (α= .71), conditional knowledge (α= .71), planning (α= .79), information management (α= .79),

monitoring (α= .74), debugging (α= .60), evaluating (α= .75). In another study, Sungur (2007) found the alpha coefficients for the knowledge of cognition and regulation of cognition subscales of MAI were found to be .77 and .88 respectively. In the present study, Cronbach's alpha coefficients were calculated for the subscales as .76 for declarative knowledge, .66 for procedural knowledge, .43 for conditional knowledge, .55 for planning, .57 for information management, .76 for monitoring, .42 for debugging, and .69 for the evaluating subscale. Also, the alpha coefficients for the knowledge of cognition and regulation of cognition subscales of MAI were computed as .83 and .87 respectively.

In order to validate the factor structure of the MAI, Sungur and Senler (2009) conducted confirmatory factor analysis. According to Sungur and Senler (2009), overall, the interpretation of fit indices revealed a good model fit for the instruments' subscales while the findings concerning the declarative knowledge should be interpreted cautiously.

3.3.3.1. Factor Structure of MAI

In order to validate the factor structure of the Metacognitive Awareness Inventory, confirmatory factor analyses were conducted by using LISREL. The fit statistics indices were shown in Table 3.3. Goodness of Fit (GFI) was above .90 for all the subscales as well as Comparative fit index (CFI) was found above .90 for all the subscales. Moreover, Root mean square error of approximation (RMSEA) was computed below .10 for all the subscales and Standardized root mean square residuals (SRMR) were below .05 for all the subscales except the debugging

subscale. On the other hand, the chi-square estimates for 5 of the subscales (planning, information management, monitoring, debugging, and evaluating) were statistically significant. According to Tabachnick and Fidell (2007) and Jöreskog & Sörbom (1996), the χ^2 measure is very sensitive to sample size. Hence, the chi-square estimates may be elevated with larger sample sizes (Tabachnick & Fidell, 2007). Overall, interpretation of fit indices revealed a good model fit for the subscales of the MAI. However, the debugging subscale should be interpreted cautiously. According to Sungur and Senler (2009), while interpreting the findings, it should be taken into consideration that the self-report measures of individuals' metacognition may not capture the actual situation in individuals' metacognition and this may be a threat to the validity of the findings.

3.4. Data Collection

Data collection was carried out over two semesters, 2010-2011 Fall, 2010-2011 Spring. Before data collection started, the researcher got the required permissions from Ethical Committee of the three universities for conducting the research. Three questionnaires were administered to the participants in their classroom and administration of them took about 25-30 minutes for the participants to complete all the three questionnaires in the same class hour. Administration of the questionnaires was done by the same researcher to ensure the consistency of data collection procedure. At each collection sites, the researcher explained the aim of the study and ask the participants not to leave any part unanswered. Before the administration of the questionnaires, participants signed a consent form confirming that every subject was participated the research study voluntarily.

Table 3.3.

Fit Statistics for the Subscales of MAI

	Fit statistics							
Subscales	χ^2	d*f*	χ^2/ d*f*	p	GFI	CFI	SRMR	RMSEA
Declarative Knowledge	77.03	20	3.85	.048	.97	.97	.03	.06
Procedural Knowledge	8.26	2	4.13	.207	.99	.99	.02	.06
Conditional Knowledge	20.35	5	4.07	.145	.98	.98	.03	.06
Planning	122.48	14	8.74	.000	.95	.94	.05	.10
Information Management	225.88	35	6.45	.000	.93	.93	.05	.09
Monitoring	88.37	14	6.31	.000	.96	.96	.04	.08
Debugging	61.55	5	12.31	.000	.96	.93	.06	.13
Evaluating	52.76	9	5.86	.004	.97	.96	.03	.08

3.5. Data Analysis

In order to analyze the collected data, SPSS PASW Statistics 18 (Statistical Package for Social Sciences – Predictive Analytics SoftWare) was used. There were three major variables involved in this study; pre-service science teachers' epistemological beliefs, metacognitive awareness, and informal reasoning regarding nuclear power usage. Participants' epistemological beliefs were assessed quantitatively by utilizing a close-ended questionnaire. Their metacognitive awareness was also assessed by the gathered data by using a close-ended

questionnaire. In addition to these two variables, data about the third variable, informal reasoning regarding nuclear power usage, was obtained by using an open-ended questionnaire and this data were assessed by utilizing the integrated framework that was mentioned before. Hence, participants' responses to the open-ended questionnaire were first assessed qualitatively by utilizing the aforementioned framework. Then, the same data were assessed quantitatively to gain deeper insights. In order to explore the relationship between the three variables, informal reasoning regarding SSI, epistemological beliefs, and metacognitive awareness, some statistical analyses were conducted.

More specifically, descriptive statistics including mean, standard deviation, range was used to describe participants' informal reasoning outcomes, epistemological beliefs, and metacognitive awareness, MANOVA was conducted to examine the differences in students' epistemological beliefs and metacognitive awareness within the two different decision groups (evidence-based and intuitive decision groups), Pearson's correlation analyses were conducted to examine the correlation between the participants' epistemological beliefs and their informal reasoning outcomes also between the participants' metacognitive awareness and their informal reasoning outcomes. Finally, stepwise multiple regression analyses were conducted to examine the participants' epistemological beliefs and their metacognitive awareness as predictors for their rebuttal construction, counterargument construction, and their amount of using different reasoning modes respectively.

3.6. Internal Validity Threats

Internal validity implies that the differences on the dependent variables were directly related to the independent variable, not caused by any other unintended variables (Frankel & Wallen, 2006). In the following part, the possible threats to the internal validity of the present study were discussed.

3.6.1. Subject Characteristics

Some characteristics of the subjects such as age, maturity, ethnicity, intelligence, and gender may affect the study and this may result in subject characteristics threat (Frankel & Wallen, 2006). In this study, subjects were selected based on some characteristics such as university students from the departments of elementary science education and all the universities were from Ankara. Hence, subject characteristics threat is not a problem for the present study. However, some characteristics of the subjects such as motivation or intelligence could not be controlled.

3.6.2. Mortality

Mortality threat may occur when some of the subjects drop out of the study as the study progresses and they are absent in the administration day (Frankel & Wallen, 2006). Since, in the present study, the sample of the study constituted 64% of the target population which is quiet a high percentage to represent the target population, mortality is not a threat for this study.

3.6.3. Location

The data collection locations may create alternative explanations for the results. This is called as location threat (Frankel & Wallen, 2006). In this study, the data collection instruments were administered in subjects' own classrooms and the location sites were similar in average, the classrooms in the three universities in Ankara. Hence, location threat is not an essential threat for the present study.

3.6.4. Instrumentation

The instrumentation threat occurs when there is instrument decay, influence of data collector characteristics and data collector bias. In the present study, since there were no any change in the data collection instruments, instrumentation decay was not a threat. All the data were collected by the same researcher so data collector characteristics was not an internal validity threat. The data collector may unconsciously distort the data in such as way as to make certain outcomes such as support for the hypothesis more likely (Frankel & Wallen, 2006). In this study, the researcher was aware of this at the beginning of the data collection process so behaved in a standard way throughout the data collection sites such as just making the necessary explanations. Hence, data collector bias is also not a threat for this study.

3.6.5. Testing

In intervention studies, it is common to test the subjects at the beginning of the intervention. If substantial improvement is found in posttest scores, the researchers conclude that this is due to the intervention however this improvement

may be due to the pre-test. This internal validity threat is called testing threat (Frankel & Wallen, 2006). In the present study, testing is not a threat since the instruments were used for one time. As well as since the three instruments that were used in the study were not related to each other, none of the instruments might be caused a clue for the other two instruments.

3.6.6. History

History threat occurs when one or more unanticipated and unplanned events may occur during the course of a study that may affect the responses of the subjects (Frankel & Wallen, 2006). In this study, all the conditions tried to be controlled by the data collector. However, in the last days of the data collection period, in Japan, a nuclear power plant accident was occurred. This was an enormous accident which announced from all the televisions and newspapers. This accident may attract some PSTs' attention and they might read some information from the media. Although this may cause a history threat, since the accident happened in the last period of the data collection and more than ninety percent of the whole data had been collected at the time that the accident occurred, history threat is not an essential threat for this study.

3.6.7. Maturation

Sometimes, change occurred during the intervention may be due to factors associated with the passing of time rather than the intervention itself (Frankel & Wallen, 2006). There could not be a maturation threat in this study since the data were collected at one time.

3.6.8. Attitude of Subjects

The way subjects view the study and participate in it may be an internal validity threat which is named attitude of subjects (Frankel & Wallen, 2006). This threat was tried to be controlled by the explanations written in the consent form.

3.6.9. Regression

Regression threat may occur when the change is studied in a group that is comprised of extremely low or high in its preintervention performance (Frankel & Wallen, 2006). Since the aim of the study is not to investigate the change in a group, regression threat might not be occurred.

3.6.10. Implementation

In the experimental studies, the experimental group may be treated in a way that are unintended or not a part of the method which may give advantage to this group of one sort or another. This is known as implementation threat (Frankel & Wallen, 2006). Since there is no ant experimental group in this study, there could not occur any implementation threat.

3.7. Assumptions

The following assumptions are made by the researcher for the present study:

1. PSTs participated in the study responded to the items of the three instruments sincerely.

2. The administration of the instruments was under standard conditions.

3. There was no interaction between the participants while responding to the questionnaires.

3.8. Limitations

The present study was subject to the following limitations:

1. The study was limited to the three universities in Ankara.
2. The study was limited by its reliance on self-reported data of the participants.
3. Participants' informal reasoning regarding nuclear power usage was assessed by the framework used in the study; different conclusions may be drawn by following different steps in different frameworks.

CHAPTER 4

RESULTS

In the present chapter, first some descriptive statistics about PSTs' informal reasoning outcomes, epistemological beliefs and metacognitive awareness were given. Then, the results regarding each research questions were given in the same sequence presented in the introduction chapter.

4.1. Descriptive Statistics

4.1.1. PSTs Informal Reasoning Outcomes

Results about PSTs' informal reasoning on socioscientific issues, namely nuclear power usage revealed that 615 of the participants (about 91%) made evidence-based decisions while 44 (about 7%) PSTs chose to make intuitive-based decisions. As shown in Table 4.1 PSTs, on average, constructed more than one initial supportive arguments (mean=1.68), initial counterarguments (mean=1.96), supportive arguments (1.86), counter arguments (1.48) and rebuttals (1.38). Besides, they generated more than eight arguments in total (mean=8.37). The average scores for PSTs' usage of different reasoning modes are as the following; 0.71 for science or technology oriented arguments, 1.46 for economic oriented arguments, 1.40 for ecology oriented arguments and 1.14 for social oriented arguments. PSTs' total number of reasoning modes was 2.59 on average which revealed that they utilized more than two argumentation modes on average.

Table 4.1.

PSTs' Argument Construction and Usage of Reasoning Modes

	Mean	SD	Range
Argument construction before making personal positions			
Initial supportive arguments	1.68	1.05	0-9
Initial counterarguments	1.96	1.07	0-7
Argument construction for different purposes			
Supportive argument	1.86	1.20	0-6
Counterargument	1.48	1.13	0-5
Rebuttal	1.38	1.11	0-5
Total number of arguments	8.37	3.98	0-29
Usage of different reasoning modes			
Number of science-or-technology oriented arguments	0.71	1.06	0-8
Number of economic oriented arguments	1.46	1.16	0-6
Number of ecology oriented arguments	1.40	1.26	0-7
Number of social oriented arguments	1.14	1.10	0-5
Total number of reasoning modes	2.59	1.25	0-9

4.1.2. PSTs' Epistemological Beliefs

Table 4.2 presents PSTs' average scores and standard deviations on the dimensions of Schommer's Epistemological Questionnaire. According to the results, pre-service science teachers scored highest on Depend on authority (Omniscient Authority) with an average of 3.84, followed by Ability to learn is innate (Innate

Ability) with an average of 2.72, Knowledge is certain (Certain Knowledge) with an average of 2.51, Learn the first time (Quick Learning) with an average of 2.49, and Success is unrelated to hard work (Innate Ability) with an average of 2.23. Results revealed that accept the omniscient authority subdimension, pre-service science teachers did not score high and most of the scores were around the absolute mean of the 1-5 Likert scale. That means PSTs in this study, displayed relatively sophisticated epistemological beliefs toward science.

Table 4.2.

PSTs' Scores on the Subdimensions of SEQ

Dimension	Mean	SD	Range
Innate Ability			
Ability to learn is innate	2.72	0.76	1-5
Success is unrelated to hard work	2.23	0.62	1-5
Omniscient Authority			
Depend on authority	3.84	0.80	1-5
Certain Knowledge			
Knowledge is certain	2.51	0.59	1-4.67
Quick Learning			
Learn the first time	2.49	0.69	1-5

4.1.3. PSTs' Metacognitive Awareness

PSTs' average scores and standard deviations on the scales of MAI were shown in Table 4.3. According to the results, PSTs scored highest on debugging strategies (an average of 4.01), declarative knowledge (an average of 3.92), and information management strategies and conditional knowledge (an average of 3.91). All of the mean scores for the other scales of MAI were higher than the absolute mean of 1-5 Likert-scale. This revealed that PSTs had relatively high metacognitive awareness.

Table 4.3.

PSTs' scores on the dimensions of MAI

	Mean	SD	Range
Declarative Knowledge	3.92	0.44	2-5
Procedural Knowledge	3.83	0.55	2-5
Conditional Knowledge	3.91	0.57	2.20-11.40
Planning	3.67	0.67	2.14-11.86
Information Management Strategies	3.91	0.50	2.50-7.90
Monitoring	3.69	0.52	2.14-5
Debugging Strategies	4.01	0.57	2.20-12
Evaluating	3.65	0.55	2.17-5

4.2. Relationship between Epistemological Beliefs and Informal Reasoning on SSI

In order to investigate the relationships between PSTs' informal reasoning regarding nuclear power usage (supportive argument construction, counterargument construction, rebuttal construction, and total number of arguments) and their epistemological beliefs (innate ability, omniscient authority, certain knowledge, quick learning), two main analyses were conducted. The first one was MANOVA which enabled us to determine whether there are any differences in PSTs' epistemological beliefs between the two decision making groups: evidence based and intuitive based decision making groups. The second analysis was correlational analysis that enabled to examine the correlation between PSTs' epistemological beliefs and informal reasoning outcomes regarding nuclear power usage.

4.2.1. Multivariate Analysis of Variance

Research Question 1: Is there a significant mean difference in PSTs' epistemological beliefs within the evidence based and intuitive based decision making groups?

Multivariate Analysis of Variance was conducted in order to determine whether there are any differences in PSTs' epistemological beliefs (Innate Ability, Omniscient Authority, Certain Knowledge, Quick Learning) between the two decision making groups: evidence based and intuitive based decision making groups. Before conducting the analyses, the assumptions were checked:

1. Sample size: According to Pallant (2007), it is needed to have more cases in each cell than the number of dependent variables. The minimum required number of cases in each cell for the present study was four (the number of dependent variables). Since in this study, the number of dependent variables was four and the sample size was 674, the sample size assumption was not violated.

2. Normality: Univariate and multivariate normalities were checked. To check for the univariate normality, skewness and kurtosis values as well as histograms were examined. The skewness and kurtosis values were in acceptable range which is between -2 and +2 for all dependent variables. To check for the multivariate normality, Mahalanobis distances were calculated. To decide if a case is an outlier, the Mahalanobis distance need to be compared to the critical value presented in the chi-square table (Pallant, 2007). The Mahalanobis distance was computed as 25.79 and the critical value was 18.47 suggesting that there are a few multivariate outliers in the data.

3. Outliers: Since MANOVA is quite sensitive to outliers, it should be checked for the outliers (Pallant, 2007). To do this, Mahalanobis distances were examined and it was seen that 22 cases exceed the critical value but their scores were not too high. Also, the Cook's distances of these cases were lower than 1. Moreover, since there is a reasonable size of data, the outliers may not be omitted (Pallant, 2007). Hence, no cases were deleted from the data.

4. Linearity: Linearity assumption refers to the existence of a straight-line relation between each pair of the dependent variables. To assess this, scatterplots between each pair of the variables were generated. The scatterplots revealed that there was no apparent violation of linearity assumption.

5. Multicollinearity and singularity: The correlation coefficients among the dependent variables were computed to check for this assumption. The correlation coefficients between the dependent variables ranged from .100 to .312 which were below .8. This showed the moderate correlation among the dependent variables. Hence, this assumption was not violated in the present study.

6. Homogeneity of variances: The significance values revealed from the Levene's Test were non-significant. They were .454 for the dependent variable certain knowledge, .850 for the omniscient authority, .164 for the quick learning, and .180 for the innate ability dimension which showed that the homogeneity of variances assumption was not violated. Details were shown in Table 4.4.

After checking for the assumptions, MANOVA was performed. The results revealed that there was not a statistically significant mean difference in PSTs' epistemological beliefs within the evidence based and intuitive based decision making groups, F (8, 1254) = .531, p = .834; Wilks' Lambda = .993. Mean values

which were very near to each other for the SEQ dimensions of evidence based and intuitive based decision making groups were shown in Table 4.5.

Table 4.4

Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Certain knowledge	,791	2	630	,454
Omniscient authority	,163	2	630	,850
Quick learning	1,812	2	630	,164
Innate ability	1,720	2	630	,180

4.2.2. Correlational Analyses

Research Question 2: What are the relationships among PSTs' informal reasoning regarding nuclear power usage and their epistemological beliefs?

Before examining the correlation between PSTs' epistemological beliefs (innate ability, omniscient authority, certain knowledge, quick learning) and informal reasoning regarding nuclear power usage (supportive argument construction, counterargument construction, rebuttal construction, and total number of arguments), preliminary analyses were conducted to check the assumptions of correlational analyses. Normality, homoscedasticity, linearity and outliers assumptions were checked by the means of bivariate plots. The bivariate plots were examined and according to the results, no assumptions were violated. After checking the

Table 4.5

Mean Values for SEQ Dimensions of Evidence based and Intuitive based Decision Making Groups

	Certain knowledge	Omniscient authority	Quick learning	Innate ability
Evidence based	2,51	3,85	2,49	2,47
Intuitive based	2,46	3,84	2,50	2,50

assumptions, Pearson product moment correlation coefficients were calculated. Alpha level was .05 (two-tailed) as the significance level and pairwise deletion was performed with subjects, N=647. Results of the bivariate correlation revealed that there were statistically significant correlation between PSTs' total argument construction and the dimensions of SEQ except omniscient authority. Also, there was a significant correlation between pre-service science teachers' certain knowledge dimension of SEQ and their counterargument construction. Results were shown in Table 4.6.

4.3. Relationship between Metacognitive Awareness and Informal Reasoning on SSI

In order to investigate the relationships between PSTs' informal reasoning regarding nuclear power usage (supportive argument construction, counterargument construction, rebuttal construction, and total number of arguments) and their metacognitive awareness (declarative knowledge, procedural knowledge, conditional

Table 4.6

Correlation between PSTs' Epistemological Beliefs and Informal Reasoning Outcomes

	Supportive arguments	Counterarguments	Rebuttals	Total arguments
Innate Ability	-.065	-.048	-.069	-.117*
Omniscient Authority	-.015	-.027	-.030	-.034
Certain Knowledge	-.067	-.087*	-.061	-.121*
Quick Learning	-.056	-.061	-.068	-.100*

*Correlation is significant at the 0.05 level (2-tailed).

knowledge, planning, IMS, monitoring, debugging, evaluating), two main analyses were conducted. The first one was MANOVA which enabled us to determine whether there are any differences in PSTs' metacognitive awareness between the two decision making groups: evidence based and intuitive based decision making groups. The second analysis was correlational analysis that enabled to examine the correlation between PSTs' metacognitive awareness and informal reasoning outcomes regarding nuclear power usage.

4.3.1. Multivariate Analysis of Variance

Research Question 3: Is there a significant mean difference in PSTs' metacognitive awareness within the evidence based and intuitive based decision making groups?

Multivariate Analysis of Variance was conducted in order to determine whether there are any differences in PSTs' metacognitive awareness (Declarative knowledge, Procedural knowledge, Conditional knowledge, Planning, Information management, Monitoring, Debugging, Evaluating) between the two decision making groups: evidence based and intuitive based decision making groups. Before conducting the analyses, the assumptions were checked:

1. Sample size: According to Pallant (2007), it is needed to have more cases in each cell than the number of dependent variables. The minimum required number of cases in each cell for the present study was eight (the number of dependent variables). Since in this study, the number of dependent variables was eight and the sample size was 674, the sample size assumption was not violated.

2. Normality: Univariate and multivariate normalities were checked. To check for the univariate normality, skewness and kurtosis values as well as histograms were examined. The skewness and kurtosis values were in acceptable range which is between -2 and +2 for all dependent variables. To check for the multivariate normality, Mahalanobis distances were calculated. To decide if a case is an outlier, the Mahalanobis distance need to be compared to the critical value presented in the chi-square table (Pallant, 2007). The Mahalanobis distance was computed as 312.08 and the critical value was 26.13 which indicated the existence of outliers in the data.

3. Outliers: Since MANOVA is quite sensitive to outliers, it should be checked for the outliers (Pallant, 2007). To do this, Mahalanobis distances were examined and it was seen that 17 cases exceed the critical value. However, the Cook's distances of these cases were lower than 1. Moreover, since there is a reasonable size of data, the outliers may not be omitted (Pallant, 2007). Hence, no cases were deleted from the data.

4. Linearity: Linearity assumption refers to the existence of a straight-line relation between each pair of the dependent variables. To assess this, scatterplots between each pair of the variables were generated. The scatterplots revealed that there was no apparent violation of linearity assumption.

5. Multicollinearity and singularity: The correlation coefficients among the dependent variables were computed to check for this assumption. The correlation coefficients between the dependent variables ranged from .408 to .689 which were below .8. This showed the moderate correlation among the dependent variables. Hence, this assumption was not violated in the present study.

6. Homogeneity of variances: The significance values revealed from the Levene's Test were non-significant. They were .054 for the dependent variable declarative knowledge; .748 for the procedural knowledge; .938 for the conditional knowledge; .745 for planning; .126 for information management strategies; .622 for monitoring; .757 for debugging; and .297 for

the evaluation dimension which showed that the homogeneity of variances assumption was not violated. Details were shown in Table 4.7.

Table 4.7

Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Declarative knowledge	2,930	2	632	,054
Procedural knowledge	,290	2	632	,748
Conditional knowledge	,063	2	632	,938
Planning	,294	2	632	,745
IMS	2,080	2	632	,126
Monitoring	,475	2	632	,622
Debugging	,278	2	632	,757
Evaluating	1,217	2	632	,297

After checking for the assumptions, MANOVA was performed. The results revealed that there was not a statistically significant mean difference in PSTs' metacognitive awareness within the evidence based and intuitive based decision making groups, F (16, 1250) = .546, p = .923; Wilks' Lambda = .986.

Mean values which were very near to each other for the MAI dimensions of evidence based and intuitive based decision making groups were shown in Table 4.8.

Table 4.8

Mean Values for MAI Dimensions of Evidence based and Intuitive based Decision Making Groups

	Evidence based	Intuitive based
Declarative knowledge	3,92	3,94
Procedural knowledge	3,84	3,74
Conditional knowledge	3,91	3,85
Planning	3,67	3,58
IMS	3,92	3,93
Monitoring	3,69	3,64
Debugging	4,02	3,93
Evaluating	3,66	3,59

4.3.2. Correlational Analyses

Research Question 4: What are the relationships among PSTs' informal reasoning regarding nuclear power usage and their metacognitive awareness?

Correlational analyses were conducted to examine the relationship among PSTs' metacognitive awareness (declarative knowledge, procedural knowledge, conditional knowledge, planning, information management, monitoring, debugging, and evaluating) and informal reasoning outcomes (supportive argument construction, counterargument construction, rebuttal construction, and total number of arguments). Before examining the correlation between PSTs' metacognitive awareness and

informal reasoning regarding nuclear power usage, preliminary analyses were conducted to check the assumptions of correlational analyses. Normality, homoscedasticity, linearity and outliers assumptions were checked by the means of bivariate plots. The bivariate plots were examined and according to the results, no assumptions were violated. After checking the assumptions, Pearson product moment correlation coefficients were calculated. Alpha level was .05 (two-tailed) as the significance level and pairwise deletion was performed with subjects, N=647. Results of the bivariate correlation revealed that there was a significant correlation between pre-service science teachers' metacognitive awareness and informal reasoning outcomes. Results were shown in Table 4.9.

Declarative knowledge component was positively correlated with all the four outcomes of informal reasoning on nuclear power usage. Namely, it was positively correlated with supportive argument construction at α=.05 with r=.106, p=.007 values, with the counterarguments construction at α=.05 with r=.097, p=.013 values, with the rebuttals construction at α=.05 with r=.079, p=.044 values, and finally with the total number of arguments at α=.05 with r=.126, p=.001 values.

Procedural knowledge component was positively correlated with supportive argument construction at α=.05 with r=.086, p=.028 values, with rebuttal construction at α=.05 with r=.086, p=.029 values, with total number of arguments at α=.05 with r=.097, p=.014 values.

Planning component was only correlated with supportive argument construction and the correlation was positive, α=.05, r=.079, and p=.046.

Table 4.9

Correlations between PSTs' Metacognitive Awareness and Their Informal Reasoning Outcomes

	Supportive arguments	Counterarguments	Rebuttals	Total arguments
Declarative knowledge	.106*	.097*	.079*	.126*
Procedural knowledge	.086*	.042	.086*	.097*
Conditional knowledge	.054	.037	.061	.057
Planning	.079*	.029	.040	.063
IMS	.085*	.089*	.087*	.101*
Monitoring	.091*	.059	.047	.098*
Debugging	.054	-.008	.037	.022
Evaluating	.062	.041	.024	.071

*Correlation is significant at the 0.05 level (2-tailed).

Information management component was also positively correlated with all of the four informal reasoning outcomes, as for the declarative knowledge component. It is positively correlated with supportive argument construction at α=.05 with r=.085, p=.030 values, with counterargument construction at α=.05 with r=.089, p=.024 values, with rebuttals construction at α=.05 with r=.087, p=.027 values, and finally with the total number of arguments at α=.05 with r=.101, p=.010 values.

Monitoring component was positively correlated with supportive argument construction at α=.05 with r=.091, p=.020 values and with the total number of arguments at α=.05 with r=.098, p=.013 values.

4.4. Predictors for PSTs' Informal Reasoning on SSI

Research Question 5: What are significant predictors for PSTs' informal reasoning on nuclear power usage regarding epistemological beliefs and metacognitive awareness?

4.4.1. Stepwise Multiple Regression Analyses

Stepwise regression analyses were used to investigate whether PSTs' epistemological beliefs or metacognitive awareness outcomes are significant predictors for their informal reasoning regarding SSI. All the variables regarding PSTs' epistemological beliefs (Innate Ability, Omniscient Authority, Certain Knowledge, and Quick Learning) as well as those concerning their metacognitive awareness (Declarative Knowledge, Procedural Knowledge, Conditional Knowledge, Planning, Information Management, Monitoring, Debugging, and Evaluating) were used as the predictors in the stepwise regression analyses. Before starting the analyses, assumptions of multiple regression analyses were checked as the following:

1- Sample size: According to Pallant (2007), with small samples the results of the study cannot be generalized. For stepwise regression, there should be a ratio of 40 cases for every independent variable (Tabachnick & Fidell).

According to this calculation, the minimum number the present study required is 480. We met this assumption with having a sample of 674 subjects. Sample size assumption was not violated.

2- Multicollinearity and singularity: Correlation among the independent variables (r=.9 and above) which refers to multicollinearity and singularity which occurs when one independent variable is a combination of other independent variables are not accepted in multiple regression analyses (Pallant, 2007). In this study, correlations among independent variables are checked and results revealed that no any correlation between the independent variables is greater than .9. In addition to this, the tolerance value is 1.00 which is greater than 0.10 and VIF value is also 1.00 which lower than 10 indicated that there is no multicollinearity. Hence this assumption was also met.

3- Outliers: Pallant (2007) suggested that multiple regression is very sensitive to the outliers which are very low or very high scores. In this study, the outliers were checked from standardized residual plot and removed from the analyses. This assumption was also met.

4- Normality, linearity, homoscedasticity, independence of residuals: Normality assumption requires that the residuals should be normally distributed about the predicted dependent variable scores; linearity refers that the residuals should have a straight-line relationship with predicted DV scores; and homoscedasticity assumptions requires that the variance of the residuals about predicted DV scores should be the same for all predicted scores (Pallant, 2007). All these were checked by the means of residuals scatterplots. The

residuals were normally distributed and there is a straight line that shows the relationship between residuals and predicted DV scores. These two indicated that the assumptions of normality and linearity were met in this study. Also, the residuals were rectangularly distributed which indicated that the homoscedasticity assumption was also met (Tabachnick & Fidell, 2007).

In this study, PSTs' rebuttal construction, counterargument construction, and usage of different reasoning modes were viewed as the indicator of reasoning quality. Thus, PSTs' epistemological beliefs and metacognitive awareness were used as the indicator of their rebuttal construction, counterargument construction, and the amount of using different reasoning modes in this analysis.

Results indicated that PSTs' information management strategy (IMS) which is one of the metacognitive awareness outcomes was the only significant predictor for their rebuttal construction ($p < 0.05$). The IMS component of metacognitive awareness explained the 8% (Adjusted $R^2 = .006$, $F(1,642) = 4.90$) of the variance in the rebuttal construction. The β value for the IMS was .087 ($p = .027$) which indicated the contribution to the prediction of the rebuttal construction.

Results of the stepwise regression analysis that were conducted to examine PSTs' epistemological beliefs and metacognitive awareness outcomes as the predictors for their counterargument construction revealed that at the first step of the model declarative knowledge which is one of the metacognitive awareness outcomes entered the equation indicating declarative knowledge was the best predictor of PSTs' counterargument construction ($p < 0.05$). The declarative knowledge component of metacognitive awareness explained the 9% (Adjusted $R^2 = .008$, F

(1,642) = 6.13) of the variance in the counterargument construction. The β value for the declarative knowledge was .097 (p = .014) which indicated the contribution to the prediction of the counterargument construction.

At the second step of the regression, certain knowledge subdimension of SEQ entered the equation, indicating that certain knowledge is the second best predictor for PSTs' counterargument construction ($p < 0.05$). The total variance explained by the model as a whole was 17% (Adjusted R^2= .014, F (2,641) = 5.40) in the counterargument construction. The β value for the certain knowledge was -.084 (p = .032) which indicated the contribution to the prediction of the counterargument construction.

When the stepwise regression analysis were also conducted to examine PSTs' epistemological beliefs and metacognitive awareness outcomes as the predictors for their use of different reasoning modes, results revealed that PSTs' declarative knowledge which is one of the metacognitive awareness outcomes was the only significant predictor for the amount of their reasoning modes ($p < 0.05$). The declarative knowledge component of metacognitive awareness explained the 14% (Adjusted R^2= .019, F (1,642) = 13.43) of the variance in the amount of reasoning modes. The β value for the declarative knowledge was .143 (p = .000) which indicated the contribution to the prediction of the amount of reasoning modes.

4.5. Summary of the Results

In the result section, firstly descriptive statistics results were presented. According to the descriptive statistics, 615 of the participants (about 91%) made

evidence-based decisions while 44 (about 7%) PSTs chose to make intuitive-based decisions. PSTs generated more than eight arguments in total (mean=8.37). The average scores for their usage of different reasoning modes are as the following; 0.71 for science or technology oriented arguments, 1.46 for economic oriented arguments, 1.40 for ecology oriented arguments and 1.14 for social oriented arguments. Besides, according to the results, PSTs in this study displayed relatively sophisticated epistemological beliefs toward science and PSTs had relatively high metacognitive awareness.

According to MANOVA results, PSTs did not differ in epistemological beliefs and metacognitive awareness within the two decision making mode groups: evidence based and intuitive based groups. In addition, results of the bivariate correlation revealed that there were statistically significant correlation between PSTs' total argument construction and the dimensions of SEQ except omniscient authority. Also, there was a significant correlation between pre-service science teachers' certain knowledge dimension of SEQ and their counterargument construction. Bivariate correlation was also revealed that there was a significant correlation between pre-service science teachers' metacognitive awareness and informal reasoning outcomes. Declarative knowledge and information management skill components were positively correlated with all the four outcomes (supportive argument construction, counterargument construction, rebuttal construction, and total number of arguments) of informal reasoning on nuclear power usage. Procedural knowledge component was positively correlated with supportive argument construction, rebuttal construction and total number of argument construction. Also,

planning component was only correlated with supportive argument construction. Finally, monitoring component was positively correlated with supportive argument construction and total number of argument construction.

Stepwise multiple regression analyses revealed that PSTs' information management strategy (IMS) which is one of the metacognitive awareness outcomes was the only significant predictor for their rebuttal construction ($p < 0.05$). Declarative knowledge component of MAI was the best predictor of PSTs' counterargument construction ($p < 0.05$) where the certain knowledge subdimension of SEQ was the second best predictor of PSTs' counterargument construction. Finally, declarative knowledge component of MAI was the only significant predictor for the amount of PSTs' reasoning modes ($p < 0.05$).

CHAPTER 5

DISCUSSION

In this chapter, summary of the study, conclusions and discussions of its findings as well as its' implications and recommendations for further research were presented.

5.1. Summary of the Study

In order to investigate the aforementioned purposes of this correlational study, a sample of 674 PSTs who enrolled in the three public universities in Ankara participated in the study. Data were collected through three instruments which are Open-ended Questionnaire for Assessing Participants' Informal Reasoning Regarding Socioscientific Issues developed and revised by Wu and Tsai (2010), Schommer's Epistemological Questionnaire developed in 1990, and Metacognitive Awareness Inventory developed by Schraw and Dennison (1994). Data collection was carried out during 2010-2011 Fall, 2010-2011 Spring semesters. PSTs' informal reasoning regarding SSI was first analyzed by qualitatively and then the frequencies were computed and the data were analyzed quantitatively. Similarly, PSTs' epistemological beliefs and metacognitive awareness outcomes were analyzed quantitatively. Statistical analyses were performed to investigate the relationship between PSTs' epistemological beliefs and informal reasoning regarding nuclear power usage, as well as relationship between their metacognitive awareness and

informal reasoning regarding nuclear power usage. Finally, the ability of PSTs' epistemological beliefs as well as their metacognitive awareness for predicting their informal reasoning regarding nuclear power usage was investigated.

5.2. Discussions

Descriptive statistics results revealed the mean scores of PSTs' reasoning modes. In the present study it was revealed that PSTs' generated economic oriented and ecology oriented arguments mostly with a mean value of 1.46 and 1.40 respectively. Secondly, they generated social oriented and science or technology oriented arguments with a mean value of 1.14 and 0.71 respectively. When these mean values was compared to the results of Wu and Tsai's research, it was surprising that the participants in their study generated science or technology oriented arguments (with a mean value of 1.09) mostly, then ecology oriented (with a mean value of 0.81), economic oriented (with a mean value of 0.74), and social oriented arguments (with a mean value of 0.25) was generated. Participants in Turkey and Taiwan gave the same level of importance to ecology however they highly differ in science or technology oriented arguments. This might be because of the reason that people in Taiwan were more knowledgeable about the nuclear power plant since the fourth nuclear power plant is trying to be built in Taiwan. However, since there is no any nuclear power plant in Turkey yet, participants did not generate sufficient number of arguments about the science or technology aspects of the issue. In addition, this may be because of the reason that participants in Turkey did not intend to view from the perspectives of science and technology on a specific issue.

Moreover, while participants in Turkish context generated economic oriented arguments mostly, participants in Taiwan scored low on the mean value of economic oriented arguments. The reason behind this may be the idea that nuclear power plants will solve the energy shortage problem hence it will provide improvement in our economy. Nowadays the energy shortage problem in Turkey is being discussed in society and the nuclear energy is seen the only solution. Hence it was not surprising that Turkish participants had economic considerations more than the other aspects of the issue.

In the following parts, the discussion of the results of inferential statistics was presented in three parts. Firstly, the relationship between PSTs' epistemological beliefs and informal reasoning outcomes, in following, the relationship between PSTs' metacognitive awareness and informal reasoning outcomes and finally significant predictors for PSTs' informal reasoning on SSI were discussed.

5.2.1. PSTs' Epistemological Beliefs and their Informal Reasoning Outcomes

In order to investigate the relationship between PSTs' epistemological beliefs and their informal reasoning, firstly MANOVA was conducted to determine whether there is a difference on PSTs' epistemological beliefs within the two decision making groups: evidence-based and intuitive-based decision groups and later, correlational analyses were conducted namely, product moment correlation coefficients were calculated to examine the correlation between their epistemological beliefs and informal reasoning outcomes.

MANOVA results revealed that the difference between PSTs' epistemological beliefs within the two decision-making groups were not statistically significant. It indicated that individuals holding low or sophisticated epistemological beliefs do not necessarily make evidence based decisions. A research study conducted by Wu and Tsai (2010) used the same framework for assessing informal reasoning with the present study and it also indicated the same finding that high school students' epistemological beliefs did not differ in the two decision making groups which were intuitive based and evidence based groups. This might be because of the reason that, PSTs did not present enough evidences while making their decisions on SSI. They might have enough knowledge or awareness about the nuclear power issue however, they should also have the ability to generate evidence based decisions about SSI.

Correlational analyses revealed that there is a negative and high correlation between PSTs' certain knowledge and their counterargument construction. That means, as PSTs believe the certainty of knowledge, they construct less counterarguments regarding SSI. According to Means and Voss (1996), supporting the idea of Baron (1988, 1991), Kuhn (1991), Schauble (1990) and Perkins (1985), as the individuals present reasons from the both sides of the issue, the reasoning quality becomes higher. That shows, counterargument construction is an important indicator for higher-level reasoning. Hence, in the present study, as for rebuttal construction and usage of different reasoning modes, counterargument construction was seen as the indicator of higher informal reasoning quality. As the results revealed, only the certain knowledge is significantly correlated to the counterargument construction. As

aforementioned, the certainty of knowledge refers to belief that knowledge is absolute and the sophisticated beliefs in certain knowledge refers to the belief that knowledge is tentative and evolving. According to Schommer (1994) those who are holding "sophisticated" views about the certainty of knowledge believe that knowledge is evolving and uncertain and only a small part of it is unchanging. In contrast, those who are holding "naive" views about the certainty of knowledge believe that a big amount of our knowledge is certain and unchanging. The finding that certain knowledge is negatively correlated to the counterargument construction on SSI was in parallel with the literature on epistemology and informal reasoning regarding SSI. For instance, Kardash and Scholes (1996) reported that as people less believe in certain knowledge, they hold less extreme beliefs about the HIV-AIDS relationship which is a controversial issue and the more they likely write and draw conclusions that shows the inconclusive and tentative nature of the mixed evidence. A similar finding was also stated in the study of Schommer-Aikins and Hutter (2002) who investigated the relationship between individuals' epistemological beliefs and their thinking about everyday controversial issues. Schommer-Aikins and Hutter (2002) stated that the more individuals believe the changing nature of the knowledge which shows the sophisticated view of certain knowledge, the more they were likely to accept the multidimensional nature of an issue which in turn ease individuals' generation of reasons from different perspectives. In addition, Schommer-Aikins and Hutter (2002) could not found any relationship between reflective thinking on controversial everyday problems and both omniscient authority and quick learning. This finding supported our results that there is no any relationship between

omniscient authority, innate ability and quick learning factors of epistemological beliefs and informal reasoning quality regarding nuclear power usage.

Moreover, it was revealed from the correlational analyses that there is a significant negative correlation between PSTs' innate ability, certain knowledge, and quick learning and their total argument construction. This indicated that individuals holding the beliefs that ability to learn is genetically determined instead of improving with education and experience (innate ability), learning is quick or not-at-all (quick learning), and knowledge is certain and unchanging (certain knowledge), construct less arguments about the nuclear power issue. Hence, as individuals have naive epistemological beliefs, their argument construction on controversial SSI decreases. According to Schommer-Aikins and Hutter (2002) as the more individuals possess sophisticated views of knowledge and learning, the more they can view the multidimensional perspectives of an issue. In the present study, pre-service science teachers' arguments were categorized into four according to the integrated framework that was used. Arguments generated by PSTs were evaluated according to these four different perspectives. The four categories were social-oriented arguments, economic-oriented arguments, science or technology-oriented arguments and finally ecology-oriented arguments. From this point, it is not surprising that individuals holding naive epistemological beliefs generated less argument that shows less ability to view from multidimensional perspectives.

In addition, Kuhn (1991) proposed that the subjects in the evaluative category most likely to possess the skills of argument. According to Kuhn's (1991) argumentative reasoning theory, individuals have three categories of epistemological

beliefs which are absolutist, multiplist, and evaluative. Those in the evaluative category have relatively more sophisticated epistemological beliefs and Kuhn acknowledge them as the ones who are more likely to have developed skills to generate arguments. Hence, Kuhn's study was also support the idea that as individuals possess sophisticated epistemological beliefs, they are more likely to generate arguments.

5.2.2. PSTs' Metacognitive Awareness and their Informal Reasoning Outcomes

In order to explore the relationship between PSTs' metacognitive awareness and their informal reasoning, firstly MANOVA was conducted to determine whether there is a difference on PSTs' metacognitive awareness within the two decision making groups: evidence-based and intuitive-based decision groups and later, correlational analyses were conducted namely, product moment correlation coefficients were calculated to examine the correlation between their metacognitive awareness and informal reasoning outcomes.

MANOVA results revealed non-significance of PSTs' metacognitive awareness between the two decision making groups. As for the epistemological beliefs, this indicated that metacognitively aware individuals do not necessarily make evidence based decisions.

Correlational analyses revealed that PSTs' informal reasoning outcomes (for all dimensions which are supportive argument construction, counterargument construction, rebuttal construction and total argument construction) had positive and significant relationship with declarative knowledge and information management

strategies subdimensions of metacognitive awareness. These relationships suggested that as individuals' declarative knowledge and information management strategies increases, their informal reasoning regarding SSI will also increase. In addition, the findings revealed that procedural knowledge and monitoring component of metacognitive awareness had a significant and positive relation with supportive argument construction and total argument construction. Finally, there was a significant correlation between planning and supportive argument construction. Results of the present study indicated that as PSTs' metacognitive awareness increases, their informal reasoning regarding SSI will also increases. Although there are very limited number of studies conducted to investigate the relationship between metacognitive awareness and informal reasoning regarding SSI in the literature, research studies conducted so far support the stated findings. For instance, Flavell (1979) asserted that metacognition that encompassing epistemology has a crucial importance in the decision making of adults. Based on this idea, Hofer (2001) proposed the two models developed by Kitchener (1983) and Kuhn (2000) as the evidence of the importance of metacognitive processes in the decision making of individuals. The first one, 3-level model of cognitive processing developed by Kitchener (1983) comprised of three stages which are cognition, metacognition, and epistemic cognition. According to Kitchener (1983), the third level, epistemic cognition, which performs encompassing the first two is very crucial for the solution of ill-structured problems. In addition, the second model, 3-level model of meta-knowing is a developmental model of metacognition which is developed by Kuhn (2000) include the stages metacognitive knowing, metastrategic knowing, and

epistemological meta-knowing. Declarative knowledge refers to the metacognitive knowing, procedural knowledge refers to the metastrategic knowing and the third level epistemological meta-knowing refers to a more abstract process of knowledge and knowing (Kuhn, 2000). According to Kuhn (2000) achieving to the third level occurs "in the transition from simply knowing that something is true to evaluating whether it might be" (p.317).

Apart from these two models, Kuhn (1991) proposed the idea of thinking as argumentative reasoning and examined how individuals respond to the everyday ill-structured problems that lack clear-cut solutions. Kuhn then concluded that the skills of argument requires cognitive processes in which there is a judgement of alternative theories and evidence and these cognitive processes requires metacognitive ability to be reflective. Hence, the importance of metacognitive ability and awareness for the solution of ill-structured controversial issues in the process of informal reasoning was also supported by Kuhn (1991).

Besides, according to Bendixen and Rule (2004) "An individual who is highly engaged metacognitively would be more aware of the need for resolution strategies and would closely monitor the effectiveness of those strategies." (p. 74). Similarly, Zohar and Nemet's (2002) conclusion was also in the same direction that one's consciousness about the principles and standards of his/her reasoning processes is a part of metacognitive thinking.

Dole and Sinatra (1998) emphasized that individuals engagement in thinking an issue may be at different levels from low to medium and finally to high level of

engagement. Taking the metacognition literature into consideration the high level of engagement, according to them, consists "deep thinking and processing of the information and reflection on one's progression through the process" (p. 124). Basing on Dole and Sinatra's idea, Wu and Tsai (2010) suggest that metacognitive engagement of individuals has a crucial effect on how they use their concepts and notions about and SSI in the resolution process of these issues.

In summary, the idea that there is a relationship between PSTs' metacognitive awareness and informal reasoning regarding nuclear power usage was revealed from the analyses of the present study. This finding was also supported by the literature although there is a limited number of research studies investigating the relationships between these two constructs.

5.2.3. Significant Predictors for PSTs' Informal Reasoning on SSI regarding Epistemological Beliefs and Metacognitive Awareness

The final aim of the present study was to investigate which variables considering PSTs' epistemological beliefs and metacognitive awareness is a better predictor for their informal reasoning quality. As aforementioned, one of the indicators of PSTs' high quality reasoning is the counterargument construction (Means & Voss, 1996; Sadler & Zeidler, 2004). Besides, PSTs' rebuttal construction and usage of different reasoning modes were seen as the indicators of high-level reasoning quality. According to Kuhn (1993), rebuttals are crucial because they complement the structure of the argument as well as integrating the argument, and counterargument. Hence, PSTs generated more rebuttals were seen as the

participants having better reasoning quality. Also, according to Wu and Tsai (2007), individuals' usage of different reasoning modes may be helpful for them to generate more arguments, hence more counterarguments which in turn influence the construction of rebuttals. Thus, besides the counterargument construction, PSTs' epistemological beliefs and metacognitive awareness were used as the predictors of their rebuttal construction and the amount of using different reasoning modes in the analyses.

The results of the analyses revealed that PSTs' information management strategy which is one of the metacognitive awareness dimensions were the best predictor for their rebuttal construction. In addition, declarative knowledge which was also one of the components of metacognitive awareness was the best predictor for PSTs' usage of different reasoning modes. Finally, declarative knowledge was also the best predictor for pre-service science teachers' counterargument construction. At the second step in the regression, certain knowledge entered the equation indicating that PSTs' certain knowledge dimension of epistemological beliefs was the second best predictor for their counterargument construction, namely for their informal reasoning quality.

Hence, in order to develop PSTs' informal reasoning on SSI, their information management strategies, declarative knowledge and certain knowledge should be taken into consideration. As revealed from the regression analyses, PSTs' metacognitive awareness had stronger relationship than their epistemological beliefs with informal reasoning on SSI. This indicates that while designing PST education programs which aim to develop their informal reasoning regarding SSI, strategies

improving PSTs' metacognitive awareness should be incorporated in the first place. Then, these programs should aim to develop pre-service science teachers' epistemological beliefs which give them chance to hold sophisticated epistemological beliefs.

Apart from these three research questions, demographic results also revealed some important points that should be taken into consideration such as PSTs' informal reasoning modes. Since nuclear energy usage was chosen as an SSI, the present study has an environmental aspect. With the developing technologies, our world has been changing by human action. Nuclear energy power plants were one of the debating issues that may be risky to our environment. That's way it is accepted as one of SSI that is ill-structured and lack clear-cut solutions.

While analyzing PSTs' arguments, they were categorized into four as social oriented, economic oriented, ecology oriented, and science and technology oriented. It was seen from the results that economic oriented and ecology oriented arguments were the first two reasoning modes that pre-service science teachers generated mostly. According to Hungerford and Volk (1990) the prevention of environmental problems can only be realized as the people in the society have critical citizenship. As aforementioned, informal reasoning regarding controversial SSI helps individuals develop critical citizenship (Kolstø, 2001; Sadler, Barab, & Scott, 2007). According to Sadler, Barab, & Scott, (2007) this is thanks to the nature of SSI that it bridges school science to individuals' daily lives. Hence, it can be concluded that implementation of SSI into science curriculum and science classrooms helps

improving the quality of environmental education and increasing individuals' environmental awareness.

5.3. Implications of the Study

The present study has some important implications that should be taken into consideration by policy makers of teacher education, teachers, curriculum developers and the researchers interested in informal reasoning regarding SSI.

According to Sadler, Barab, and Scott (2007) SSI may be a suitable context for teaching and learning science content. In such a developing world, it is hard to watch a TV program or read a newspaper without encountering an SSI (Sadler & Chambers, 2004). Hence, researchers are in an agreement that controversial SSI should be a part of science education. By this way, students' engagements to the society that they live in, in turn citizenship awareness will increase. Besides, dealing with controversial SSI give a great chance to students to interpret data, and value the different positions that people in the society and stakeholders hold (Sadler & Chambers, 2004) and to increase their scientific literacy (Holbrook & Rannikmae, 2009).

Inclusion of SSI into science curriculum requires some changes in teacher education programs. According to Lee and Witz (2009), for the implementation of SSI into science curriculum teachers play the major role and they emphasized that curriculum changes should be consistent with teachers' beliefs, values, philosophies, and their understanding of science. This idea reveals the importance of PST education for the accomplishment of science curriculum goals. Hence, the first thing that should be done is to make some modifications in PST education programs. For

instance, PST education programs may include courses aiming to improve science teachers' usage of SSI in classroom environment and directing the discussions of SSI. Research studies also support the idea that PST education should involve the teaching of controversial SSI (e.g., Albe, 2008; Gray & Bryce, 2006; Kolstø et al., 2006; Simmons & Zeidler, 2003; Sadler & Chambers, 2004; Topcu, Sadler, & Yilmaz-Tuzun, 2010; Walker & Zeidler, 2007; Zeidler et al., 2002). According to Simmons and Zeidler (2003), in order for a teacher to implement SSI into science courses, s/he should know about the issue well, as well as possess the required skills to guide the classroom in the discussion process. Hence, according to these researchers, pre-service teacher education programs should provide future teachers with awareness, theoretical background, and the application of using SSI in science classes through method courses.

As the results of the present study revealed, PSTs' informal reasoning on SSI was in correlation with their epistemological beliefs and metacognitive awareness. For instance, results showed that as PSTs' hold more sophisticated beliefs on certain knowledge, which means believing in the tentative and evolving nature of science instead of believing that knowledge is certain and unchanging, their counterargument construction increases. Also, as PSTs become more metacognitively aware, their informal reasoning quality regarding SSI increases. Hence, epistemological beliefs and metacognition may be used as the two crucial reinforcing factors to improve the quality of PSTs' informal reasoning regarding SSI. Thus, pre-service teacher education programs should also aim to improve PSTs' epistemological beliefs and metacognitive awareness.

In summary, SSI should be implemented into the science curriculum in Turkey and before doing this; teachers should be educated as qualified for the using of SSI in science classrooms effectively.

5.4. Recommendations for Further Research

Based on the findings of the present study and the previous work, the following recommendations can be offered. Firstly, different contexts and samples can be used to replicate this study to reveal the correlations among PSTs' informal reasoning regarding SSI which is nuclear power usage in this study, epistemological beliefs and metacognitive awareness and different types of SSI such as genetic engineering, global warming and environmental issues rather than the nuclear power usage may be used. In addition, different frameworks can be used to assess PSTs' informal reasoning regarding SSI.

Secondly, one important area that is in need of more research is the practices of PSTs' informal reasoning. Research studies should be conducted on how PSTs' informal reasoning skills on SSI can be improved and how they will use these skills to improve students' reasoning skills in their future classes. To accomplish this, intervention studies can be designed. Research studies on the classroom applications of teachers, namely how teachers may use SSI in classroom such as directing the discussion or improving the reasoning skills of students are required.

Besides, studies aiming to design curriculum materials for the use of teachers and students in the classroom can be conducted. These materials may improve the better implementation of SSI into the science curriculum and science courses.

Finally, research is needed to understand the nature of students' informal reasoning on SSI. What factors influence students' informal reasoning on SSI, how their reasoning skills may be improved regarding the social-related scientific issues can be explored. In addition, the effectiveness of the implementation of SSI with respect to students' scientific literacy may also be investigated through intervention studies. Moreover, research studies exploring the correlation among students' epistemological beliefs, metacognitive awareness and their informal reasoning on SSI is needed so that the findings can be utilized while designing an SSI-based science curriculum for students.

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APPENDICES

APPENDIX A

PERMISSION OBTAINED FROM MIDDLE EAST TECHNICAL UNIVERSITY

Orta Doğu Teknik Üniversitesi
Middle East Technical University
Öğrenci İşleri Daire Başkanlığı
Registrar's Office
06531 Ankara, Türkiye
Phone: +90 (312) 2103417
Fax: +90 (312) 2107960
www.odtu.metu.edu.tr

/420-8273-1462

15/12/2010

İLKÖĞRETİM BÖLÜM BAŞKANLIĞINA

Üniversitemiz İlköğretim İlköğretim Fen ve Matematik Eğitimi Yüksek Lisans Programı öğrencisi Nilay Öztürk'ün 2010-2011 eğitim öğretim yılı I. ve II. dönemlerinde "*Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Konular Hakkındaki Kritik Düşünme Yeteneklerinin Epistemolojik İnançlarla ve Üstbilişsel Farkındalıkla Olan İlişkisinin İncelenmesi*" başlıklı çalışmasına ilişkin olarak ODTÜ Eğitim Fakültesi İlköğretim Fen Bilgisi Öğretmenliği Bölümünde öğrenim gören öğrencilere uygulama yapmak için, öğrencinin isteği doğrultusunda görevlendirilmesi Etik Komite onayı ile uygun görülmüştür.

Uygulamanın yapılabilmesi için gereğini arz ederim.

Saygılarımla.

Nesrin Ünsal
Öğrenci İşleri Daire Başkanı

Ekler:
1-Öğrencinin dilekçesi
2-Danışmanın dilekçesi
3-Anketler
4-Çalışma özeti

APPENDIX B

PERMISSION OBTAINED FROM HACETTEPE UNIVERSITY

HACETTEPE ÜNİVERSİTESİ
GENEL SEKRETERLİK

ÖĞRENCİ İŞLERİ DAİRESİ BŞK. YAZI İŞLERİ MÜDÜRLÜĞÜ

06.01.11

Sayı: B.30.2.HAC.0.70.01.00/ 240-54

Orta Doğu Teknik Üniversitesi Rektörlüğüne,

İlgi: 06.12.2010 tarih ve ODT.72.00/420-8171-016320 sayılı yazınız.

Üniversiteniz İlköğretim Fen ve Matematik Eğitimi Anabilim Dalı öğretim üyelerinden **Doç.Dr. Özgül YILMAZ TÜZÜN**'ün sorumluluğunda hazırlanan 2010 – 2011 eğitim – öğretim yılı I. ve II. dönemlerinde "**Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Konular Hakkındaki Kritik Düşünme Yeteneklerinin Epistemolojik İnançlarla ve Üstbilişsel Farkındalıklarla Olan İlişkisinin İncelenmesi**" konulu 410.01-3354 başvuru nolu çalışma, Üniversitemiz Senatosu Etik Komisyonunun **29 Aralık 2010** tarihinde yapmış olduğu toplantıda incelenmiş olup, etik açıdan uygun bulunmuştur.

Bilgilerinize saygılarımla arz ederim.

Prof. Dr. Sevil GÜRSAN
Rektör a.
Rektör Yardımcısı

APPENDIX C

PERMISSION OBTAINED FROM GAZİ UNIVERSITY

T.C.
GAZİ ÜNİVERSİTESİ
GAZİ EĞİTİM FAKÜLTESİ DEKANLIĞI

SAYI : B.30.2.GÜN.0.12.72.02/ 5963
KONU : İzin

GAZİ ÜNİVERSİTESİ REKTÖRLÜĞÜ
Öğrenci İşleri Dairesi Başkanlığına

İLGİ: 08.12.2010 tarih ve B.30.2.GÜN.0.72.01.42/5650-20138 sayılı yazınız .

Orta Doğu Teknik Üniversitesi Yüksek Lisans öğrencisi Araş.Gör.Nilay ÖZTÜRK'ün **"Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Konular Hakkındaki Kritik Düşünme Yeteneklerinin Epistemolojik İnançlar ve Üstbilişsel Farkındalıkla Olan İlgisinin İncelenmesi "** konulu tezi ile ilgili olarak Fakültemiz İlköğretim Bölümü Fen Bilgisi Eğitimi Anabilim Dalı öğrencilerine anket uygulama isteği Dekanlığımızca uygun görülmüştür.

Bilgilerinizi ve gereğini saygılarımla rica ederim.

Prof.Dr.Mustafa SAFRAN
DEKAN

APPENDIX D

TURKISH VERSION OF THE OPEN-ENDED QUESTIONNAIRE FOR ASSESSING INFORMAL REASONING ON NUCLEAR POWER USAGE

1-) Birisi size Türkiye'de yapılacak olan nükleer enerji santraliyle ilgili duruşunuzu sorsaydı, bu konuda sezgisel mi karar verirdiniz yoksa kararınızı vermeden önce düşünür müydünüz?

2-) Türkiye'de nükleer enerji santralinin yapılmasını destekleyen bir kişinin bu konudaki argümanları ve bakış açısı neler olabilir?

3-) Türkiye'de nükleer enerji santralinin yapılması fikrine katılmayan bir kişinin bu konudaki argümanları ve bakış açısı neler olabilir?

4-) Türkiye'de nükleer enerji santrali yapılması gerektiği fikrine katılıyor musunuz?

5-) Arkadaşlarınızı kendi fikrinizin doğru olduğuna ikna etmeye çalışsaydınız, onlara sunacağınız argümanlar neler olurdu?

6-) Bu konuyla ilgili bir tartışmada sizinle karşıt düşünceye sahip birinin argümanları neler olabilir?

7-) Altıncı soruyu cevaplarken sizinle karşıt görüştekilerin öne sürdükleri argümanların neler olabileceğini belirttiniz. Siz bu argümanlara karşı kendi duruşunuzu hangi fikirlerle savunursunuz?

APPENDIX E

TURKISH VERSION OF SCHOMMER'S EPISTEMOLOGICAL QUESTIONNAIRE

	Kesinlikle Katılmıyorum	**Katılmıyorum**	**Kararsızım**	**Katılıyorum**	**Kesinlikle Katılıyorum**
1. Eğer bir şeyi anlayabileceksen, onu ilk duyduğunda sana anlamlı gelecektir.	❑	❑	❑	❑	❑
2. Kesin olan tek şey, hiçbir şeyin kesin **olmadığıdır.**	❑	❑	❑	❑	❑
3. Okulda başarılı olmak için yapacağın en iyi şey çok soru **sormamaktır.**	❑	❑	❑	❑	❑
4. Nasıl çalışman gerektiğini anlatan bir ders faydalı olacaktır	❑	❑	❑	❑	❑
5. Bir kişinin okuldaki eğitimden kazanacakları öğretmenin kalitesine çok bağlıdır.	❑	❑	❑	❑	❑
6. Okuduğun herşeye inanabilirsin.	❑	❑	❑	❑	❑
7. Öğretmenlerimin gerçekten ne kadar bildiğini çok sık merak ederim.	❑	❑	❑	❑	❑
8. Öğrenme yeteneği doğuştan gelen bir kabiliyettir.	❑	❑	❑	❑	❑
9. Neye inandığı konusunda karar verememiş öğretmeni dinlemek rahatsız edicidir.	❑	❑	❑	❑	❑
10. Başarılı öğrenciler herşeyi çok çabuk anlarlar.	❑	❑	❑	❑	❑
11. İyi bir öğretmen işi öğrencilerini merak ettiği konulardan uzaklaştırmaktır.	❑	❑	❑	❑	❑
12. Eğer bilim adamları yeterince sıkı çalışırsa, hemen hemen herşeyin doğrusunu bulabilirler.	❑	❑	❑	❑	❑
13. Bilim otoritelerini sorgulayan insanlar, kendilerine olması gerektiğinden fazla güvenenlerdir.	❑	❑	❑	❑	❑
14. Farklı konu başlıklarından, hatta farklı derslerden öğrendiğim bilgileri birleştirmek için elimden geleni yaparım.	❑	❑	❑	❑	❑
15. En başarılı insanlar öğrenme yeteneklerinin nasıl geliştiğini keşfeden insanlardır.	❑	❑	❑	❑	❑
16. Profesörlerin size anlattıkları şeyler aslında gerçeklerinden daha basittir.	❑	❑	❑	❑	❑
17. Bilimsel çalışmaların en önemli özelliği çok hassas ölçümler ve dikkatli çalışmalardan oluşmasıdır.	❑	❑	❑	❑	❑
18. Benim için çalışmak; okuduğum şeyden, detaylı bilgiler yerine genel bir fikir elde etmektir.	❑	❑	❑	❑	❑
19. Öğretmenler yeri geldiğinde en iyi öğretim metodunun ne olduğuna karar verebilmelidirler.	❑	❑	❑	❑	❑

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
20. Zor bir kitabın bölümlerini tekrar tekrar okumak, o bölümleri anlamana **yardım etmez.**	❑	❑	❑	❑	❑
21. Bilim adamları en sonunda doğruları bulurlar.	❑	❑	❑	❑	❑
22. Yazarın amacını bilmeden, onun kitabının vermek istediği fikri asla **bilemezsin**.	❑	❑	❑	❑	❑
23. Bilimsel çalışmanın en önemli kısmı orijinal düşüncesidir.	❑	❑	❑	❑	❑
24. Bir kitabın bölümünü ikinci kez okumaya zaman ayırabilirsem, bu ikinci okumadan çok sey öğrenirim.	❑	❑	❑	❑	❑
25. Öğrencinin bir kitaptan sahip olacağı bilginin miktarı daha çok kendi kontrolündedir.	❑	❑	❑	❑	❑
26. Dahi olmanın %10'u yetenek, %90'ı çalışmaktır.	❑	❑	❑	❑	❑
27. Bilimsel otoritelerin anlaşamadıkları konular hakkında düşünmeyi ilginç bulurum.	❑	❑	❑	❑	❑
28. Herkesin nasıl öğrenebileceğini öğrenmeye ihtiyacı vardır.	❑	❑	❑	❑	❑
29. Kitapta zor bir kavram ile karşılaştığın zaman yapacağın en iyi şey kendi kendine anlamaya çalışmaktır.	❑	❑	❑	❑	❑
30. Bir cümlenin hangi durum için söylendiğini bilmiyorsan anlaşılması zordur.	❑	❑	❑	❑	❑
31. Genellikle iyi bir öğrenci olmak, bilgileri ezberlemeyi gerektirir.	❑	❑	❑	❑	❑
32. Akıllılık cevapları bilmek değil, cevapların nasıl bulunduğunu bilmektir.	❑	❑	❑	❑	❑
33. Kelimelerin çoğu tek bir anlama sahiptir.	❑	❑	❑	❑	❑
34. Gerçek hiçbir zaman **değişmez**.	❑	❑	❑	❑	❑
35. Bir insan okuduğu şeyin ayrıntılarını unutsa bile, eğer o konu hakkında yeni fikirler üretebiliyorsa o kişinin oldukça akıllı olduğunu düşünürüm	❑	❑	❑	❑	❑
36. Hayatımda zor bir problemle karşılaştığımda aileme danışırım.	❑	❑	❑	❑	❑
37. Tanımları kelime kelime öğrenmek, sınavda başarılı olmak için her zaman gereklidir	❑	❑	❑	❑	❑
38. Çalışırken, belirli (spesifik) gerçekleri ararım	❑	❑	❑	❑	❑
39. Eğer bir insan bir şeyi kısa bir zaman içerisinde anlayamazsa, onu anlamak için çalışmaya devam etmelidir.	❑	❑	❑	❑	❑

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
40. Bazen bir öğretmenin verdiği cevapları anlamasan da kabul etmelisin	❑	❑	❑	❑	❑
41. Eğer üniversitedeki profesörler bilimsel teorilerden çok bilimsel gerçeklere dayanarak eğitim verirlerse, öğrenciler üniversitelerden daha çok şey öğrenirler.	❑	❑	❑	❑	❑
42. Sonu belli olmayan filmleri **sevmem**.	❑	❑	❑	❑	❑
43. Bir konuda ilerlemek, gelişmek çok çaba gerektirir.	❑	❑	❑	❑	❑
44. Kesin cevabı belli olmayan problemler üzerinde çalışmak tam bir zaman kaybıdır.	❑	❑	❑	❑	❑
45. Eğer bir konuyu iyi biliyorsan, o konu hakkında yazılmış bir kitaptaki bilginin doğruluğunu değerlendirmelisin.	❑	❑	❑	❑	❑
46. Uzmanların tavsiyeleri bile, sık sık sorgulanmalıdır.	❑	❑	❑	❑	❑
47. Bazı insanlar doğuştan öğrenme kapasiteleri yeterli doğarlar, diğerleri ise sınırlı öğrenme kabiliyetine mahkumdur.	❑	❑	❑	❑	❑
48. Hiçbir şey kesin değildir, ölüm dışında.	❑	❑	❑	❑	❑
49. Gerçekten zeki öğrencilerin okulda başarılı olmaları için çok sıkı çalışmalarına **gerek yoktur**.	❑	❑	❑	❑	❑
50. Zor bir problem üzerinde uzun zaman çok sıkı çalışmak, sadece gerçekten zeki öğrenciler için iyi bir sonuç verir.	❑	❑	❑	❑	❑
51. Eğer bir insan bir problemi anlamak için çok çalışırsa, kafası karışmış bir şekilde bu işi bırakacaktır.	❑	❑	❑	❑	❑
52. Bir kitaptan öğrenebileceğiniz bilginin hemen hemen hepsini ilk okumada edinirsiniz.	❑	❑	❑	❑	❑
53. Genellikle çok zor kavramları; dışarıdan gelebilecek dikkat dağıtıcı şeyleri azalttığında ve iyice konsantre olduğunda öğrenebilirsin.	❑	❑	❑	❑	❑
54. Bir kitabı anlayabilmenin en iyi yolu kitabın içindeki bilgileri kendi anlayacağın şekilde tekrar organize etmendir.	❑	❑	❑	❑	❑
55. Okulda ortalama bir başarıya sahip olan öğrenci hayatının diğer kısımlarında da ortalama bir başarıya sahiptir.	❑	❑	❑	❑	❑
56. Bilgileri düzenli olan bir insan, kafası boş bir insandır.	❑	❑	❑	❑	❑

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
57. Bir alanda uzman olan kişi, o alanda doğuştan kazanılmış özel bir yeteneğe sahiptir.	❑	❑	❑	❑	❑
58. Ders planlarına sıkı sıkıya bağlı olan ve özenle ders notlarını organize eden öğretmenleri gerçekten takdir ediyorum.	❑	❑	❑	❑	❑
59. Fen dersindeki en iyi şey, bu dersteki çoğu problemlerin sadece tek bir doğru cevabının olmasıdır.	❑	❑	❑	❑	❑
60. Öğrenmek, bilginin yavaşça üst üste inşa edildiği bir işlemdir.	❑	❑	❑	❑	❑
61. Bugünkü bilimsel gerçekler, gelecekte hayal ürünü veya hikaye olabilir.	❑	❑	❑	❑	❑
62. Kendi kendinize öğrenmenizi sağlayan kitaplar çok fazla **yardımcı olmaz**.	❑	❑	❑	❑	❑
63. Bir konu hakkında bir kitaptan öğrendiğiniz bilgileri, o konu hakkında sahip olduğunuz bilgilerle birleştireceğiniz zaman kafanız karışacaktır.	❑	❑	❑	❑	❑

APPENDIX F

TURKISH VERSION OF METACOGNITIVE AWARENESS INVENTORY

	Her Zaman	Çoğunlukla	Bazen	Nadiren	Hiçbir Zaman
1. Hedeflerime ulaşıp ulaşmadığımı düzenli olarak sorgularım.					
2. Bir problemi çözmeden önce farklı alternatifleri göz önüne alırım.					
3. Çalışırken daha önce işe yarayan yöntemleri kullanmaya çalışırım.					
4. Yeni konular öğrenirken daha fazla zamana sahip olmak için öğrenme hızımı ayarlayabilirim.					
5. Zihinsel olarak güçlü ve zayıf yönlerimi bilirim.					
6. Yeni bir ödeve başlamadan önce gerçekten neyi öğrenmem konusunda düşünürüm.					
7. Bir sınavı bitirdiğimde, o sınavda ne kadar iyi yaptığımı bilirim.					
8. Bir ödeve başlamadan önce kendime açık, net ve özel hedefler belirlerim.					
9. Önemli bir bilgiyle karşılaştığımda çalışma hızımı yavaşlatırım.					
10. Ne tür bilgiyi edinmenin önemli olduğunu bilirim.					
11. Bir problemi çözerken her türlü çözüm yolunu gözönüne alıp almadığımı kendime sorarım.					

	Her Zaman	Çoğunlukla	Bazen	Nadiren	Hiçbir Zaman
12. Bilgiyi iyi bir şekilde organize edebilirim.					
13. Bilinçli olarak dikkatimi önemli bir bilgiye odaklayabilirim.					
14. Öğrenirken kullandığım her bir strateji için özel bir amacım vardır.					
15. Bir konu hakkında önceden bilgim varsa en iyi o zaman öğrenirim.					
16. Öğretmenimin benden neyi öğrenmemi istediğimi bilirim.					
17. Öğrendiğim bilgiyi iyi bir şekilde hatırlayabilirim.					
18. Duruma bağlı olarak farklı öğrenme stratejileri kullanabilirim.					
19. Bir ödevi bitirdikten sonra o ödevi yapmanın daha kolay bir yolu olup olmadığını düşünürüm.					
20. Ne kadar iyi öğrendiğim benim kontrolümdedir.					
21. Konular kavramlar arasındaki ilişkileri anlamama yardımcı olması için düzenli olarak derslerde öğrendiklerimi tekrar ederim.					
22. Bir konuya başlamadan önce, o konu hakkında kendime sorular sorarım.					
23. Bir problemin farklı çözüm yollarını düşünür ve en iyisini seçerim.					

	Her Zaman	Çoğunlukla	Bazen	Nadiren	Hiçbir Zaman
24. Yeni bilgiler edindiğimde, öğrendiklerimin bir özetini yaparım.					
25. Herhngi bir konuyu anlamadığımda başkalarından yardım isterim.					
26. İhtiyaç duyduğumda, öğrenmek için kedimi motive edebilirim.					
27. Çalışırken hangi öğrenme stratejilerini kullandığımı bilirim.					
28. Çalışırken kullandığım stratejilerin ne kadar işe yaradığını değerlendiririm.					
29. Zihinsel yönden güçlü yanlarımı, zayıf yanlarıı telafi etmek için kullanırım.					
30. Yeni bilginin anlamı ve önemine odaklanırım.					
31. Bilgiyi daha anlamlı bir hale getirebilmek için kendi örneklerimi oluştururum.					
32. Birşeyi ne kadar iyi anladığımı doğru bir şekilde yargılayabilirim.					
33. İşe yarar öğrenme stratejilerini otomatik olarak kullanırım.					
34. Öğrenme sürecinder düzenli olarak belli noktalarda durur ve ne kadar iyi anladığımı kontrol etmek için kendimi sorgularım.					
35. Kullanıdğım her bir öğrenme stratejisinin ne zaman en fazla yararlı olacağını bilirim.					
36. Çalışmanın sonuna geldiğimde, hedeflerime ne ölçüde ulaştığımı sorgularım.					

	Her Zaman	Çoğunlukla	Bazen	Nadiren	Hiçbir Zaman
37. Öğrenirken, konuları daha iyi anlayabilmek için resimler ya da şekiller çizerim.					
38. Bir problemi çözdükten sonra, her türlü seçeneği göz önüne alıp almadığımı kendime sorarım.					
39. Yeni bilgiyi kendi cümlelerimle ifade etmeye çalışırım.					
40. Bir konuyu anlayamazsam, kullandığım öğrenme staratejisini değiştiririm.					
41. Öğrenmeme yardımcı olması için bir konunun nasıl organize edildiğine dikkat ederim.					
42. Bir ödeve başlamadan önce ilgili yönergeleri (ne yapmam gerektiğini) dikkatle okurum.					
43. Okuduklarımın daha önceden bildiklerimle ilgili olup olmadığını kendime sorarım.					
44. Kafam karıştığında konu doğrultusundaki varsayımları tekrar gözden geçirim.					
45. Zamanımı hedeflerime en iyi şekilde ulaşabilmek için programlarım.					
46. Bir konuya ilgim olduğunda daha iyi öğrenirim.					
47. Bir konuyu aşama aşama çalışırım.					

	Her Zaman	Çoğunlukla	Bazen	Nadiren	Hiçbir Zaman
48. Konunun ayrıntılarından çok genel anlamına odaklanırım.					
49. Yeni bir konuyu çalışırken ne kadar iyi öğrendiğime dair kendime sorular sorarım.					
50. Bir konuyu çalıştıktan sonra sonra gerektiği kadar öğrenip öğrenmediğimi kendime sorarım.					
51. Yeni bilgi anlaşılır değl ise durur ve üzerinden bir kez daha giderim.					
52. Bir şeyler okurken kafam karıştığında durur ve yeniden okurum.					