INVESTIGATING PRE-SERVICE SCIENCE TEACHERS' QUALITY OF WRITTEN ARGUMENTATIONS ABOUT SOCIO-SCIENTIFIC ISSUES IN RELATION TO EPISTEMIC BELIEFS AND ARGUMENTATIVENESS

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ABSTRACT

INVESTIGATING PRE-SERVICE SCIENCE TEACHERS' QUALITY OF WRITTEN ARGUMENTATIONS ABOUT SOCIO-SCIENTIFIC ISSUES IN RELATION TO EPISTEMIC BELIEFS AND ARGUMENTATIVENESS

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The purpose of this study was to investigate pre-service science teachers' (PST) quality of written argumentations about socio-scientific issues in an online discussion environment in relation to their epistemic beliefs and argumentativeness.

A total of 30 pre-service elementary science teachers who will teach elementary school science from 6th through 8th grade students after graduation voluntarily participated in this study. The sample was chosen by purposive and convenience sampling from the PSTs registered for the course named "Science, Technology, and Society" in the fall semester of 2009-2010 academic year at a public university in Ankara. In this study, the PSTs participated in an online discussion environment in which climate change, nuclear power, genetically modified foods, and human genome project issues were discussed for a total of four week period. The major data of this study were collected through the Epistemic Beliefs Questionnaire developed by Kuhn, Cheney and Weinstock

(2000) and the Argumentativeness Scale by Infante and Rancer (1982). For the analysis of the quality of argumentations, an adapted version of Sadler and Fowler's (2006) argumentation analysis framework was employed.

The results of the study illustrated that the PSTs frequently generated high quality argumentations for each socio-scientific issue which was interpreted as a positive indication that the online discussion environment was effective in promoting students' argumentation. In addition, the results also showed that argumentation quality levels varied across socio-scientific issues. Another result of this study was that the PSTs' argumentation qualities were higher for multiplist and evaluativist levels. Finally, the correlation results between argumentativeness and argumentation quality levels did not reveal a significant correlation between these variables. However, there was a significant correlation between epistemic belief levels and argumentativeness.

Keywords: Argumentation, Socio-scientific Issues, Online Discussion Environments, Epistemic Beliefs, Argumentativeness

ÖZ

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ SOSYO-BİLİMSEL KONULAR HAKKINDAKİ BİLİMSEL TARTIŞMA NİTELİKLERİNİN EPİSTEMİK İNANÇLAR VE TARTIŞMAYA EĞİLİMLERİ AÇISINDAN İNCELENMESİ

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Bu çalışmanın amacı fen bilgisi öğretmen adaylarının sosyo-bilimsel konular hakkındaki yazılı bilimsel tartışmalarının çevrimiçi tartışma ortamında epistemik inançlar ve tartışmaya eğilimleri açısından incelenmesidir.

Bu çalışmaya mezuniyetlerinden sonra ilköğretim 6 – 8. sınıflarda fen bilgisi öğretmenliği yapabilecek toplamda 30 fen bilgisi öğretmen adayı gönüllü olarak katılmıştır. Bu çalışmanın örneklemi amaçlı örnekleme ve elverişli örnekleme yöntemleri kullanılarak Ankara'daki bir devlet üniversitesinin "Fen, Teknoloji, ve Toplum" adlı dersine kayıtlı öğrencilerden seçilmiştir. Bu çalışmada, iklim değişikliği, nükleer enerji, genetiği değiştirilmiş gıdalar ve insan genom projesi konuları fen bilgisi öğretmen adayları ile çevrimiçi tartışma ortamında toplamda dört hafta tartışılmıştır. Bu çalışmanın temel verileri Kuhn, Cheney, ve Weinstock (2000) tarafından geliştirilen Epistemik İnançlar Ölçeği ve Infante ve Rancer (1982) tarafından geliştirilen Tartışmaya

Eğilimler Ölçeği ile toplanmıştır. Bilimsel tartışmaların analizi için Sadler ve Fowler (2006) tarafından geliştirilen bilimsel tartışma analiz yöntemi kullanılmıştır.

Çalışmanın sonuçları fen bilgisi öğretmen adaylarının her bir sosyo-bilimsel konu için yüksek seviyede bilimsel tartışma ürettiklerini göstermiştir. Bu sonuçlar çevrimiçi tartışma ortamlarının öğrencilerin bilimsel tartışmalarını desteklemede etkili olduğu yönünde olumlu bir göstergedir. Bununla birlikte, sonuçlar bilimsel tartışma seviyelerinin sosyo-bilimsel konulara göre değiştiğini göstermiştir. Bu çalışmanın bir başka sonucu fen bilgisi öğretmen adaylarının tartışma düzeylerinin mutlakçılar hariç çoğulcular ve değerlendiriciler için daha yüksek olduğunu göstermiştir. Sonuç olarak, tartışmaya eğilimleri ve tartışma düzeyleri arasında anlamlı bir ilişki bulunamamıştır. Ancak bu çalışmanın sonucunda öğrencilerin epistemik inanç düzeyleri ile tartışmaya eğilimleri arasında anlamlı bir ilişki orataya çıkmıştır.

Anahtar Kelimeler: Bilimsel tartışma, Sosyo-bilimsel konular, Çevrimiçi Tartışma Ortamları, Epistemik İnançlar, Tartışmaya Eğilim

I dedicate this study to my dearest parents

Hamdi İŞBİLİR and Müzeyyen İŞBİLİR

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TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

PST: Pre-service Science Teacher

TAP: Toulmin's Argument Pattern

SSI: Socio-scientific Issue

CC: Climate Change

NP: Nuclear Power

GMFs: Genetically Modified Foods

HGP: Human Genome Project

NJ: No Justification

JwNG: Justification with no grounds

JwSG: Justification with simple ground

JwEG: Justification with elaborated grounds

JwEG/CP: Justification with elaborated grounds and counter-position

CHAPTER 1

INTRODUCTION

Throughout the history of human interaction, argumentation has been an essential component of discourse practices employed by individuals as well as by groups of individuals in societies. As a matter of fact, argumentation is a ubiquitous discourse type encountered in many situations such as courtrooms, classroom discussions, debates, political conflicts, committee meetings and family disagreements (Voss & Van Dyke, 2001). As a theory, argumentation followed a developmental path starting from the time of Aristotle to the 21st century in which time both its definition and the scope has changed prominently. Argumentation was defined as three types such as analytic, rhetoric, and dialectic arguments by Aristotle. The examples given for these types of arguments were mathematical proofs for analytic arguments, persuasion of listeners to a particular view for rhetoric arguments and exchange of ideas through dialogue for dialectic arguments. Aristotle's argumentation established the fundamentals of argumentation theory and influenced the development of argument and scientific reasoning both in his time and in the following centuries (Puvirajah, 2007). However, in Aristotle's argumentation theory, the influence of contextual and situational factors as well as individuals' experiences in their daily argumentations was not considered. Therefore, in the literature on the development of argumentation theory, the next was Toulmin's (1958) argumentation pattern which was developed to investigate daily argumentations of individuals and to consider contextual and situational factors in argumentation rather than formal argumentation structure (Sampson & Clark, 2008). However, Toulmin's argumentation pattern had also some methodological difficulties (Driver, Newton, & Osborne, 2000) and as a result, alternative argumentation frameworks were developed such as Johnson and Blair's (1994) non-formal argumentation and Walton's (1996) presumptive reasoning. In these frameworks, the relationship between the premises of arguments and conclusions was shown to be important in evaluating the quality of arguments (Greenwell, Knight, Holloway, & Pease, 2005) as well as dialogic events which were neither deductive nor inductive were considered in argumentation analysis (Puvirajah, 2007). In summary, these argumentation frameworks established the foundations of argumentation theory, provided investigation of individuals' daily argumentations and guided the future research in argumentation.

In relation to the important place argumentation holds in discourse practices by individuals and in societies, it has also a central position in doing science and in science education (Driver et al., 2000). Argumentation in science education is defined as a discursive process in which scientific claims are justified or evaluated based on empirical or theoretical evidence (Jiménez-Aleixandre & Erduran, 2007). A great body of research in the field of argumentation in science education investigated the nature and the quality of students' argumentations by focusing on structure, content, and justification of arguments (Sampson & Clark, 2008). Especially in recent years, argumentation has received an increasing attention in science education research (e.g., Driver et al., 2000; Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; Osborne, Erduran, & Simon, 2004). In the related literature, a variety of frameworks which can be classified mainly in two categories as domain-general and domain-specific frameworks were developed to analyze and evaluate the quality of student generated arguments. Domain-general frameworks are defined as frameworks such that argument quality could be analyzed inside or outside specific scientific fields (e.g., Schwarz, Neuman, Gil, & Ilya, 2003; Toulmin, 1958) while domain-specific frameworks were used to analyze arguments specific to scientific area and contexts (e.g., Kelly & Takao, 2002; Lawson, 2003; Sandoval, 2003; Sandoval & Millwood, 2005; Zohar & Nemet, 2002). In early as well as in contemporary research, Toulmin's argumentation framework was implemented to analyze the quality of student generated arguments in science education based on the argument structure (e.g., Bell & Linn, 2000; Jiménez-Aleixandre et al., 2000). In other domain general and domain specific frameworks, student argumentations were analyzed: (1) in terms of argument structure and some other features such as soundness of arguments, quality of reasons, argument type and number of reasons supporting counter-arguments (e.g., Schwarz et al., 2003), (2) in terms of justification and content of arguments in dilemmas in genetics topic (e.g., Zohar & Nemet, 2002), (3) supporting a theoretical framework by using multiple data in an oceanography course (e.g., Kelly & Takao, 2002), (4) in terms of comparisons of tentative explanations for the observed phenomenon and alternative hypotheses in a hypothetico-predictive argument structure (e.g., Lawson, 2003) and (5) conceptual and epistemological qualities of students' arguments in terms of use of evidence rather than structural features of arguments (e.g., Sandoval, 2003; Sandoval & Millwood, 2005). In addition to the domain-general and domain-specific frameworks, students' dialogic argumentations were also analyzed and defined as levels of quality based on Toulmin's argumentation pattern in classroom environments (e.g., Erduran et al., 2004). In brief, in the literature, it was shown that there was a diversity of argumentation analysis frameworks and focus of argumentation quality for analyzing students' argumentation in a variety of contexts. Informed from the related literature, in the present study, the pre-service science teachers' (PST) argumentation qualities were analyzed as regards to students' generation of justifications, providing supporting data in terms of grounds as well as integration of counter-positions into their argumentations.

In relation to the literature on argumentation in science education, another factor to be considered was the integration of socio-scientific issues in science teaching and learning. With the development of science and technology, socio-scientific issues which are defined as controversial issues with societal and technological ties (Sadler, 2004) were also advocated to be included in science education and argumentation practices in science learning environments since in the literature it was promoted that the incorporation of such issues in science education provided opportunities for argumentation (Driver et al., 2000). In the related literature, there was a variety of studies which investigated students' generation of arguments in socio-scientific issues (e.g., Jiménez-Aleixandre et al., 2000; Kortland, 1996; Patronis, Potari, & Spiliotopoulou, 1999; Zohar & Nemet, 2002). The results of these studies illustrated that (1) students' understanding of socio-scientific issues increased and alternative claims were evaluated (Kortland, 1996), that (2) students created well-formulated arguments (Patronis et al., 1999), that (3) students' arguments showed a variance from naïve to sophisticated arguments (Jiménez-Aleixandre et al., 2000), that (4) students were able to create high-quality arguments about controversial issues (Zohar & Nemet, 2002) and that (5) students' levels of argumentations were higher when they were more knowledgeable about socio-scientific issues (Sadler & Fowler, 2006). Thus, these results indicated that the students' argumentations about socio-scientific issues were higher in general and in some cases showed variance depending on the issue and on the students' levels of knowledge about these issues. Therefore, in the light of related literature about socio-scientific issues and their integration in science education, in the present study four different socio-scientific issues which were related to students' daily lives and the courses they took were included in order to facilitate students' engagement and promote generation of argumentation about socio-scientific issues.

In the related literature on students' discussion environments, there is a great body of research about students' scientific and socio-scientific argumentations in offline discussion environments such as science classrooms (e.g., Duschl & Osborne, 2002; Jiménez-Aleixandre et al., 2000). In addition, many researchers also analyzed the quality of student-generated arguments in online and computer-supported environments (e.g., Bell & Linn, 2000; Clark & Sampson, 2007; Simon, 2008). These online environments provided students' engagement in and production of quality argumentations (Clark, Sampson, Weinberger, & Erkens, 2007). In addition, several features of online discussion environments such as collaborative communication, sharing of and access to information, and scripts and awareness heightening tools also helped students improve construction of high-quality arguments (Clark et al., 2007). Moreover, the researchers illustrated that online discussion environments improved the researchers' analysis of students' arguments (e.g., Bell & Linn, 2000; Clark & Sampson, 2007; Okada & Shum, 2008; Simon, 2008). In addition, in the literature, the research on students' argumentations in online discussion environments was mainly focused on students' scientific argumentations rather than socio-scientific argumentation (e.g., Bell & Linn, 2000; Clark & Sampson, 2007; Okada & Shum, 2008). Therefore, in reference to the existing literature, the PSTs' argumentations about socio-scientific issues in an online discussion environment were analyzed in the present study.

In relation to the above mentioned studies concerning the place of argumentation in human interaction and in science education, integration of argumentation about socio-scientific issues in science education and utilization of online discussion environments, another factor identified by the literature to be considered in analyzing argumentation quality is the students' epistemic belief levels. In the related literature, epistemic beliefs were investigated by many researchers and with a variety of models regarding developmental sequence of students' epistemologies (e.g., Baxter Magolda, 2004; Belenky, Clinchy, Goldberger, & Tarule, 1986; Perry, 1970 as cited in Hofer & Pintrich, 1997). In addition to the models which investigated students' developmental sequence of epistemologies, the influence of students' epistemic beliefs on their justifications and reasoning were also investigated by the researchers (e.g., King & Kitchener, 2004; Kuhn, 1993). The results of these studies have shown that students' epistemic beliefs and assumptions about knowledge influenced their thinking and reasoning processes and justifications about ill-structured problems (King & Kitchener, 1994) and argumentation skills (Kuhn, 1993). Therefore, in the present study, based on the related literature on students' epistemologies and its effects on their reasoning and justifications, the PSTs' epistemic belief levels were also measured and the relationships between their epistemic belief levels and argumentation qualities were investigated.

In the related literature, besides investigating students' epistemic belief levels in relation to their argumentations about socio-scientific issues, another construct which is shown to be effective in students' generation of arguments was students' tendency to argue. Infante and Rancer (1982) showed that some individuals had a motivation towards arguing and identified argumentativeness as a trait which was defined as students' general tendency to argue about controversial issues. In the literature, several studies investigated the individuals' tendency to argue about controversial issues and generation of arguments about these issues. The results of these studies were varied such that when a high and a low argumentative were matched more arguments were produced (Levine & Boster, 1996) while in another study both pairs were high argumentatives, there were more arguments generated by the students (Semic & Canary, 1997). In another study, there were more arguments generated by the students when high and moderately argumentative members were paired in group discussions (Kazoleas & Kay, 1994). At this point, it is necessary to investigate the pre-service science teachers' tendencies to argue about controversial issues in relation to their qualities of argumentation in online discussion environments about socio-scientific issues. Therefore, in the present study, based on the literature regarding students' tendency to argue about controversial issues, the PSTs' argumentativeness were measured and its relationship with their argumentation qualities were investigated.

1.1. Definitions of Important Terms

In this section, the definitions of important terms used in this study were presented.

1.1.1. Argumentation

Argumentation in this study was defined as justification of claims, presentation of grounds as well as counter-positions in the contexts of socio-scientific issues

(Sadler & Fowler, 2006). In this study, Sadler and Fowler's (2006) argumentation framework was adapted for analyzing the quality of the PSTs' written argumentations.

1.1.2. Socio-scientific Issues

Socio-scientific issues were defined as social issues with conceptual and technological relations to science and are controversial in nature (Sadler, 2004) such that, in this study, opposing points of views were presented to and were discussed by the students.

1.1.3. Epistemic Beliefs

Epistemic beliefs of students were defined in this study as beliefs and assumptions regarding the nature of knowledge and knowing in terms of five domains that are personal taste, aesthetics, values, truth about the social world and truth about the physical world (Mason & Scirica, 2006). In this study, the PSTs' epistemic belief levels were measured by the Epistemic Beliefs Questionnaire developed by Kuhn, Cheney, and Weinstock (2000) according to which the PSTs were categorized into three epistemic belief levels such as absolutists, multiplists, and evaluativists.

1.1.4. Argumentativeness

Argumentativeness (i.e. students' general trait or tendency to argue) was defined as a communication trait in social interactions such that some individuals have a motivation to argue about controversial issues more than others since they find arguing challenging, pleasurable, and as a form of recreation (Infante & Rancer, 1982). In this study, the PSTs' predispositions to argue about controversial issues were measured by a 20-item Likert-type Argumentativeness Scale developed by Infante and Rancer (1982) as a function of two subscales such as dispositions to approach arguments and dispositions to avoid arguments.

1.2. Significance of the Study

The reasons to conduct the present study were explained in terms of place of argumentation in science education, importance of integration of socio-scientific issues in science discussions, utilization of online discussion environments, students' epistemic beliefs regarding knowledge and justification of argumentations, and argumentativeness (i.e. tendencies to argue) about controversial issues.

Argumentation, as a theory, comprises an important place in daily lives of individuals in the society (Voss & Van Dyke, 2001) as well as it has a central position in science education (Driver et al., 2000). Therefore, students' argumentations in science education have been the focus of many studies (Sampson & Clark, 2008). In order to categorize, analyze and investigate the quality of students' argumentations various argumentation analysis frameworks were utilized by many researchers for a variety of contexts (e.g., Kelly & Takao, 2002; Lawson, 2003; Sandoval, 2003; Sandoval & Millwood, 2005; Schwarz et al., 2003; Toulmin, 1958; Zohar & Nemet, 2002). However, many of these frameworks were only applicable to the specific contexts in which the study was conducted (i.e. domain-specific frameworks) (e.g., Kelly & Takao, 2002; Lawson, 2003; Sandoval, 2003; Sandoval & Millwood, 2005; Zohar & Nemet, 2002) and domain-general frameworks such as Toulmin's argumentation pattern and Schwarz et al.'s approach to argumentations were mainly based on the argument structure in order to analyze argumentation quality and some methodological difficulties were identified (Driver et al., 2000). Therefore, there was a need to use an argumentation analysis framework which considered students' argumentations in socio-scientific issues in terms of justifications provided and counter-positions given. Consequently, in this study, an adapted version of Sadler and Fowler's (2006) argumentation analysis framework developed to analyze socio-scientific issues in terms of justifications, grounds and counter-positions given was implemented. The results will provide researchers with important information about the PSTs' argumentation practices in terms of justifications of their claims, presentation of grounds to their claims as well as inclusion of counter-claims about socio-scientific issues in online discussion environment.

Integration of socio-scientific issues in science education was also advocated by many researchers since such issues provided opportunities for argumentation (Driver et al., 2000). As a result, in the literature, there was a great body of research about students' argumentations in socio-scientific issues and the results of these studies indicated that students generated high quality argumentations (e.g., Jiménez-Aleixandre et al., 2000; Kortland, 1996; Patronis et al., 1999; Sadler & Fowler, 2006; Zohar & Nemet, 2002). However, the results of these studies were varied and context specific. Therefore, in this study, students' argumentations about four different socio-scientific issues such as climate change, nuclear power, genetically modified foods, and human genome project were investigated. The results of the present study will give an idea about the nature of the PSTs' argumentation qualities in terms of different socio-scientific issues. Moreover, the results will be of importance not only for science education researchers but also for science teachers in terms of integration of socio-scientific issues in the science classroom and how students argue about such issues and their argumentation qualities.

In the present study, students' argumentations were also investigated in an online discussion environment. The related research about students' argumentations in online environments illustrated that these environments improved students' generation of high quality argumentations (Clark et al., 2007). However, in the literature, most of the research was focused on students' scientific argumentations rather than socio-scientific argumentations (e.g., Bell & Linn, 2000; Clark & Sampson, 2007; Okada & Shum, 2008). Therefore, in the present study, in order to promote students' argumentations in an online discussion environment and to fill the gap in investigating argumentation about socio-scientific issues in online discussion environments, an online environment to which students would be able contribute with their written argumentations about the topic under discussion was utilized. In addition, the results of the present study will inform science education researchers and science teachers about the use of online environments in students' discussions regarding controversial issues as well as students' argumentation patterns and argumentation qualities.

In the literature, students' epistemic beliefs and assumptions about knowledge were shown to be effective in students' reasoning and justifications of their argumentations about controversial issues (King & Kitchener, 1994). In reference to these studies in the related literature, in the present study, the PSTs' epistemic belief levels were measured with Epistemic Beliefs Questionnaire developed by Kuhn et al. (2000). The results of the present study will provide science education researchers to compare and evaluate the proposed relationship between the students' epistemic beliefs and their justifications and reasoning about controversial issues. Moreover, the pattern of students' epistemic belief levels and their argumentation qualities across different socio-scientific issues will also provide important information regarding argumentation quality and epistemic beliefs in different contexts.

Another construct which was investigated in the present study was students' argumentativeness (i.e. tendency to argue) about controversial issues. In the literature, argumentativeness was identified as a communication trait such that some individuals have a motivation towards arguing (Infante & Rancer, 1982). In addition, several studies about pairing of students with different argumentativeness levels indicated that there were varied results in terms of generation of arguments (e.g., Kazoleas & Kay, 1994; Levine & Boster, 1996; Semic & Canary, 1997). Therefore, in the present study, the PSTs' argumentativeness was measured by Infante and Rancer's Argumentativeness Scale and the results of the present study will provide researchers with the relationship between students' argumentativeness and their argumentation qualities in different socio-scientific issues. The results will also be important for science teachers and curriculum developers since the integration of argumentation about socio-scientific issues in science education will be informed from students' argumentativeness.

Pre-service science teachers were chosen to be participants in this study. The reasons for them to be chosen as participants were first of all, in relation to the policy of elementary science education and the curriculum in Turkey, students are to be educated such that they would be able to access information, solve problems, take the risks, consider benefits, and options while making decisions regarding science and technology issues as well as in production of new information (MoNE, 2006, p.5). Therefore, as stated in the national curriculum, pre-service science teachers' argumentations about socio-scientific issues in online environments were investigated in this study since they will be the educators for future generations such that they will implement their knowledge into their own classrooms. Therefore, investigating about pre-service science teachers' argumentation processes will inform researchers about the current condition of the policy objectives of science education. Another reason to study with pre-service science teachers was that, in the literature, it was indicated that integration of argumentation in science classrooms were difficult mainly due to current science educators in classrooms who need to be trained in such issues (Driver et al., 2000). As a result, it is of importance to educate pre-service science teachers in implementing argumentation related to socio-scientific issues and online discussion environments into their own classrooms in order to fulfill the objectives of the elementary science education policy presented in national curriculum.

1.3. Purpose of the Study

Regarding the existing literature on students' argumentation, online discussion environments, and the relationships with students' epistemic belief levels and argumentativeness, the present study aimed to investigate the PSTs' quality of written argumentations about socio-scientific issues in an online discussion environment in relation to their epistemic belief levels and argumentativeness.

1.4. Research Questions

In the present study, the PSTs' written argumentations about socio-scientific issues in an online discussion environment in relation to epistemic belief levels and argumentativeness through addressing the following research questions:

RQ1. What are the quality levels of the PSTs' argumentation regarding each socio-scientific issue?

RQ2. What is the variation of the PSTs' levels of argumentation across socio-scientific issues?

RQ3. What are the relationships among the PSTs' levels of argumentations regarding their epistemic belief levels?

RQ4. What are the PSTs' levels of argumentation regarding their argumentativeness?

1.5. Research Hypotheses

RH1. The quality levels of the PSTs' argumentation are higher for each socio-scientific issue.

RH2. The quality levels of the PSTs' argumentation do not show variance across socio-scientific issues.

RH3. The quality levels of the PSTs' argumentation increase with their epistemic belief levels from absolutist to multiplist to evaluativist.

RH4. The quality levels of the PSTs' argumentation increase with their argumentativeness.

RH5. The quality levels of the PSTs' argumentation increase with their epistemic belief levels from absolutist to multiplist to evaluativist.

CHAPTER 2

REVIEW OF LITERATURE

This chapter includes a review of the related literature on the development of argumentation theory, and argumentation research in science education.

2.1. Development of Argumentation Theory

Argumentation is an essential part of doing science as well as it is a discourse process and an epistemological framework in science education (Driver, Newton, & Osborne, 2000; Lemke, 1990; Siegel, 1995 as cited in Puvirajah, 2007). Specifically, argumentation, as defined by Kuhn (1993), is one of the discursive practices in science in which claims are formed, evidence is provided, warrants are established and alternative explanations are evaluated (Kuhn, 1993). In addition, argumentation is also considered a key component of science education by the national science standards in the USA (American Association for the Advancement of Science, 1993; National Research Council, 1996). Jiménez-Aleixandre and Erduran (2007) define argumentation as a discursive process in which scientific claims are justified or evaluated based on empirical or theoretical evidence.

In the following section, the development of argumentation theory in science education will be examined under three main titles which are Aristotle's argumentation theory, Toulmin's argumentation pattern, and informal logic with two approaches to argumentation as Johnson and Blair's (1994) analysis of non-formal arguments and Walton's (1996) presumptive reasoning.

2.1.1. Aristotle's Argumentation Theory

Aristotle, in his treatises, described three forms of arguments, namely analytic, dialectic, and rhetoric arguments which established the fundamentals of argumentation theory (Puvirajah, 2007).

In analytic arguments, it is assumed that there is an absolute truth or reality and therefore these types of arguments are considered as absolutely objective and free of subjective interpretations. Consequently, in applying analytical arguments, it is assumed that given identical problems, the same conclusions will be reached by any well-trained individual. Mathematical proofs are examples of analytical arguments (Puvirajah, 2007).

The dialectical argument is related to the exchange of ideas through dialogue. Although the origins of dialectical arguments are attributed to philosophers Socrates and Plato, Hegel made a significant contribution to dialectical argument with his triadic approach which comprises of *thesis*, *antithesis*, and *synthesis*. According to Hegel's triadic, every *thesis* would create an *antithesis* and a negotiation of opposing ideas would result in the *synthesis* of a new thesis. In dialectical arguments positions of opposing parties (thesis & antithesis) are proposed and through discussion a common ground (synthesis) is reached among participants of the discussion (Puvirajah, 2007).

The rhetorical argument is related to the persuasion of listeners to the legitimacy of a particular view or claim. In rhetorical argumentation, the skills of the speaker in addition to the use of evidence, witnesses, and documentation play a significant role in persuading the audience. This type of argument is common in judicial and parliamentary proceedings (Puvirajah, 2007).

Aristotle's treatises on the forms of the argument provided principal basis for the argumentation theory and were referred to both in his time and in following centuries. However, many problems still remain controversial and unresolved mainly because it is not always possible to come up with an absolute truth, or to reach at a mutually agreed solution, or persuade listeners to the legitimacy of particular views or claims since individuals rely on their experiences, values as well as contextual and situational factors while constructing arguments in daily life.

2.1.2. Toulmin's Argumentation Pattern

Toulmin (1958), in his book *The Uses of Argument*, presents a distinction between formal arguments as in mathematics and use of arguments in linguistic contexts (Sampson & Clark, 2008). In his book, Toulmin explains how argumentation occurs in daily lives of individuals in a natural process and defines arguments which are grounded in the context of particular situations rather than in so-called absolute truths or universal principles as substantial or practical arguments. According to Toulmin, the type of justification used in substantial or practical arguments, depends on the context in which the argument is constructed. Puvirajah (2007) gives the example that "a claim in the context of theology may not be valid in other contexts such as natural sciences" (p. 50). Therefore, according to Toulmin, it is possible for practical arguments to be applied to various fields.

Driver, Newton, and Osborne (2000) stated that Toulmin in his book, *The Uses of Argument*, also analyzed arguments and presented a model which describes the components and the relationships between these components of an argument (Figure 2.1). According to Toulmin's argumentation pattern, the main components identified by the model are:

1. Data: Facts or evidences, which support the claim.
2. Claim: Conclusion put forward for general acceptance.
3. Warrants: Reasons (rules, principles etc.) proposed to justify the link between data and claim.
4. Backings: Basic assumptions or generalizations which provide the justification for warrants.

As Driver et al. (2000) mentioned, in addition to four main components, Toulmin in his book, also proposed two more features for complex arguments:

5. Qualifiers: Phrases that show the conditions under which the claim is reliable.
6. Rebuttals: Circumstances under which the claim is refutable or undermined (Driver, Newton, & Osborne, 2000).

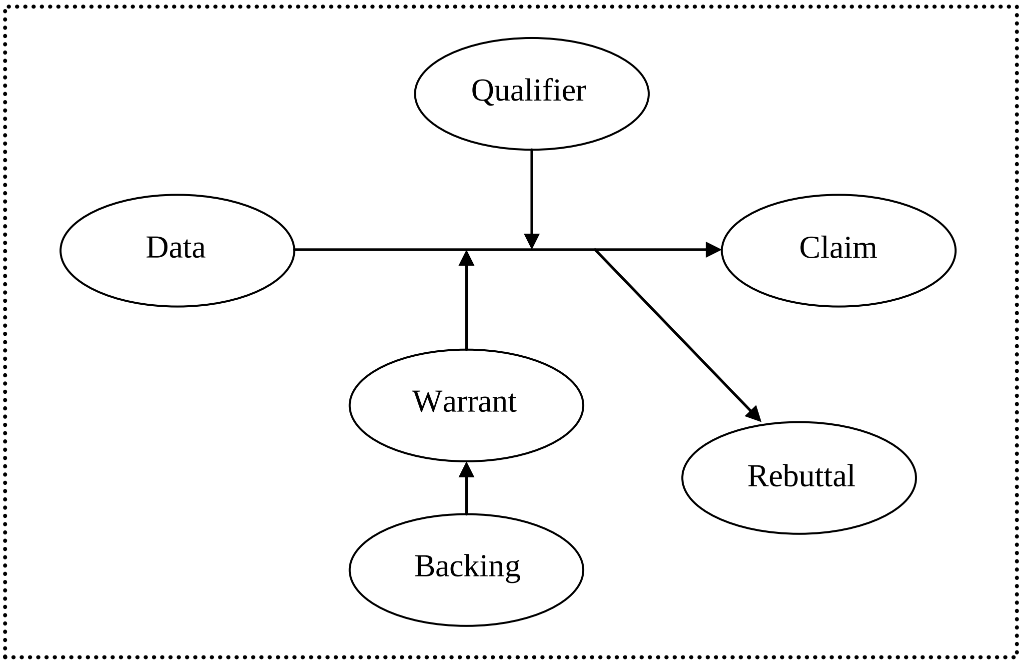

Figure 2.1 Toulmin’s Argumentation Pattern. Adapted from Argumentation in Science Education: Perspectives from classroom-based research p. 57, by S. Erduran, 2008, Dordrecht, London: Springer.

Based on this model, Driver, Newton, and Osborne (2000) presented these basic structures of an argument in sentences as: “because (data)… since (warrant)… on account of (backing)… therefore (conclusion)” (p. 293). As an illustration of his argument pattern, Toulmin gives an example in his book, *The Uses of Argument*, in which he discusses the claim that *Harry is a British subject*. This claim can then be supported by the datum that *Harry was born in Bermuda*. The warrant establishes the connection between the claim and the datum, such that *a man born in Bermuda will generally be a British subject*. The backing *that there are certain statutes and other legal provisions to that effect* supports the warrant of the argument. Since the warrant does not have full justifying strength, the claim that Harry is a British subject needs to be qualified as *presumably*. In addition to these, there are possible rebuttals such as *his parents were aliens* and *he has become a naturalized American* (Erduran, 2008) (Figure 2.2).

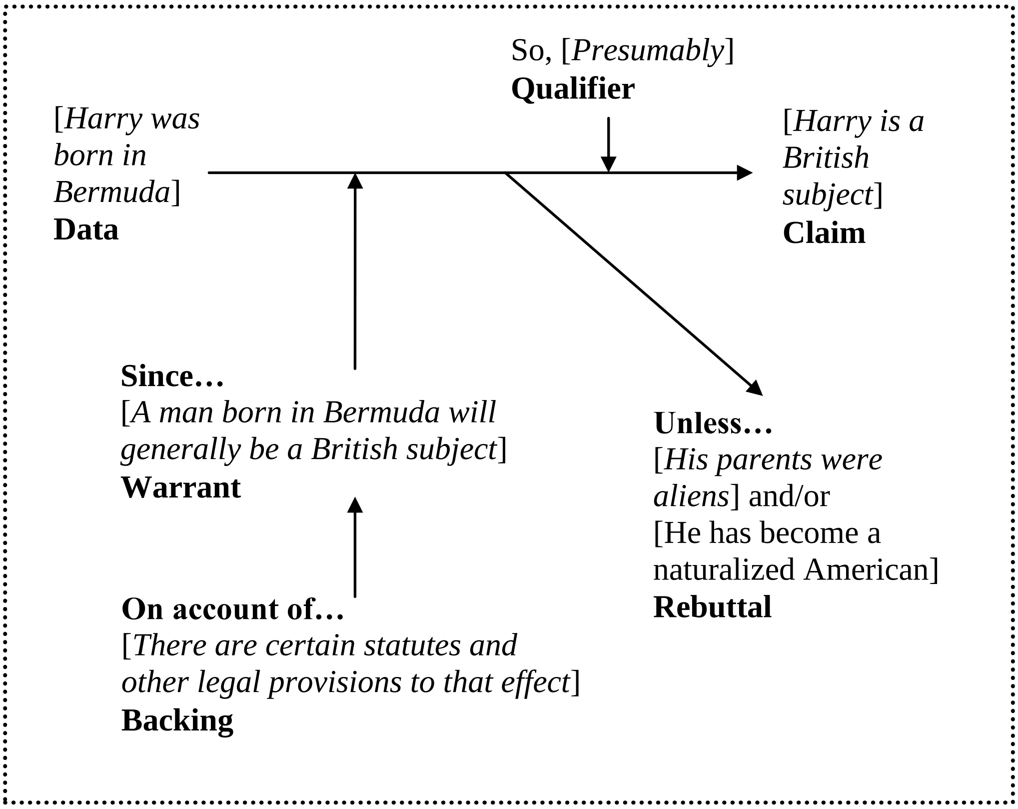

Figure 2.2 Application of Toulmin's Argumentation Pattern. Adapted from "Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions" by V. Sampson and D. B. Clark, 2008, *Science Education*, *92*(3), pp. 447-472.

Erduran (2008) indicated that although Toulmin's argumentation pattern proved useful in making structural distinctions between data, claim, warrants, and backings, some methodological difficulties in its application have been documented by many researchers (e.g., Driver, Newton, & Osborne, 2000; Kelly & Takao, 2002; Sampson & Clark, 2008). These methodological difficulties were mainly related to reliably distinguishing between components of the arguments identified by Toulmin's argument pattern and were mentioned in detail in the section related to the analyses of the argumentation quality in science education.

Other constraints of Toulmin's argumentation pattern, as discussed by Driver et al. (2000) are:

1. It deals with only the structure of arguments, leaving judgments about correctness of arguments unexamined.
2. It does not consider the dialogical aspects of arguments, that is, leaving out the interactional aspects of arguments.
3. Toulmin's argumentation pattern is de-contextualized, that is context dependent and situational aspects are not emphasized (Driver et al., 2000, p. 294).

In summary, a number of drawbacks are identified by many researchers in classifying and analyzing students' argumentations using Aristotle's analytic, dialogic, and rhetoric arguments as well as Toulmin's argumentation pattern.

In the following section, it is described in detail about informal logic and two related argumentation frameworks that were developed by Johnson and Blair (1994) and Walton (1996) in order to address the above mentioned shortcomings of Aristotle's argumentation and Toulmin's argumentation pattern.

2.1.3. Informal Logic

Informal logic has been developed by some researchers in 1970s in order to address the shortcomings of Aristotle's forms of argumentation and Toulmin's argumentation pattern and deals primarily with the arguments formed in everyday discourse of individuals rather than formal arguments (Groarke, 2007). Therefore, informal logic provides researchers with tools to analyze and improve argument practices of individuals' daily use of language.

In this respect, two argumentation frameworks which are Johnson and Blair's (1994) description of non-formal argumentation and Walton's (1996) presumptive reasoning are described in detail in the following section.

2.1.3.1. Johnson and Blair’s Non-formal Argumentation

Johnson and Blair (1994) described informal logic as a branch of formal logic that is aimed to analyze, construct and evaluate arguments in everyday discourse as well as in disciplined inquiry in non-formal ways. They enabled researchers to analyze arguments constructed in non-formal contexts with their focus on informal logic and their definition of RSA triangle for quality arguments such that relevancy, sufficiency, and acceptability of arguments in relation to nature of premises and conclusions (as cited in Puvirajah, 2007). The relevancy of a premise is related to the relationship between the premise and the conclusion of an argument in such a premise that does not have a relation to the truth of the conclusion would not be relevant. Similarly, for the premise of an argument to be sufficient, it must provide enough evidence in support of the conclusion of the argument. Lastly, the acceptability of a premise depends on the truth of the premise itself since use of a premise which itself is faulty is not acceptable (as cited in Greenwell et al., 2005).

2.1.3.2. Walton’s Presumptive Reasoning

Walton (1996), in his book *Argumentation Schemes for Presumptive Reasoning*, presents, explains and analyzes his argumentation scheme framed in informal logic such as everyday arguments that occur as an interactive dialogue between two or more people in non-formal contexts. Early researchers in informal logic treated dialogic events which were neither deductive nor inductive or arguments with flawed components as invalid and called these arguments as fallacious arguments (Puvirajah, 2007). Unlike these early researchers, Walton’s presumptive nature of argument provided the consideration of many everyday dialogic events which were neither deductive nor inductive. Walton proposed that some of these fallacious arguments were indeed fallacies; however, some of them were not actually fallacies and thus they were labeled as presumptive arguments. According to Walton, in presumptive nature of reasoning, the premise of an argument is accepted on a conditional basis for the purpose of moving the dialogic event forward and a weight of presumption is shifted from one arguer to the other as the dialogic event unfolds until a satisfactory answer is reached. In Walton's presumptive reasoning, there may be arguments that are in favor and against a claim and a balance of considerations must be made when evaluating these arguments (Puvirajah, 2007).

Walton identified 25 argumentation schemes in his book *Argumentation Schemes for Presumptive Reasoning*. Some of the argumentation schemes were fundamental and some were composites made up from basic or fundamental ones (Walton, 1996). Each argumentation scheme described by Walton was presented with its associated critical questions. This association provided both the emphasis for the presumptive nature of the argument schemes and the pragmatic and dialectic nature of the reasoning process (Walton, 1996). The function of each argumentation scheme described by Walton was to shift the weight of presumption from one arguer to the other in a back-and-forth manner until a satisfactory answer is given to the associated critical question (Walton, 1996).

In summary, Johnson and Blair's description of non-formal argumentations and their identification of a RSA triangle for arguments as well as Walton's presumptive reasoning provided researchers with tools to analyze, interpret and evaluate arguments and dialogic events that occur in everyday discourse of individuals.

In the following section, argumentation research in science education will be described in detail in terms of various frameworks used to analyze student generated arguments as well as relationships between socio-scientific issues, epistemic beliefs and argumentativeness of students and the nature and quality of student generated argumentations.

2.2. Argumentation Research in Science Education

Argumentation has a central position in science education and is considered as a type of discourse and an epistemological framework both for written and spoken forms of communication where individuals create, evaluate and discuss knowledge claims (Driver et al., 2000; Kuhn, 1993; Lemke, 1990; Puvirajah, 2007; Siegel, 1995).

In the following part, literature related to the argumentation research in science education was reviewed in four sections. In the first section, the analyses of the quality of argumentation in science education were discussed. The next section examined the researches on assessing the quality of argumentation in online discussion environments. In the last two sections, research on socio-scientific issues and argumentation in science education and research on epistemic beliefs and argumentativeness of students related to argumentation in science education were mentioned, respectively.

2.2.1. The Analyses of the Quality of Argumentation in Science Education

The analyses of argumentation in science education mainly focused on the nature and the quality of argumentation in terms of structure, content and justification of arguments generated by the students (Sampson & Clark, 2008). In this section, several analytical frameworks developed by science educators to assess the nature and the quality of students' argumentations were reviewed.

A critical review of the literature related to the assessment of the quality of argumentation in science education was presented by Sampson and Clark (2008). In their review, Sampson and Clark (2008) emphasized on the importance of scientific inquiry in which individuals construct, present and evaluate knowledge claims and accordingly the ability to generate persuasive arguments which establish logical connections between claims, use of data and justification so as to support or refute a point of view or explanation. However, for the arguments to be persuasive, they also needed to be consistent with the epistemological criteria used by the larger scientific community.

These epistemological criteria used for valid scientific claims were identified by the researchers as:

1. Backings and rationales should be provided for knowledge claims (Hogan & Maglienti, 2001).
2. Theoretical frameworks and observational phenomena should be coherent (Passmore & Stewart, 2002).
3. The credibility of evidence should be established (Driver et al., 2000).
4. The simplest explanation among equally plausible ones should be chosen (i.e. the value of parsimony) (Sandoval & Reiser, 2004).
5. Arguments should be based on logically valid reasoning (Zeidler, 1997).

In addition to these epistemological criteria for student generated arguments to be persuasive and valid, Sampson and Clark (2008), in their review, described several analytic frameworks used to assess the quality of scientific arguments under two main headings as domain-general and domain-specific frameworks. Domain-general frameworks for argumentation analysis were defined as the frameworks that can be implemented to analyze the argument quality inside or outside of scientific fields whereas domain-specific frameworks were defined as the frameworks that were used to analyze the argument quality specific to scientific area and contexts of science. As related to this study, two relatively domain-general frameworks such as Toulmin's (1958) argumentation pattern, and Schwarz, Neuman, Gil, and Ilya's (2003) approach on the structure and acceptability of reasons in arguments, and four domain-specific frameworks such as Zohar and Nemet's (2002) argumentation framework, Kelly and Takao's (2002) argumentation framework, Lawson's (2003) hypothetico-predictive argumentation, and Sandoval's (2003) framework were described in this section (Table 2.1). As seen in the Table 2.1, the first domain-general framework described was Toulmin's argumentation framework. Toulmin, in his book *The Uses of Argument,* distinguished between formal arguments as used in mathematics and non-formal arguments as used in linguistic contexts such as everyday discourse of individuals and suggested an analytic framework which defined six components for arguments which are claim, data, warrants, backings, qualifiers, and rebuttals (Sampson & Clark, 2008). Toulmin's argumentation framework influenced many science education researchers and several successive studies were conducted based on his argumentation pattern. Bell and Linn (2000), for example, used Toulmin's argumentation pattern in their study to analyze the structure of students' arguments about the nature of light. They found that students generally used data in order to support their claims; however, they did not use warrants and backings. In another study, Jiménez-Aleixandre et al. (2000) also used Toulmin's argumentation pattern for the analysis of high school students' argumentation about the genetics topic. In their study, they also found that students' argumentation included many detailed claims but were not supported by justification and warrants.

Toulmin's argumentation pattern provided researchers with a powerful tool to assess the quality of student generated arguments by analyzing the utilization and the relations between the components of arguments. However, in applying Toulmin's argumentation pattern for analysis of student argumentations, researchers encountered several methodological complications. First, reliably distinguishing between claim, data, warrants, backings, and rebuttals was difficult (Sampson & Clark, 2008). Second, Toulmin's argumentation pattern was pertinent to relatively short episodes of argumentation. In cases where longer arguments were created by students such as in term papers, position papers and journal articles, classification of claims, data, warrants, backings, qualifiers, and rebuttals was problematical since students' statements could serve as a new claim as well as warrants or backings for preexisting claims (Kelly & Takao, 2002). In addition, although research related to the analysis of student argumentations which relied on Toulmin's argumentation pattern provided researchers with tools to consider the components of arguments and argument structures generated by students, the issues of justification and scientific correctness of content were not considered by Toulmin's argumentation pattern (Sampson & Clark, 2008).

As depicted in the Table 2.1, another relatively domain-general framework mentioned in the review by Sampson and Clark was Schwarz et al.'s (2003) approach on the structure and acceptability of reasons in arguments. Schwarz et al. (2003) developed their argumentation framework for contexts where "students produce text arguments in structured interviews or in essays where they were invited to express their standpoint" and "participants know they are expected to be explicit" (p. 229). Schwarz et al.'s framework focused on the structure of arguments as Toulmin's argumentation framework and evaluated the argument quality based on the structural complexity of the arguments. In addition, their argument framework characterized the arguments by a coding scheme which largely depended on previous studies of Means and Voss (1996). The coding of arguments in Schwarz et al.'s framework focused on features of arguments such as:

a. Argument type
b. Soundness of arguments
c. Overall number of reasons
d. Number of reasons supporting counter-arguments
e. Quality of reasons

In their framework, Schwarz et al. (2003) defined arguments as assertions supported by at least one reason. According to this framework, argument structures can range from simple assertions to compound arguments. There were four argumentation structures defined by Schwarz et al.'s framework such as simple assertions, one-sided arguments, two-sided arguments, and compound arguments. Simple assertions consisted of only conclusions which were not supported by any justification or reasons. One-sided arguments consisted of only one conclusion supported by one or more reasons. Two-sided arguments included two conclusions which both supported and opposed the issue with one or more reasons; however, Schwarz et al. (2003) emphasized that two-sided arguments "do not show clearly whether the student or group undertook an analysis of the pros and cons necessary to solve the issue" (p. 229). Compound arguments were similar in structure to two-sided arguments; yet in contrast to two-sided arguments, in compound arguments this type of analysis was made by using phrases such as "it depends…, if…, but only if…," (p. 229) in terms of pros and cons of the issue (Figure 2.3).

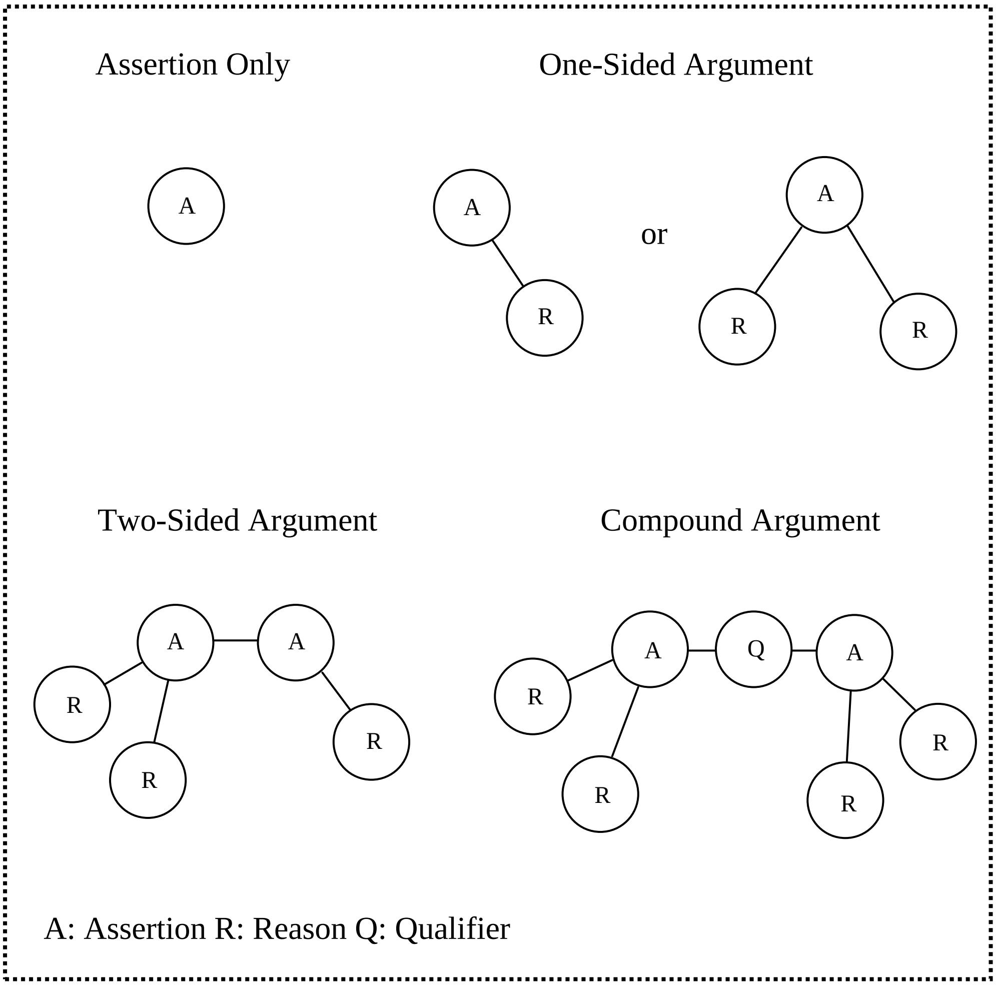

Figure 2.3 Schwarz et al.'s (2003) structures of arguments. Adapted from "Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions" by V. Sampson and D. B. Clark, 2008, *Science Education*, *92*(3), pp. 447-472.

Schwarz et al. in their framework also pointed out other features of student generated arguments such as soundness of arguments, overall number of reasons, number of reasons supporting counter-arguments, and quality of reasons in order to evaluate the quality of arguments. Schwarz et al.'s argumentation framework focused mainly on the structure of arguments in order to evaluate the quality of arguments much the same as Toulmin's argumentation pattern. In their framework, domain-general criteria were used as in Toulmin's argumentation pattern in assessing the argument quality. As a difference from Toulmin's argumentation pattern, Schwarz et al.'s framework provided an insight into students' argumentation practices such that the nature of student generated arguments and their development through instruction, for example from one-sided arguments to compound arguments, could be analyzed (Sampson & Clark, 2008).

In addition to explaining two relatively domain-general frameworks that were used to analyze argument quality, four domain-specific frameworks were also described in this section (Table 2.1). The first of these was Zohar and Nemet's (2002) argumentation framework. In their framework, Zohar and Nemet modified Toulmin's argumentation pattern such that they grouped Toulmin's data, warrants, and backings into a single category in order to handle the reliability issues associated with Toulmin's argumentation framework. Zohar and Nemet (2002) based their framework on the study of Means and Voss (1996) in evaluating the quality of students' written arguments in terms of both structure and content (Sampson & Clark, 2006) and they defined arguments as "assertions and conclusions and their justifications; or of reasons and supports" (p.38). Therefore, according to Zohar and Nemet's argumentation framework, strong arguments were arguments which incorporate multiple scientifically accurate justifications in order to support conclusions, weak arguments consisted of non-relevant justifications while conclusions without justifications were not considered as arguments. These justifications were analyzed in terms of how students include scientific ideas into their argumentations rather than focusing on the components of justifications (Sampson & Clark, 2008). Thus, the criteria for these justifications were defined as:

a. No consideration of scientific knowledge
b. Inaccurate scientific knowledge
c. Non-specific scientific knowledge
d. Correct scientific knowledge (Zohar & Nemet, 2002)

Zohar and Nemet in their argumentation framework, focused on the content of student generated arguments by consideration of these criteria for justifications as well as modification of Toulmin's argumentation pattern for the evaluation of the quality of arguments (Sampson & Clark, 2008). Although Zohar and Nemet's argumentation framework provided researchers with an insight into justification and content of student generated arguments, there were also several limitations associated with this framework. First, the accuracy of the claim itself was not evaluated in this framework. It was possible to put forward valid claims from many different perspectives especially in socio-scientific issues; however, in scientific issues, the content of the claims was important for them to be valid (Sampson & Clark, 2008). Another constraint of this framework was that it did not provide a measure for how well students incorporate all available scientific evidence in their argumentations. According to Zeidler (1997), students could construct elaborate arguments with several scientifically accurate justifications; however, the claim itself might still include inaccurate scientific information if students did not bring together all available scientific information (Sampson & Clark, 2008).

The next domain-specific framework used to analyze argument quality was Kelly and Takao's (2002) argumentation framework. Kelly and Takao developed their argumentation framework to analyze longer and more complex written arguments found in students' term papers in an oceanography course in which students were required to support a theoretical framework by means of using multiple data. Therefore, students in this study included multiple propositions in their argumentations in order to support their conclusions. In the framework, Kelly and Takao focused on the classification of epistemic statuses of students' propositions and the links between them. These epistemic statutes of students' proposition were defined by domain-specific criteria and were categorized as lower level and higher level descriptions of the data within that particular domain. Kelly and Takao's argumentation framework provided a more comprehensive understanding of student generated arguments in terms of the structure and the justification as well as the types of propositions used in arguments in order to support conclusions. The use of Toulmin's or Zohar and Nemet's argumentation framework instead of Kelly and Takao's to analyze long and complex scientific arguments would leave some important aspects of students' written arguments unexamined (Sampson & Clark, 2008). Sampson and Clark also indicated that although Kelly and Takao's framework has several advantages over previously explained frameworks in analyzing long and complex written arguments in domain-specific areas of science, some limitations of the framework were also identified. Specifically, Kelly and Takao's framework did not consider the appropriateness of the links between the propositions that were categorized according to epistemic levels identified in that particular domain. In addition, the scientific accuracy of propositions themselves was not evaluated (Sampson & Clark, 2008). Another constraint of the framework identified by Kelly and Takao was that there were discrepancies between the ratings of the researchers of the students' term papers and that of the instructor of the course which could be attributed to several factors such as the accuracy of the propositions, the appropriateness of linkages between these propositions or students' insufficient support for their conclusions.

Another domain-specific framework used for the analysis of argumentation quality was Lawson's (2003) hypothetico-predictive argumentation framework. Lawson stated that the reason for generating arguments in science is to "determine which of two or more proposed alternative explanations (claims) for a puzzling observation is correct and which of the alternatives are incorrect" (p.1389). This process requires the generation of arguments which present a tentative explanation for the observed phenomenon and alternative hypotheses to be tested (Sampson & Clark, 2008). Arguments as described by Lawson start with a perplexing question and the generation of one or more tentative explanations. In order to test a hypothesis, first the hypothesis is assumed to be correct and a test is imagined. The If/and/then link as depicted in Figure 2.4 is followed. Once this link is established, the observed result of the test constitutes the evidence to be compared with the prediction. The comparison of the evidence with the prediction and the match or mismatch of evidence and prediction determines the validity of the hypothesis (Lawson, 2003). Lawson described this type of argument as hypothetico-predictive argument and indicated that the assessment of the quality of arguments was much more convincing with this type of argumentation framework than arguments that relied on evidence, warrants, and backings in order to evaluate the validity of a claim (Sampson & Clark, 2008). Lawson's framework focused mostly on hypothesis generation and testing. In addition, Lawson stated that science instruction with a focus on hypothetico-predictive arguments as well as students' engagement in verbal and written discourse related to science concepts being taught would improve students' argumentative/reasoning skills (Lawson, 2003).

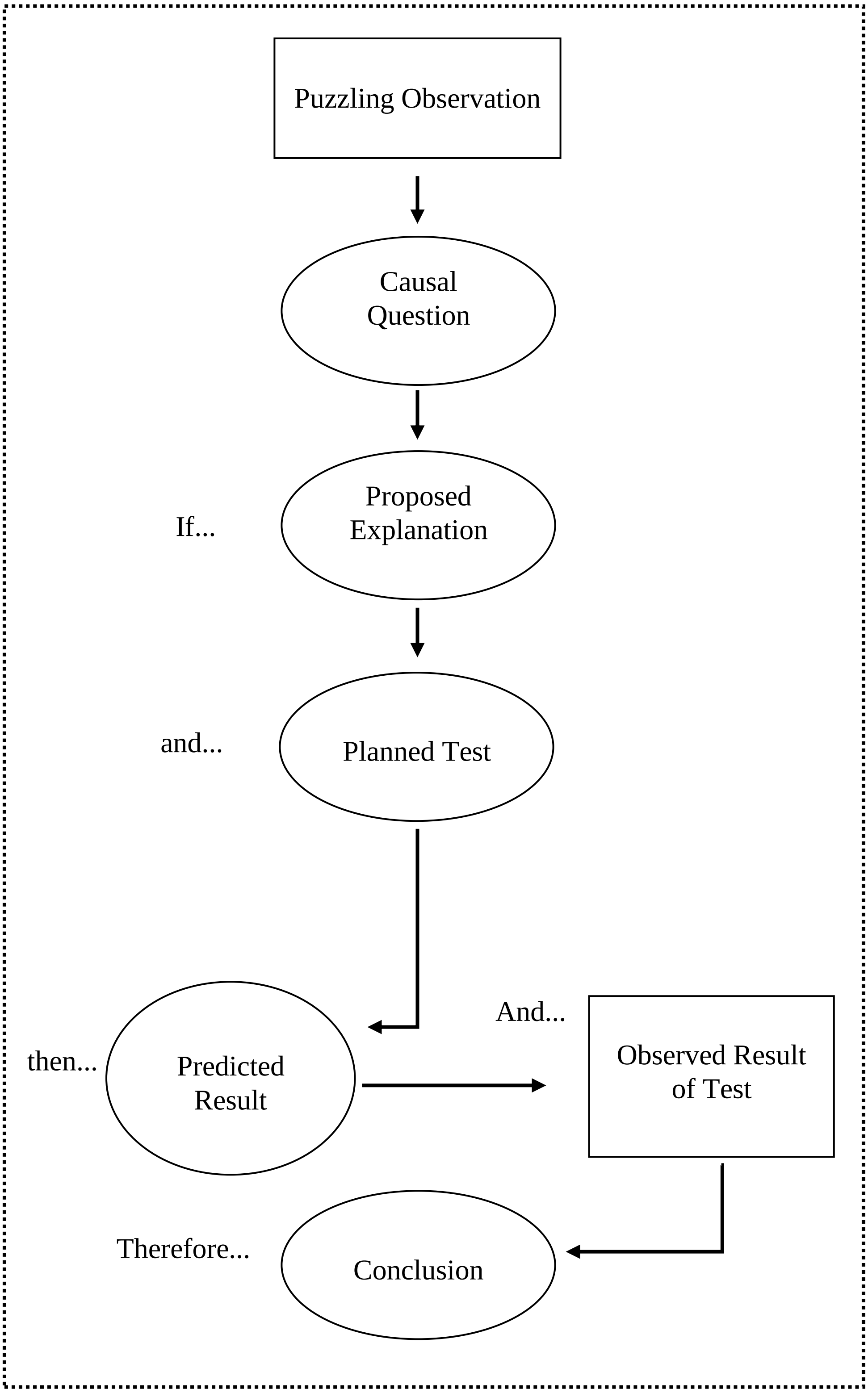

Figure 2.4 Lawson's hypothetico-predictive argumentation. Adapted from "The nature and development of hypothetico-predictive argumentation with implications for science teaching" by A. E. Lawson, 2003, *International Journal of Science Education*, *25*(11), 1387-1408.

Lawson's framework focused on the forms of justification such that although it was different from previously mentioned structural frameworks defined for quality analysis of student argumentations, Lawson's framework also defined a very precise structural form for student generated arguments and their justifications. In Lawson's argumentation framework, an argument should match the complete template of components depicted in Figure 2.4 for them to be considered strong arguments. Besides, this framework was mostly suitable for specific scientific issues and arguments generated in relation to these issues rather than more general scientific or socio-scientific issues (Sampson & Clark, 2008).

The last domain-specific framework for analysis of the quality of argumentation explained in this section was Sandoval (2003) and Sandoval and Millwood's (2005) argumentation framework. Sandoval and Sandoval and Millwood developed an alternative framework such that rather than assessing the structural components of arguments, their argumentation framework focused on two main issues which were the conceptual quality and the epistemological quality of arguments (Sampson & Clark, 2008). For the conceptual quality of arguments, Sandoval measured (a) articulation of causal claims within a specific theoretical framework and (b) warranting these claims using available data. For the epistemological quality of arguments (a) citing sufficient data in warranting a claim, (b) writing a coherent causal explanation for a given phenomenon, and (c) incorporating appropriate references when referring to data are measured in this framework (Sandoval & Millwood, 2005). Sandoval's framework with its main focus on justification of arguments in terms of conceptual and epistemological criteria rather than structural features of student generated arguments provided important information about students' use of evidence, in constructing and supporting arguments within a specific scientific domain (Sampson & Clark, 2008). In this respect, Sandoval's framework enabled researchers to look for student generated arguments in terms of how students incorporated theories and used evidence in warranting claims in specific scientific areas of study. In addition, their framework also helped students to understand the nature of scientific knowledge. Sampson and Clark (2008) mentioned that although Sandoval's framework has many advantages in analyzing student generated arguments such as examining both conceptual and epistemological quality of arguments, this framework was identified as the most discipline-specific framework described so far since arguments and the quality assessment of these arguments depend mainly on students' use of domain-specific theories and evidence in warranting their claims both from a conceptual and epistemological points of view. For these reasons, significant adaptation was required for this argumentation framework when it is to be used for analyzing the quality of arguments in other contexts.

Table 2.1 Domain-general and domain-specific argumentation analysis frameworks

Argumentation Analysis Frameworks	Main Focus	Advantages	Limitations
Domain-General Frameworks			
Toulmin's Argumentation Pattern (TAP)	Analysis of students' arguments in terms of argument components	Analysis of non-formal arguments as used in linguistic contexts such as everyday discourse of individuals Powerful tool to analyze the utilization and the relations between components of arguments	Suitable for short arguments Difficulty in reliably distinguishing between argument components No consideration of justification and scientific correctness of content
Schwarz, Neuman, Gil, and Ilya's Approach	Analysis of the structural complexity of students' written arguments	Provides an insight into students' argumentation practices such as the nature and development of arguments	Limited classification of arguments such as simple, one-sided, two-sided, and compound arguments based on patterns of justifications of assertions

Table 2.1 (continued)

Domain-Specific Frameworks			
Zohar and Nemet's Argumentation Framework	Analysis of students' arguments in terms of both structure and content	Grouping of Toulmin's data, warrants, and backings into a single category in order to handle the reliability issues Provides insight into justification and content of student generated arguments	No evaluation of the accuracy of the claim itself No measure for how well students incorporate all available scientific evidences
Kelly and Takao's Argumentation Framework	Analysis of longer and more complex arguments in relation to epistemic statuses of students' propositions	A more comprehensive understanding of student generated arguments in terms of structure and justification as well as types of propositions used to support conclusion	No consideration of appropriateness of the links between the propositions categorized according to the epistemic belief levels No evaluation of scientific accuracy of the propositions themselves

Table 2.1 (continued)

Lawson’s Hypothetico-Predictive Argument	Analysis of arguments which present a tentative explanation for the observed phenomenon and alternative hypotheses	More convincing assessment of quality of arguments as hypothetico-predictive arguments than relying on evidence, warrants, and backings in order to evaluate the validity of a claim	An argument should match the complete template of components to be considered strong arguments.
		Science instruction with a focus on hypothetico-predictive arguments would improve students’ argumentative/reasoning skills	Mostly suitable for specific scientific issues and arguments generated in relation to these issues rather than more general scientific or socio-scientific issues

Table 2.1 (continued)

Sandoval's Argumentation Framework	Analysis of arguments in terms of conceptual and epistemological quality	Enables researchers to look for student generated arguments in terms of how students incorporate theories and use evidence in warranting claims in specific scientific areas of study	Students' use of domain-specific theories and evidence in warranting their claims is required for the quality assessment of arguments Significant adaptation is required for this framework to be used in other contexts

In addition to domain-general and domain-specific frameworks described thus far; Erduran, Simon, and Osborne (2004) developed a framework which was based on Toulmin's Argument Pattern (TAP) to analyze students' argumentations. In their study, Erduran et al. collaborated with 12 middle-school science teachers in order to investigate argumentation in science classrooms. Their study which was part of a large project titled "Enhancing the Quality of Argument in School Science" for years between 1999 and 2002 resulted in two methodological approaches for tracing student argumentations in science classrooms. Erduran et al. (2004) used audio-taped verbal conversations in 12 classes of year 8 students. The lessons focused on a socio-scientific issue which is about the funding of a new zoo. The task was to present arguments for and against the funding of a new zoo together with whole-class discussions and group discussions as well as presentations and homework about the issue. In the first methodological approach, teachers implemented the same activities for two years with comparable students such that the students across two years were from the same neighborhood with similar ethnic, linguistic and racial backgrounds. The distribution and clusters of the features of Toulmin's Argument Pattern (TAP) was traced and analyzed. As Erduran et al. (2004) reported, at the beginning of the study, the clusters with two or three components of TAP such as CD (claim-data) and CDW (claim-data-warrant) occurred more frequently as compared to the second year of the study in which clusters with four or five components such as CDWB (claim-data-warrant-backing) and CDWBR (claim-data-warrant-backing-rebuttal) occurred more frequently. In the second methodology, Erduran et al. (2004) focused on the reliability issues associated with TAP in distinguishing between data, warrants, and backings. Therefore, in order to resolve the reliability problem, they focused on the presence of rebuttals and reasons (data, warrants, or backings) in the arguments. The presence of reasons in an argument was important since arguments with reasons transcend mere opinion and establish support for one's position. Besides, arguments with rebuttals were considered as higher quality arguments than those without rebuttals because in arguments without rebuttals individuals remain epistemologically unchallenged, the opposing ideas were merely presented without an attempt to rebut the other point of view and thus the oppositional episodes could continue forever without any change of mind (Erduran et al., 2004). In determining rebuttals in students' argumentations Erduran et al. (2004) identified oppositional episodes in the classroom discourse. These episodes were identified by phrases such as "but", "I disagree with you", and "I don't think so". These oppositional episodes in students' argumentations were analyzed according to essential features of Toulmin's Argument Pattern (TAP) as well as the nature and the quality of argumentations were decided based on TAP with some modifications such as focusing on presence of rebuttals and reasons (data, warrants, or backings) proved useful in identifying students' discourses in classrooms, oppositional episodes in group discussions, as well as assessing the quality of dialogic argumentations in small-group and whole-class discussions.

In summary, several widely used domain-general and domain-specific frameworks and the framework developed by Erduran et al. based on TAP for analysis of quality of student generated argumentation in science education were examined in this section in terms of structure, content and justifications. As many researchers indicated, there was a diversity of the frameworks for analyzing quality of argumentation which suggested that researchers should be aware of the fact that these frameworks were tools developed to measure the quality of arguments generated by students in specific topics and contexts (Sampson & Clark, 2008). In addition, each argumentation framework defined has its strengths and weaknesses in determining the quality of argumentation depending on the focus of the argumentation framework implemented by the researchers such as domain-general or domain-specific frameworks, as well as examination of structural, conceptual, or epistemological quality of student generated arguments. Therefore, these frameworks were not fully interchangeable and require significant adaptation before using for analysis of argumentation in other contexts. Finally, the research on argumentation in science education was fragmented in terms of frameworks used for analysis of argumentations and focusing on very specific parts of student generated arguments and thus there was a need for more holistic considerations for the measurement of the quality of argumentation (Sampson & Clark, 2008).

In this research, student generated arguments in socio-scientific issues in an online discussion environment were examined in terms of the nature of justifications students used and the quality of argumentation as related to students' epistemic beliefs and argumentativeness. Therefore, in the following part, research on assessing the quality of argumentation in online discussion environments, socio-scientific issues and argumentation in science education, and research on epistemological beliefs and argumentativeness of students related to argumentation will be described in detail.

2.2.2. Research on Assessing the Quality of Argumentation in Online Discussion Environments

Until now, students' argumentations in offline discussion environments were described and various frameworks that were used to assess the quality of these argumentations were examined. The quality of student generated arguments has also been analyzed in online or computer-based discussion environments and a variety of frameworks for the purposes of analyzing the nature and the quality of argumentations in online discussion environments were implemented by the researchers.

These online argumentation environments include several features such as collaborative communication, co-creation and sharing, enriched access to information, scripts and awareness heightening tools, as well as integration of multiple such features in order to facilitate students' engagement in argumentation and promote the quality of argumentation (Clark, Sampson, Weinberger, & Erkens, 2007). *Collaborative communication interfaces* include synchronous (e.g., CONNECT, TC3) and asynchronous discussion environments (e.g., CSILE, Allaire Forum) developed to support students to participate in these online discussion environments. Among synchronous discussion environments, CONNECT (Confrontation, Negotiation, and Construction of Text) is an environment which provides a memory of what has been constructed by the students, acts as a focus for action and discourse in the environment, presents knowledge and the relations between these knowledge elements and is a medium for communication (de Vries, Lund, & Baker, 2002). TC3 (Text Composer, Computer-supported, and Collaborative) is an online discussion environment in which students discussed about socio-scientific issues using the chat feature (Munneke, Andriessen, Kirschner, & Kanselaar, 2007). Among asynchronous discussion environments CSILE (Computer-Supported Intentional Learning Environments) and Allaire Forum environment are online discussion environments in which activities of scientists are taken as a model for students' learning activities (de Vries et al., 2002) and commercially available, threaded online discussion forum in which students generate and share their arguments are used in discussions in research in education. Joiner and Jones (2003) argued that while asynchronous interfaces provided students more time to construct and elaborate on their arguments and participate more equitably, synchronous interfaces could facilitate a higher degree of cooperative construction and elaboration of arguments. *Co-creation and sharing* of argumentation in online environments enables students to compare and refine their arguments through dialogic argumentation. For example, Schwarz and Glassner (2007) in their DUNES online argumentation environment encouraged students to co-construct argumentation maps through dialogic argumentation. *Enriched access to information* in online discussion environments provides students with visualizations such as TELS (Technology Enhanced Learning in Science) and WISE (Web-based Inquiry Science Environment) and knowledge bases (e.g., CSILE) such that students could utilize these resources in developing their argumentations. *Scripts and awareness heightening tools* are embedded in these online discussion environments in order to promote students' argumentations and they have functions such as improving students' construction of arguments, grouping students into opposing discussion groups, and providing feedback about the quality of arguments (Clark et al., 2007; Jermann, Soller, & Muehlenbrock, 2001). In addition, these online learning environments could also integrate several of these features such as integration of databases, synchronous or asynchronous interactive environments, visualizations of students' argumentations, guidance of students through their argumentations, and making students aware of their contributions and argumentations depending on the researcher's pedagogical goals (Clark et al., 2007).

The analyses of argumentation in online discussion environments by using several analytical frameworks were conducted by some researchers. For example, Simon (2008) indicated that a software program Digalo which was based on an extension of Toulmin's argument pattern was used in science classrooms. In this software, small-group student discussions were mapped as the argumentation proceeded among the participants. At the end, an argumentative map with similar features of a structured argument to Toulmin's argument pattern was constructed. Simon argued that the use of a software program, Digalo, in students' argumentations enabled the whole process to be visualized and the application of TAP to these argumentative maps for analysis of the quality of argumentations became more feasible. In addition, with this framework, TAP could be applied to written texts and transcripts of students' oral discussions. However, the use of this framework has also similar limitations associated with Toulmin's argument pattern such as implicit claims and ambiguity in distinguishing between data, warrants, and backings in argumentations (Simon, 2008). Bell and Linn (2000) used Knowledge Integration Environment (KIE) project which was part of Scaffolded Knowledge Integration framework to assess the quality of arguments constructed by students about light propagation. This framework was resulted from the Computer as Learning Partner project of which purpose was to promote knowledge integration in science learning. This framework consisted of several tenets such as selecting accessible and generative goals for science education, making thinking visible and production of explanation for the evidence observed (Bell & Linn, 2000). Bell and Linn, in their KIE project used SenseMaker software in order to make students' arguments visible by promoting students to construct and edit their arguments using graphical representations provided by the software program. The analyses of students' arguments in Bell and Linn's (2000) Knowledge Integration Environment (KIE) were based on Toulmin's (1958) argumentation framework. The researchers specifically analyzed how students used evidence and backings and provided further ideas and claims as they construct their arguments and found that students' experiences were effective in incorporating backings in their arguments. Besides, Bell and Linn argued that KIE scaffolds students' argumentations by using SenseMaker software which provided a visualization of argumentation such that students could identify claims and connect evidences for their arguments. However, in their framework, Bell and Linn also used Toulmin's argumentation framework to analyze the quality of student generated arguments. Therefore, this framework also had the reliability issues associated with TAP.

In another study, Okada and Shum (2008) used evidence-based dialogue maps as a participatory research tool to investigate students' scientific argumentations. Evidence-based dialogue mapping was used in a software program, Compendium, which both scaffolded students to generate argument and to analyze the quality of argumentations. The purpose of this study was to engage students in action learning and using dialogue maps to represent, visualize, reflect and improve arguments as a spiral process. In their study, Okada and Shum created cases in which students generated evidence-based claims and teachers evaluated those claims as well as students reflected on their own argumentations and took feedback to improve their arguments. In evidence-based dialogue mapping, researchers developed their analysis criteria for students' argumentations based on Toulmin's (1958) argumentation framework and analyzed data that are gathered from participants' discussions in forums, dialogue-maps and essays and reflective comments about the uses of the environment. In order to analyze their data, the researchers defined four levels of quality for dialogue maps ranging from very weak, weak, moderate, and strong arguments (Table 2.2). Levels with very weak argumentation consisted of only claims and no argument while levels with weak arguments consisted of claims and warrants and levels of moderate and strong arguments included claims, warrants, rebuttals and data.

Table 2.2 Criteria for analyzing dialogue maps

Level of argumentation	**Description**
(1) Very weak	Only claims, no argument
(2) Weak	Claims and (weak) warrant (based on convictions)
(3) Moderate	Claims, (weak) warrants and rebuttals or data
(4) Strong	Good claims, good warrants, rebuttals/data

Note. Adapted from "Evidence-based dialogue maps as a research tool to investigate the quality of school pupils' scientific argumentation" by A. Okada and S. B. Shum, 2008, *International Journal of Research & Method in Education*, *31*(3), 291-315.

In addition to defining the levels for argumentations in dialogue maps, Okada and Shum also determined criteria as five levels for students' writing. These levels range from very week to very good. Levels with very week writings consisted of few words, no sentences, and weak argumentation whereas very good writings included good paragraphs with strong argumentation and domain knowledge (Table 2.3).

Table 2.3 Criteria for analyzing level of writing

Level of writing	Description
(1) Very weak	Few words, no sentences, weak argumentation
(2) Weak	Few sentences with weak or simple argumentation
(3) Moderate	Connected sentences with simple argumentation
(4) Good	Well connected sentences with strong argumentation
(5) Very good	Good paragraphs with strong argumentation and domain knowledge

Note. Adapted from "Evidence-based dialogue maps as a research tool to investigate the quality of school pupils' scientific argumentation" by A. Okada and S. B. Shum, 2008, *International Journal of Research & Method in Education*, *31*(3), 291-315.

Okada and Shum reported that the use of evidence-based dialogue maps provided the visualization of the reasoning sequence and argumentations of students as well as helped both researchers and students to analyze and formulate arguments, respectively. However, the analysis framework was based on Toulmin's (1958) argumentation pattern in which distinguishing between claims, data, warrants and backings could be unclear and discrimination between good claims and/or paragraphs represented a degree of subjectivity based on the researchers. Another framework used for analysis of student argumentations in online environments was developed by Clark and Sampson (2007) which was based on Erduran et al.'s (2004) argumentation framework. Clark and Sampson designed their argumentation framework in an asynchronous online discussion environment to evaluate the quality of arguments that are more oppositional in nature, required consensus building and related to a more scientific issue which was about a natural phenomenon rather than a socio-scientific issue (Clark & Sampson, 2007). Clark and Sampson in their framework first coded the students' comments in an asynchronous discussion forum in terms of nature of contribution, grounds quality, and conceptual quality. After the individual comments were coded, oppositional episodes were determined and a structural quality score according to criteria shown in Table 2.4 was assigned to these episodes.

Table 2.4 Analytical framework developed by Clark and Sampson (2007)

Quality	Characteristics of the discourse
Level 5	Multiple rebuttals and at least one rebuttal that challenges the grounds used to support a claim
Level 4	Multiple rebuttals that challenge the thesis of a claim but does not include a rebuttal that challenges the grounds used to support a claim
Level 3	Claims or counter-claims with grounds but only a single rebuttal that challenges the thesis of a claim
Level 2	Claims or counter-claims with grounds but no rebuttals
Level 1	A simple claim versus counter-claim with no grounds or rebuttals
Level 0	Non-oppositional

Note. Adapted from "Assessing dialogic argumentation in online environments to relate structure, grounds, and conceptual quality" by D. B. Clark and V. Sampson, 2008, *Journal of Research in Science Teaching*, *45*(3), pp.293-321.

In their framework, Clark and Sampson extended the definition of rebuttals given in Erduran et al.'s framework by introducing two types of rebuttals such as "rebuttals that challenge the thesis of a claim" and "rebuttals that challenge the grounds of a claim". According to this framework, although rebuttals that challenge the grounds of a claim were considered higher level argumentation (level 5) than rebuttals that challenge the thesis of a claim (level 3, Level 4), presence of either type of rebuttals indicated higher quality argumentations since both types of rebuttals force the opposing party to evaluate the validity of their claim. Clark and Sampson's framework suggested that use of an online asynchronous discussion environment in which students were grouped into opposing discussion groups according to their claims facilitated higher levels of argumentation. In addition, in their framework, Clark and Sampson integrated issues of structural quality with grounds quality and conceptual quality by coding students' contributions in terms of these perspectives.

Although the framework developed by Clark and Sampson enabled researchers to analyze students' argumentations in asynchronous online discussion environments, avoided reliability issues associated with Erduran et al.'s framework by defining two types of rebuttals such as "rebuttals that challenge the thesis of a claim" and "rebuttals that challenge the grounds of a claim", and integrated structural quality with grounds quality and conceptual quality, their framework was mostly suitable for argumentations about a natural phenomenon or scientific issue rather than a socio-scientific issue and students were grouped into discussion groups and oppositional episodes of group discussions were coded for the quality analysis rather than individual student comments. Therefore, according to the objectives of the current study, the framework developed by Clark and Sampson was not used by the researcher in analysis of the quality of student argumentations.

2.2.3. Research on Socio-scientific Issues and Argumentation in Science Education

Previously, student generated argumentations and a variety of frameworks which were developed to analyze argument quality in offline and online contexts were described in detail. In this part, the definition and the place of socio-scientific issues (SSI) and argumentation in science education (i.e. socio-scientific argumentation) will be described in detail by addressing to relevant research about SSI and argumentation.

Socio-scientific issues are defined as social issues with conceptual and technological relations to science and are controversial in nature which require moral reasoning in order to make decisions regarding the resolution of these issues (Sadler, 2004; Zeidler & Nichols, 2009). Sadler (2004) stated that science is inseparable from the society from which it arises and besides having a scientific knowledge base, socio-scientific issues have societal interests and effects. In addition, many researchers in science education advocated the inclusion of SSIs in science curriculum and in classroom debates since integration of SSIs that incorporate ill-structured problems in science curricula provides opportunities for argumentation (e.g., Driver, Newton, & Osborne, 2000; Sadler, 2004). Bearing in mind that one of the important goals of science education is to help students to understand how society and science are mutually dependent, the integration of SSIs in science curriculum has been supported broadly among science educators, researchers and science education community (Driver et al., 2000). As an example, Morin (1998) defined the nature of SSI as polydisciplinary, transnational and planetary considering the context of increasing globalization. As regarding to the integration of SSI in science classrooms and in the curriculum, Morin stated that science education should be based on

> *the necessity of reinforcing critical thinking by linking knowledge to doubt, by integrating particular knowledge in a global context and using it in real life, by developing individuals' ability to deal with fundamental problems with which they are confronted in their own historical epoch* (Morin, 1998. p.17 as cited in Simonneaux, 2008).

The efforts of integration of socio-scientific issues in science education dates back to early 1980s where science, technology, and society (STS) movement aimed to educate students about the interdependence of these three domains (Yager, 1996). However, STS education became diffused and isolated focusing on particular issues and ultimately was unable to attain its goal until socio-scientific issues with a more specific focus on students' handling of science-based problems that have an effect on their daily lives and future world emerged as an approach in science education (Driver et al., 2000; Sadler, 2004). In line with the efforts for integrating SSI in science curriculum, the research related to SSI and argumentation in science education greatly increased in number. Sadler (2004) critically reviewed these studies related to SSI and argumentation by specifically addressing to issues such as socio-scientific argumentation, relationships between nature of science conceptualizations and socio-scientific decision making, evaluation of information regarding socio-scientific issues focusing on students' ideas of what counts as evidence and the influence of conceptual understanding on reasoning and argumentation. In the review, Sadler described four studies which were specifically related to socio-scientific argumentation such that Jiménez-Aleixandre et al.'s (2000), Kortland's (1996), Patronis et al.'s (1999), and Zohar and Nemet's (2002) studies. Kortland (1996) investigated middle-school students' argumentation patterns about waste issue in the physical science curriculum. Interviews with students were conducted in order to establish the baseline data for argumentation skills and were analyzed based on a set of a priori categories developed by the researcher. The results of the study showed that students showed increased understanding of the waste issue and they were able to evaluate alternatives regarding their choices and in most cases they offered valid criteria in terms of supporting the original claim. However, in some cases the clarity of the proposed criteria was questionable and students used direct support for their claims and did not present counter-claims or rebuttals for their arguments. Patronis et al. (1999) also investigated middle-school students' classroom-based argumentations and, unlike Kortland's findings, they proposed that students were able to create well-formulated arguments about socio-scientific issues. In their study, the students worked in small groups in the classrooms for several months about a local socio-scientific issue which is the design of a road in their area. Each group developed and presented a plan to the classroom and participated in class discussions regarding advantages and disadvantages of the presented plan. Researchers used Toulmin's (1958) framework in order to analyze the nature and the quality of arguments students developed. The results of this study showed that students were able to develop well-formulated arguments about socio-scientific issues when students are involved in these issues and these issues have personal connections to students' daily lives (Patronis et al., 1999). Although the results of Patronis et al.'s study were promising for science educators for the integration of socio-scientific issues in science curriculum, the validity of the claims seemed doubtful since students' personal interest and involvement could have an effect on their argumentations (Sadler, 2004). Jiménez-Aleixandre et al. (2000) investigated high-school students' capacity to develop and assess arguments in genetics concepts in which students worked in groups to resolve a socio-scientific issue about genetic and environmental variability of farm-raised chickens. Students' conversations were observed, audio and video-taped during classroom discussions and transcribed by the researchers for analysis. Jiménez-Aleixandre et al. (2000), in their study, focused on two aspects of student discussions that are argumentative operations (i.e. claims, data, warrants, etc.) and epistemic operations (e.g., explanation produces, causal relations, and analogies). Argumentative operations consisted of the structure of student arguments and were analyzed by Toulmin's argument pattern. Epistemic operations represented students' use and construction of different kinds of knowledge and were defined by a priori list derived from science domains such as history and philosophy of science (Jiménez-Aleixandre et al., 2000). The results of the study indicated that students' argumentations showed a variation from naïve arguments with claims and no data or backings to sophisticated arguments with justifications for claims and backings. In addition, most of the student arguments were limited such that in terms of argumentative operations, most of the arguments consisted of claims and no rebuttals were presented. In terms of epistemic operations, student arguments were also limited and focused on causality and appeal to analogies (Sadler, 2004). In another study, Zohar and Nemet (2002) investigated ninth-grade students' argumentations about human genetics dilemmas before and after an intervention which included explicit teaching of students about reasoning patterns. Before intervention all classes studied the basic principles of genetics. During the instruction, advanced genetics topics with related social implications were introduced to the classes. For the period of the intervention, four classes were determined as control groups in which traditional textbook approach was followed and no specific attention was given to reasoning and argumentation skills while five classes were experimental groups and were exposed to the explicit teaching of reasoning skills and practiced argumentation in human genetics concepts (Zohar & Nemet, 2002). Zohar and Nemet reported that even before the intervention most of the students (i.e. 90 %) were able to formulate simple arguments with at least one justification about their claims. In addition, explicit teaching about reasoning skills and argumentation practices of students in human genetics dilemmas improved students' use of correct specific biological knowledge in supporting their conclusions compared to control group both before and after the intervention. Previous research on socio-scientific issues suggested that students were not able to formulate high-quality argumentations in which they argue about controversial issues and present claims and counter-claims as regards to these issues (Kuhn, 1991). In contrast, Patronis et al. presented an exception such that they reported that students were able to engage in high-quality argumentations when those issues had personal connections to students' daily lives. Sadler (2004) indicated that Zohar and Nemet (2002) suggested that the instruction about argumentation skills would also be favorable for the development of students' argumentation skills; however, Kortland's (1996) study in which intervention was not successful suggested that instruction does not always develop students' argumentation.

Previous studies had investigated students' argumentations in socio-scientific issues in contexts such as local environmental issues (e.g. Kortland, 1996; Patronis et al., 1999) and human genetic issues (e.g. Jiménez-Aleixandre et al., 2000; Zohar & Nemet, 2002). A common assumption underlying these studies was that students' understanding about socio-scientific issues significantly influences their argumentation practices (e.g. Patronis et al., 1999). Sadler and Fowler (2006) in their study explored the presumed link between students' understanding of the related science concepts and their argumentation practices. Previous studies about socio-scientific issues and argumentation mainly used Toulmin’s argument pattern (TAP) in analyzing the structure of arguments in terms of claims, data, warrants, backings, and rebuttals (e.g., Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; Patronis, Potari, & Spiliotopoulou, 1999; Zohar & Nemet, 2002). However, Toulmin’s argument pattern had problems in distinguishing between categories such as claims, data, warrants, and backings. Sadler and Fowler (2006) indicated that although some of the researchers (e.g. Erduran et al., 2004; Zohar & Nemet, 2002) have tried to overcome these difficulties by combining problematic categories (e.g. data, warrants, and backings) into a single category called ‘grounds’, their approach had also its own methodological drawbacks such that it can only be applied to group discussions. In their study, Sadler and Fowler conducted interviews with high school and college students with variable genetics knowledge about three scenarios related to gene therapy and cloning. The student interviews were analyzed and assessed in terms of justifications based on a five-point rubric developed by the researchers. The framework used to analyze the quality of student argumentation was based on justifications presented. The reasons for this was first, in their rubric for analyzing argumentation analysis, Sadler and Fowler sought to minimize the problems associated with structural analyses of argumentation, especially with using Toulmin’s argument pattern (TAP) and second, justification of claims was defined by the researchers as the most basic form of argumentation (Sadler & Fowler, 2006). The framework developed by the researchers with the related level of justifications identified and excerpts of student interviews about the issues is presented in Table 2.5.

Table 2.5 Argumentation Quality Rubric

Score	Description	Excerpt
0	No justification	*In response to the reproductive cloning scenario*: "Yes, I think so [reproductive cloning should be developed]."
1	Justification with no grounds	*In response to the gene therapy for Huntington's disease scenario*: "If they can stop someone from suffering then sure."
2	Justification with simple grounds	*In response to the reproductive cloning scenario*: "I don't think it's right because if you're not able to have a child …it's not God's will. If God wants you to have a child, you should have a child. But if it's not for you to have a child, I mean, I think you shouldn't tamper with it."
3	Justification with elaborated grounds	*In response to the gene therapy for intelligence scenario*: "They will develop a dichotomy even more so than we see now with the rich and poor. Now we will have the smart vs. the stupid or those who can afford this procedure and those who cannot. And that will create all kinds of sociological problems. I think that is meddling too much."

Table 2.5 (continued)

Score	Description	Excerpt
4	Justification with elaborated grounds and a counter-position	*In response to the gene therapy for Huntington's disease scenario*: "I think that gene therapy, it should be actually used very sparingly because what it does is narrows the diversity-like everyone gets the good copy now so that is not necessarily good because then we do not have a backup for anything. But in cases like this, where the only cure would be replacing the actual gene, then it could be beneficial…If there are no other treatments for it, that would be only way that I would support using gene therapy for something like that. But I think all other means should be exhausted before we start messing with someone's genes."

Note. Adapted from "A threshold model of content knowledge transfer for socioscientific argumentation" by T. D. Sadler and S. R. Fowler, 2006, *Science Education*, *90*(6), pp.986-1004.

This argumentation analysis rubric was also focused on the structure of student arguments in order to assess argument quality; however, it was not solely a structural analysis framework in the sense of TAP such that argument quality was determined according to the presence of pre-determined categories rather it was focused on the nature of justification of student claims. For example, the lowest level of argumentation described by the rubric identified situations in which a participant did not provide any justifications for the claim(s) s/he made. In the Table 2.5 this situation was described as "No Justification" and a score of 0 was assigned to the argument. In the excerpt demonstrating this level, the student agreed to the use of reproductive cloning but did not provide any justifications for his/her claim. The next level of argument quality is labeled as “Justification with no grounds”. Grounds in this case corresponded to supports regarding a justification such as in the sense of data, warrants, or backings in Toulmin’s scheme. For the second level of argumentation a score of 1 was assigned and in the excerpt, the student agreed to the use of gene therapy in response to Huntington’s disease scenario and justified his/her position by stating that gene therapy could alleviate people’s suffering. However, in this level the student did not present any ground in support of the justification. In the third and fourth levels of argumentations, justifications were supported by grounds. The difference between the levels was that in the third level (i.e. justification with simple grounds), the participant proposes his/her justification with a simple single ground in support of the justification. In this level a score of 2 was assigned to the argumentation. In the excerpt, this level was exemplified such that the student did not agree to the use of reproductive cloning on the basis of religious beliefs and provided a ground in support of this justification claiming that if God wanted someone to have a child then the individual would be able to do so, otherwise it would not be right to change God’s will. In the fourth level of argumentation, a score of 3 was assigned to the argumentation and the level was defined as “Justification with elaborated grounds”. In the excerpt, the student provided an analogy to contemporary problems in society and made a prediction about the consequences when gene therapy was used for intelligence. The final and highest level of argumentation defined by the framework was labeled as “Justification with elaborated grounds and a counter-position” and a score of 4 was given. In this level, students provided justifications with elaborated grounds and also recognized counter-positions to their own claims. In the excerpt demonstrating this level, the student agreed to the use of gene therapy for treatment of Huntington’s disease but reminded to be cautious since modification of human genes could have potentially harmful effects. Sadler and Fowler used statistical analysis for determining differences between groups (i.e. science majors, non-science major, and high school students) in terms of argumentation quality identified as the total number of justifications presented individually across three socio-scientific issues (i.e. reproductive cloning, gene therapy to enhance intelligence and gene therapy for Huntington's disease). The results revealed that science majors showed higher levels of argumentation scores and justification themes than both non-science majors and high school students. Argumentation scores and justification themes were not different among non-science majors and high school students. In addition to statistical significance, the researchers described a practical significance such that mean scores for argumentation quality for science majors was more than that of non-science majors and high school students as well as science majors provided more justifications across three scenarios in average than non-science majors and high school students (Sadler & Fowler, 2006). In addition to these results, Sadler and Fowler also suggested that students in three groups (i.e. science majors, non-science majors, and high school students) did not differ in their thinking; however, science majors supported their arguments with more specific science knowledge (Sadler & Fowler, 2006). In the present study, students' individual arguments in socio-scientific issues were also investigated by the researcher in terms of justifications presented according to the socio-scientific topic introduced. For this reason, the analysis framework developed by Sadler and Fowler was adapted for this study as an analysis framework for quality argumentation analysis. The detailed description of the adapted framework was given in the method section of this study.

In the following section, research on epistemic beliefs and students' epistemic belief levels as related to the quality of their argumentations were described in detail.

2.2.4. Research on Epistemic Beliefs of Students Related to Argumentation in Science Education

As regards to epistemic beliefs and argumentation of students and the relationship between them, a range of research has been conducted in the science education literature. However, before mentioning the related research on epistemic beliefs and argumentation; it is appropriate first to give the definition and the origins of epistemology in philosophy and educational research. Epistemology, which is described as the study of knowledge and knowing, has been broadly investigated in philosophy (Buehl & Alexander, 2001; Hofer, 2001). The origins of the term epistemology stem from the Greek words episteme meaning “knowledge” and logos meaning “explanation” (Buehl & Alexander, 2001). The field of epistemology as a philosophical inquiry has been founded by Plato’s studies such as Meno and Theaetetus in which he described the nature of knowledge as *justified true belief* (Buehl, 2003). Around 400 BC, Plato described the elements of knowledge such as truth, belief, and justification (Buehl & Alexander, 2001). For example, according to Plato’s definition, to identify something as knowledge, a proposition first should be *true*. Second, the subject should *believe* that the proposition is true. Finally, the truthfulness of the proposition should be *justified* by reason or data (Buehl, 2003; Buehl & Alexander, 2001).

In addition to studies in philosophy, epistemology has also been investigated by researchers in educational, developmental, and instructional contexts (Hofer, 2002). The studies on epistemology in these contexts developed in three main lines of research. In the first main line of research, researchers proposed structural models with developmental sequence on epistemology of students. The first of these studies was Perry’s (1970) work on moral and intellectual development of college students in Harvard University and Radcliffe College (Buehl & Alexander, 2001; Hofer & Pintrich, 1997). In his study, Perry conducted interviews with students regarding their college experiences. Although Perry, as a university professor, did not conceive his work as a study on students’ epistemologies, he identified a trend in students’ interviews and determined that students used varied perspectives regarding knowledge and learning which is associated with their levels of educational experience (Buehl & Alexander, 2001). For example, freshman exhibited a dualistic position about knowledge in which knowledge is seen as either right or wrong whereas more advanced students reflected relativistic views in which contextual nature of knowledge is discussed (Buehl & Alexander, 2001).

However, Perry worked with a predominantly male sample and as a response to Perry's study, Belenky, Clinchy, Goldberger, and Tarule (1986) studied women's ways of knowing with an entirely female sample (as cited in Clinchy, 2002). In the book chapter, *Revisiting Women's Ways of Knowing,* Clinchy (2002) stated that Belenky et al. (1986) described "five different perspectives from which women view the world of truth, knowledge, and authority" (p.64) for which Perry's scheme provided the scaffolding for initial coding. These perspectives were *silence, received knowing*, *subjectivism*, *procedural knowing*, and *constructed knowing*. Belenky et al.'s scheme mainly focused on the self-concept of women and their ways of knowing (Hofer, 2001). Similar to Perry, Belenky et al., in their study did not specifically examine epistemological beliefs of students rather they used questions not necessarily related to women's academic knowledge and learning but were more related to their lives (Buehl, 2003). The major contribution of Belenky et al.'s scheme was that it focused on a progressive integration of knowing across five domains described (Hofer, 2001). Baxter Magolda (2004), on the other hand, investigated young adults' epistemic assumptions about the nature, limits, and certainty of knowledge and the evolution of these assumptions in both male and female samples in contrast to both Perry's (1970) study with males and Belenky et al.'s study with females (as cited in Baxter Magolda, 2004). Similar to Belenky et al., Baxter Magolda tried to use Perry's scheme to students' responses but were not successful and proposed her own developmental model, the Epistemological Reflection Model, in which four different ways of knowing were determined such that *absolute knowing* where knowledge was believed as certain and absolute, *transitional knowing* where knowledge was believed to be partially certain and partially uncertain, *independent knowing* where knowledge was believed as uncertain and alternative ideas were justified and, *contextual knowing* where knowledge was judged on the basis of evidence in certain contexts (Buehl & Alexander, 2001). In her study, Baxter Magolda identified gender-related patterns for the first three ways of knowing. In the absolute knowing the two patterns were receiving (more common among women) and mastery (more common among men). For the transitional knowing, interpersonal (common among women) and impersonal (common among men) patterns were identified. For independent knowing, interindividual (more common among women) and individual (more common among men) patterns were identified. However, those gender patterns indentified for the first three ways of knowing appeared to converge for contextual knowing (Baxter Magolda, 2002). Therefore, Baxter Magolda concluded that although gender-related patterns could be identified in early stages of the developmental model, these patterns converge in later stages (Hofer, 2001). The second main line of research included investigations of how epistemological assumptions influence thinking and reasoning processes with a focus on reflective judgment (King & Kitchener, 1994) and argumentation skills (Kuhn, 1993) in samples with more variation in age and educational background (Buehl & Alexander, 2001). The third and most recent main line of research investigated epistemological ideas as a system of beliefs which could be independent rather than a sequential and coherent developmental structure (Schommer, 1990 as cited in Hofer & Pintrich, 1997).

Since the nature of and the relationship between students' argumentation practices and their epistemic orientations were investigated in this study, the second line of research on epistemology described earlier, which focused on the ways students' epistemological assumptions influence their thinking and reasoning processes and argumentation skills, was closely related to the research objectives of the current study and thus was further described. Building on the works of Perry (1970) and Dewey (1933, 1938), King and Kitchener (2004) studied how epistemic assumptions influence students' reasoning (as cited in Hofer & Pintrich, 1997). The researchers presented individuals with four different controversial (i.e. ill-structured) problems and asked a series of questions in order to determine students' beliefs about knowledge and their patterns of justifications of these beliefs (Buehl, 2003). Based on 20 years of cross-sectional and longitudinal research involving interviews with individuals from high-school students through middle-aged adults, King and Kitchener (2004) refined their reflective judgment model such that a seven-stage developmental model on epistemic cognition was developed (Hofer & Pintrich, 1997). As compared to Perry's work, the stages described in King and Kitchener's study bear resemblance to Perry's proposed levels and elaborate on these views. In point of fact, they did not focus on developing a model of epistemological beliefs rather they were interested in students' construction of arguments and their judgments of these arguments (Buehl & Alexander, 2001). In their study, King and Kitchener (1994) proposed a developmental progression of beliefs similar to Perry's scheme. They found that individuals' beliefs and assumptions about knowledge influenced their ways for justification of those beliefs such that educational activities improve individuals' reasoning on ill-structured problems as well as older and more experienced individuals in education receive higher scores (Buehl & Alexander, 2001). The other study to be mentioned in the second line of research in relation to epistemological beliefs of individuals was Kuhn's (1991) study on epistemological nature of students' solving ill-structured problems (as cited in Hofer, 2001). Similar to King and Kitchener (1994), Kuhn (1991) studied with a range of individuals in terms of age focusing on how epistemological assumptions influence thinking and reasoning (as cited in Hofer, 2001). Kuhn (1991), in her study conceptualized thinking as argumentative reasoning and in order to investigate this issue, she selected individuals in their teens, 20s, 30s, 40s, and 60s. The participants were presented with three ill-structured problems related to real-world phenomena such as what causes criminals to return crime, what causes children to fail in school, and what causes unemployment. The participants were first asked to state and justify their position with regard to each problem and then to generate and rebut an opposing view, offer a solution, and discuss their epistemological standards as they formulated the solution and justification (as cited in Hofer, 2001). The analyses of the participants' responses related to the certainty of expertise revealed three epistemological views namely, *absolutists*, *multiplists*, and *evaluativists*. Individuals who hold absolutist views consider knowledge as certain and absolute, emphasize facts and expertise for the basis of knowledge, and have a high certainty regarding their beliefs. In contrast, multiplists deny the expert certainty and believe all views are equally valid. Finally, individuals who have evaluativist views also deny the expert certainty and in contrast to multiplists, recognize that viewpoints can be compared and evaluated (Hofer & Pintrich, 1997). The classification of subjects into these categories showed similarity with Perry's and King and Kitchener's (1994) schemes; however, Kuhn (1991) investigated some of the extraneous non-epistemological issues which were not addressed in previous studies (as cited in Hofer, 2001). In addition, Kuhn in her study was focused on general knowledge beliefs rather than beliefs about academic knowledge and thus individuals were selected from a variety of age ranges to determine their argumentative reasoning and epistemic beliefs (Buehl & Alexander, 2001). Kuhn investigated the relationship between epistemologies and argument skills and defined the skills of arguments on basis of epistemological understanding. An analysis of the relationship between argument skills and epistemological category revealed that individuals with evaluativist views were more likely to generate alternative theories and use counterarguments than others (Hofer & Pintrich, 1997). Kuhn's study was noteworthy in terms of its focus on ill-structured problems and use of a sample of participants from a wide range of age through which it removes epistemological issues from the boundaries of classrooms and investigates individuals' daily reasoning in light of their epistemic beliefs (Hofer & Pintrich, 1997).

2.2.5. Research on Argumentativeness of Students Related to Argumentation in Science Education

Another construct which was hypothesized to have an effect on students' levels of arguments besides their epistemic belief levels was students' general traits or tendency to argue (i.e. argumentativeness) (Infante & Rancer, 1982). Infante (1981) defined argumentativeness as a communication trait which is common-place in social interactions (as cited in Johnson, Becker, Wigley, Haigh, & Craig, 2007). Infante and Rancer (1982) proposed that some individuals have a motivation to argue about controversial issues more than others such that they find arguing challenging, pleasurable and as a form of recreation. Therefore, resulting from this between-person variance, the researchers identified an argumentativeness trait (Infante & Rancer, 1982). They defined argumentativeness as:

> *a generally stable trait which predisposes the individual in communication situations to advocate positions on controversial issues and to attack verbally the positions which other people take on these issues* (Infante & Rancer, 1982, p. 72)

In their study, Infante and Rancer (1982) conceptualized argumentativeness as a positive, constructive trait related to people's willingness to argue about controversial issues with others. Group discussions and pair argumentations were also investigated in terms of individuals' tendency to argue about controversial issues and their generations of arguments and counter-arguments to peers' positions. Levine and Boster (1996) in their study investigated the students' arguments and pairing of individuals with either matched or unmatched levels of argumentativeness. They found that when a high and a low argumentative were paired, more arguments were constructed. In addition, Semic and Canary (1997) also found that argumentativeness and pairing of individuals with different argumentativeness levels had an effect on the amount of arguments generated. However, in contrast to Levine and Boster, they found that more arguments were generated when two high argumentatives were paired together (as cited in Johnson et al., 2007). In another study Kazoleas and Kay (1994) investigated group meetings in terms of arguments generated and argumentativeness of participants. The findings from the video-taped group discussions revealed that high and moderately argumentative members produced more counter statements to other members' ideas (as cited in Semic & Canary, 1997).

Infante and Rancer (1982) conceptualized argumentativeness as an approach-avoidance or excitation-inhibition conflict such that high argumentative person experiences excitation and has a tendency to argue while low argumentative person shows no excitement, experiences unpleasant feelings about arguing and therefore tends to avoid arguments and tries to keep them from happening. Consequently, the individual's general trait to be argumentative was seen as an interaction between these approach and avoidance components (Infante & Rancer, 1982). Infante and Rancer also made two distinctions between argumentativeness and the related constructs. The first one was the distinction between argumentation and verbal aggressiveness since argumentativeness involves arguing about controversial issues while verbal aggressiveness is related to attacking to the personality of individuals. Verbal aggressiveness is defined as a behavior which attacks a person's self concept in order to cause psychological pain in the other party (Infante & Wigley, 1986 as cited in Myers, 1998). The other distinction is related to the communication apprehension. Communication apprehension is defined as "an individual's level of fear or anxiety associated with either real or anticipated communication with another person or persons" (McCroskey, 1997, p.78 as cited in Infante & Rancer, 1982). In their study, Infante and Rancer reported that the trait argumentativeness and other related constructs have a moderate relationship such as although they share some variance, there was not much overlap between them and thus the validity of the trait argumentativeness was established (Infante & Rancer, 1982). In the present study, the argumentativeness of the pre-service science teachers was measured by the argumentativeness scale developed by Infante and Rancer (1982). In summary, developmental models of individuals' beliefs about knowledge and knowing principally focus in the hierarchical changes that occur in individuals' epistemological beliefs over time. These studies, starting with Perry's initial work on college students' moral and intellectual development, followed through longitudinal (e.g., Baxter Magolda, 1992; Perry, 1970 as cited in Hofer & Pintrich, 1997) and cross-sectional studies (e.g., King & Kitchener, 1994 as cited in Hofer, 2001) in which differences in epistemological beliefs of students were generally associated with age and educational background. In addition, students' college learning experiences were the primary aim of these studies rather than their epistemological beliefs (Buehl & Alexander, 2001). Specifically related to the aims of the present study, Kuhn's argumentative reasoning among other epistemological models in which three categories of epistemic beliefs levels of students and their related argumentations were described was adopted in this study. In terms of argumentativeness trait of students, the approach and avoidance components of students' argumentativeness (i.e. their tendency to argue about controversial issues) were defined and measured as an indication for the relationship between their levels of argumentativeness and quality of arguments constructed. In order to measure the argumentativeness of students, the scale developed by Infante and Rancer (1982) was adopted to the current study.

CHAPTER 3

METHOD

In this chapter, the analysis method for the present study was described in detail. First, the design of the study was presented. Then, the descriptions of the participants and the instruments used in this study were given. Following, data collection and data analysis parts were described. Finally, trustworthiness, assumptions and limitations of the study were given.

3.1. Design of the study

The design of the present study was mixed design with qualitative and quantitative research methodologies. Merriam (2002) defined several types of qualitative study methodologies such as basic interpretive qualitative study, ethnography, phenomenology, grounded theory, and case study that are commonly found in educational research. The basic interpretive qualitative research was used in this study since in this research; the researcher was interested in understanding "how participants make meaning of a situation or phenomenon" (Merriam, 2002, p.6) and the results of the study were descriptive. As Merriam (2002) suggested for basic interpretive qualitative study, the data for this study were collected through observations and analyzed to determine the PSTs' levels of argumentations. A rich, descriptive account of the findings was presented and discussed. In addition, as Merriam (1998) suggested basic qualitative study in education generally makes use of "concepts, models, and theories in various research areas such as educational psychology, developmental psychology, cognitive psychology, and sociology" (p.11) and for the present study the PSTs' written argumentations about socio-scientific issues were analyzed according to an argumentation quality framework derived from the related literature and descriptive results were given in this study. In addition to qualitative descriptions of the data, in this study, quantitative descriptions in terms of chi-square, Fisher's exact test, Pearson and Spearman correlations were presented for the hypothesized relationships between argumentation levels within and among socio-scientific issues, epistemic belief levels of the PSTs, and argumentativeness. In this respect, the design of the present study is a mixed method which includes both qualitative and quantitative descriptions of data.

3.2. Participants

The participants of this study were pre-service elementary science teachers (PSTs) who will teach elementary school science from 6th through 8th grade students after graduation. All the participants were in their senior year of elementary science education (ESE) program. Thus, they had completed several science courses such as physics, chemistry, mathematics, and biology and they were expected to have basic scientific understanding of natural phenomena. In addition, the participants were enrolled in the course named Science, Technology, and Society (STS) given to elementary science education students in their fourth year of the program. In this course, the participants were provided with scientific, technological and societal issues and the interrelation of these issues with each other. Thus, the participants were also expected to be motivated to provide their written argumentations about socio-scientific issues. Considering these issues, purposive sampling method was used in this study. Besides, convenient sampling method was also used since the participants of this study were from the department where the researcher was working as a research assistant. Totally, 30 pre-service elementary science teachers at a large public university in Ankara participated voluntarily in this study. There were 10 male and 20 female participants in this study. The age range of the participants was from 21 to 28 with an average of 23 years. Their cumulative GPA (cGPA) scores ranged between 1.91 and 3.79 out of 4 with an average of 2.78. Of the participants, 1 PST (3.4 %) lived in rural area, 7 PSTs lived in a small town (23.3 %) and 22 PSTs (73.3 %) lived in a big city before enrolling in the university. The educational levels of participants' mothers were primary (46.7 %), secondary (16.7 %), high school (23.3 %), and university level (13.3 %) while the educational levels of participants' fathers were primary (20 %), secondary (16.7 %), high school (26.7 %), and university level (36.6 %). In addition to these background characteristics, the participants' characteristics related to their use of computers and the Internet were also described. The majority of the participants (63.3 %) used computers and thus was familiar with them for more than five years. The 30 % of the participants were using computers for a period of 3 – 5 years while 6.7 % of the participants used computers for 1 – 3 years. There were no participants who used computers for less than a year. Besides, the frequency of using the Internet for participants was mostly several times a day with a percent of 86.6 % while 6.7 % of the participants were in the Internet once a day and 6.7 % of the participants spent time in the Internet several times a week. There were no participants who used the Internet with a frequency of once a week or once a month or less. Table 3.1 gives more detailed information regarding the background characteristics of the PSTs and their characteristics related to the use of computers and the Internet in their lives.

Table 3.1 The PSTs' characteristics related to use of computers and the Internet

	Frequency	**Percent (%)**
Mother's educational level		
Primary	14	46.7
Secondary	5	16.7
High school	7	23.3
University / Graduate	4	13.3

Table 3.1 (continued)

Father's educational level		
Primary	6	20.0
Secondary	5	16.7
High school	8	26.7
University / Graduate	11	36.6
Region lived in until now		
Rural area	1	3.4
Small town (pop. 25 000 – 100 000)	7	23.3
Big city (pop. > 100 000)	22	73.3
The length of time using computers until now		
Less than a year	-	0
1 – 3 years	2	6.7
3 – 5 years	9	30.0
More than 5 years	19	63.3
The frequency of using the Internet		
Once a month or less	-	0
Once a week	-	0
Several times a week	2	6.7
Once a day	2	6.7
Several times a day	26	86.6

3.3. Instruments

In this study, Participant Personal Information Sheet, Epistemic Beliefs Questionnaire developed by Kuhn et al. (2000) and The Argumentativeness Scale developed by Infante and Rancer (1982) were utilized in order to collect data from the PSTs and to describe the relationship between the PSTs' levels of argumentations and their epistemic belief levels and argumentativeness.

3.3.1. Participant Personal Information Sheet

As given in Appendix A, participant personal information sheet included 19 questions investigating the characteristics of the PSTs' personal background and use of computers and the Internet such as:

- Personal background characteristics of the PSTs: gender, age, academic major, grade level, cGPA, mothers' and fathers' educational level, and the region participants lived in.

- The PSTs' characteristics related to the use of computers and the Internet: the presence of computers at home, courses taken during undergraduate education related to computers and the Internet, the length of time of using computers until now, the frequency of using the Internet, purposes of using the Internet, and the presence of personal web page.

3.3.2. Epistemic Beliefs Questionnaire

In this study, epistemic beliefs questionnaire which is a 15-item questionnaire developed by Kuhn et al. (2000) was utilized in order to gather information about the PSTs' epistemic beliefs (Appendix B). Each item in the questionnaire consisted of two contrasting statements in five domains that are personal taste, aesthetics, values, truth about the social world and truth about the physical world (Mason & Scirica, 2006). For each judgment domain, there were three pairs of statements and each pair of statement was followed by the question "Can only one of their views be right, or could both have some rightness?" followed by two options "Only one right" and "Both could have some rightness". The following question in the same pair depended on the answer of the participant for the first question such as "If both could be right" then another two options "One could be more right" and "One could not be more right" followed the second question. This instrument was chosen by the researcher since unlike other instruments (e.g. Epistemological Questionnaire by Schommer, 1990); it only investigated beliefs about knowing and knowledge rather than learning and intelligence. In the literature, it was shown by the researchers (e.g., King & Kitchener, 2004; Kuhn, 1993) that students' epistemic beliefs and assumptions about knowledge have an influence on their thinking and reasoning processes and justifications about ill-structured problems (King & Kitchener, 1994) and argumentation skills (Kuhn, 1993). Therefore, the students' beliefs about knowing and knowledge were an important factor to be investigated in this study. As a result, Kuhn et al.'s (2000) epistemic beliefs questionnaire which specifically considered the students' belief about knowing and knowledge was implemented. The PSTs were categorized into three epistemic belief levels according to their answers to the questions and related scores such as absolutist (Only one right) scored 1, multiplist (One could not be more right than the other) scored 2, and evaluativist (One could be more right) scored 3. In order to examine students' general level of epistemological understanding on their argumentation about controversial issues, a total score for epistemological understanding for each participant was calculated. The scores for each participant could range from 15 (absolutist in all domains) to 45 (evaluativist in all domains). The scoring of the participants was done according to Kuhn et al. (2000) such that for each judgment domain participants were categorized as absolutists, multiplists, or evaluativists when responses to two of the three items for the particular domain represented the level. In cases where no patterns emerged across three items, multiplist level was assigned. Therefore, scores ranging from 15 to 25 were identified as absolutist, 25 to 35 as multiplist, and 35 to 45 as evaluativist positions. Examples of the questions are given below:

[Judgments of personal taste]

Robin says warm summer days are nicest Chris says cool autumn days are nicest	**Can only one of their views be right, or could both have some rightness?** ○ ONLY ONE RIGHT ○ BOTH COULD HAVE SOME RIGHTNESS **IF BOTH COULD BE RIGHT:** **Could one view be better or more right than the other?** ○ ONE COULD BE MORE RIGHT ○ ONE COULD NOT BE MORE RIGHT THAN THE OTHER

[Judgments of truth about the physical world]

Robin believes one book's explanation of what atoms are made up of Chris believes another book's explanation of what atoms are made up of	**Can only one of their views be right, or could both have some rightness?** ○ ONLY ONE RIGHT ○ BOTH COULD HAVE SOME RIGHTNESS **IF BOTH COULD BE RIGHT:** **Could one view be better or more right than the other?** ○ ONE COULD BE MORE RIGHT ○ ONE COULD NOT BE MORE RIGHT THAN THE OTHER

3.3.3. The Argumentativeness Scale

In this study, the PSTs' predispositions to argue about controversial issues were also measured by a 20-item Argumentativeness Scale developed by Infante and Rancer (1982). The scale was used to measure the PSTs' tendency to argue as a function of two subscales which are dispositions to approach arguments (10 items) and dispositions to avoid arguments (10 items) since argumentativeness could be conceptualized as an approach – avoidance conflict where tendency to approach arguments reflects a positive attraction and excitement about arguing while tendency to avoid arguments reflects negative feelings and anxiety about arguing (Nussbaum, Sinatra, & Poliquin, 2008) (Appendix C).

Each item in the scale were designed in a five-point Likert type such that with levels "Always never true" with a score of 1, "Rarely true" with a score of 2, "Occasionally true" with a score of 3, "Often true" with a score of 4, and "Almost always true" with a score of 5. Therefore, the PSTs' general trait to be argumentative (ARGgt) is calculated as the difference between the scores of tendency to approach arguments (ARGap) and tendency to avoid arguments (ARGav).

ARGgt = ARGap – ARGav

In terms of the reliability of the scale, the internal consistency was calculated by Cronbach's coefficient alpha for the 30 participants in this study. The reliability coefficient for the 10 argumentation approach (ARGap) items was found to be .794, while the coefficient for the 10 argumentation avoid (ARGav) items was .833. These results indicated a relatively high internal consistency for the argumentativeness scale and were also consistent with the reliability coefficients specified by Infante and Rancer (1982) in their analysis of the reliability coefficients for the scale.

3.4. Data Collection Procedure

Before data collection procedure began, the researcher took the required ethical permission from Ethical Committee in order to conduct research with human subjects. After that the consent form was distributed to the participants. All of the participants accepted to participate in this study voluntarily. The data collection procedure of the present study began in October 2009. Firstly, epistemic beliefs questionnaire and argumentativeness scale were administered to the PSTs before the actual data collection started in order to gather background information about participants' academic and personal lives as well as their epistemic belief levels and argumentativeness as an indication for their argumentations about socio-scientific issues. The main data for this study were collected by means of using an online forum discussion environment as part of the course Science, Technology, and Society. The researcher and the instructor for Science, Technology, and Society course together created a forum discussion environment in which participants could log-in with their student IDs and passwords and write and post their argumentations about the topics under discussion as well as respond to their peers. After the forum discussion environment was created, the researcher and the course instructor announced to the PSTs about the forum in the course and presented students the features of the system particularly as how to log-in and post their writings to the forum.

The researcher introduced four socio-scientific issues in the forum namely climate change, nuclear power, genetically modified foods, and human genome project in the order given and each of these socio-scientific issues was discussed by the PSTs in the forum for the period of a week. In this study, the argumentations were written and posted by the participants to the forum on a voluntary basis. In other words, participants were not enforced to write arguments other than to post their arguments related to the issue in a period of a week. Thus, the data collection procedure lasted for four weeks in total. In addition, the researcher informed the participants about how to structure their argumentations such that the participants were reminded to ground their claims with appropriate data whenever possible as well as to consider counter-positions to their own claims and to their peers' claims and formulate their argumentations accordingly.

The four socio-scientific issues were chosen by the researchers since these topics had an importance both national and international wide in terms of the impact of these issues on human lives and environment and at the same time they were related to the participants' daily lives through mass media such as televisions, newspapers and the Internet as well as through courses given in the schools such as courses which discuss issues related to science, technology and society and the relationships between these issues.

Each socio-scientific issue was presented to the PSTs with contrasting viewpoints and hypotheses such that participants could decide their own position related to the issue and construct their arguments in support of their positions as well as counter the arguments of their peers.

For example, for climate change issue, the researcher informed the participants that this was the first socio-scientific issue to which participants would provide their argumentations in favor of or against the issue. In order to establish a discussion environment among the participants related to climate change issue, the researcher introduced the issue with two contrasting viewpoints such as according to one of the points-of-view, climate change is due to increased human activity which accelerated along with the Industrial Revolution from 18^{th} to 19^{th} century resulting in production of goods and use of fossil fuels (i.e. primarily coal) and thus causing environmental pollution and ultimately destruction. The other point-of-view introduced was that according to some other scientists the recent warming of the Earth had nothing to do with human activity and the use of fossil fuels but it was more of natural processes and fluctuations in the temperatures which were present not only today but also in the history of the Earth. Based on these initial contrasting viewpoints, the participants generated their argumentations with ground(s) to support their justifications as well as providing counter-positions to theirs' and to peers' arguments related to climate change issue.

For nuclear power issue, first, the researcher provided some basic background information related to the definition and production of nuclear power. Then the researcher presented two contrasting viewpoints regarding this issue. The first of these viewpoints was that nuclear energy is a very high yield potential such that from very small amounts of raw material (i.e. uranium) large amounts of energy could be produced without emission of gases other than water vapor and this energy could power a large city for many years. Therefore, nuclear energy is considered to be environmentally friendly since it is not dependent on fossil fuels and there is not an environmental effect. The other viewpoint was that nuclear energy produces radioactive wastes which are dangerous for human health and for the environment and the safety and disposal of these radioactive materials were problematic. In addition, the safety of the nuclear power plant itself was another issue since in case of an accident radioactive fallout would create devastating effects on living and non-living components of the environment. In addition, the question of nuclear weaponry poses a treat in terms of international relations. Based on these viewpoints, the participants generated their written argumentations with ground(s) to support their justifications and counter-positions around these viewpoints for nuclear power issue.

For genetically modified foods issue, the researcher provided some basic background information regarding the definition and production of these foods. Then, two contrasting viewpoints were presented for this issue. The first of these issues was that genetically modified foods were foods which have specific changes introduced into their genetic code in order to enhance some of their traits such as resistance to cold, herbicides and increased nutritional content and value. Therefore, with the use of genetically modified foods, famine problem would be solved, there would be an economical improvement for the countries and humans would live a much healthier and quality life. On the other hand, the other viewpoint stressed the fact that altering the genetic makeup of organisms which were used as foods by humans had the probability to cause some unknown diseases in humans as well as devastating effects for the balance in the nature in terms of diversity of species. In addition, corporations which produce genetically modified organisms were interested in their profit but not the famine problem or improvement of human life. Therefore, use of genetically modified foods would be harmful to human health as well as environment. Based on these viewpoints, the participants discussed the genetically modified foods and generated their claims in which they supported their justifications with ground(s) and provided counter-positions.

The last socio-scientific issue discussed in the online discussion environment was human genome project. The researcher also provided some basic information regarding the definition, development and purpose of human genome project. Two contrasting viewpoints were also presented for this issue. One of the viewpoints was that human genome project would provide science to develop novel treatments for some incurable diseases as well as prevent possible diseases and malfunctions in humans by developing screening technologies of human genetic material for such diseases. In addition to the uses of human genome project in medicine, it would also provide healthier, stronger and perhaps more intelligent humans for the future societies. The other viewpoint stressed that fact that altering human genetic material could create unknown effects and most importantly it was unethical to change human genetic code in order to create stronger or more intelligent humans. In addition, access and uses of genetic material by third-parties such as companies could cause discrimination and humiliation among humans. Therefore, human genome project is essentially harmful for the society and for human health. In providing these viewpoints, the researcher did not favor any of the viewpoints related to the socio-scientific issue which was discussed among the PSTs and did not intervene to the discussions in order to avoid influencing the PSTs' arguments in any particular direction. In addition to these, the PSTs were informed that their responses will be kept strictly confidential such that the data gathered in this study will be only to the access of the researcher and to his two supervisors. Besides, participants were allowed to write their thoughts and argumentations in their native language in order to allow them to express their thoughts clearly and thoroughly.

3.5. Data Analysis Procedure

The data gathered in the present study were analyzed through descriptive statistics and based on the adapted version of Sadler and Fowler's (2006) argumentation analysis framework. The descriptive statistics were used in this study to describe the basic characteristics of the PSTs as well as argumentation levels and frequencies of participants in each of the four different socio-scientific issues. The number of occurrences of argumentation levels in different socio-scientific issues were indicated and compared within and across each week's socio-scientific issue. As defined by Glaser (1967), in this study, the quality of the participants' written argumentations was analyzed with the constant comparative method.

In this study, Sadler and Fowler's (2006) argumentation framework was adapted for analyzing the quality of the PSTs' written argumentations. In the previous studies, analysis of socio-scientific issues and argumentation were based on Toulmin's (1958) argumentation pattern in which data, warrants, and backings were difficult to distinguish from each other (Sampson & Clark, 2008) and dialogic argumentations in classroom environments and in student groups were mainly investigated (e.g. Erduran et al., 2004). Sadler and Fowler developed an argumentation analysis framework in which quality of student argumentations were analyzed based on justifications provided and methodological difficulties in distinguishing between components of argumentations (e.g. data, warrants, and backings) as in Toulmin's argument pattern were minimized. Another reason for using this framework was that justifications were defined as the most basic form of argumentation in terms of socio-scientific issues (Sadler & Fowler, 2006). The pre-determined argumentation levels in the framework were used in this study with adaptation. Sadler and Fowler (2006) proposed a five level argumentation analysis framework. As the levels of students' arguments increase the quality of the argumentation is determined to be higher. In the first level, Sadler and Fowler described situations in which participants provided no justifications for their claims and named the level as "No Justification" and scored as 0 for this level. The next level described situations in which participants provided justifications without grounds such that the PSTs did not support their claims with appropriate data and the level was named as "Justifications with no grounds" and scored as 1. The third level in the framework described argumentations in which participants provided justification and a single simple ground for their justifications. Thus this level was named as "Justification with simple grounds" and a score of 2 was assigned to this level. The next two argumentation levels in the framework described argumentations in which participants provided more than one ground for justifications provided. Level 4 was named as "Justification with elaborated grounds" in which more than one supporting data was presented for the justifications and a score of 3 was assigned to the level while the next level of argumentation (level 5) which was described as the highest level of argumentation by the framework identified argumentations in which participants provided more than one piece of evidence for their claims as in level 4 argumentations and in addition, they recognized counter-positions to their own claims. In this study, the adaptation of the framework was done for the descriptions of the first and the last level of argumentations which are level 1 and level 5 argumentations, respectively. Level 1 argumentation for the present study was defined as situations in which participants did not present any argumentation related to the socio-scientific issue discussed and for level 5 argumentation the definition was expanded such that participants provided grounded justifications and recognized positions or evidence contradictory to their own as in the original description of the level and also provided counter-arguments to their peers' argumentations as described for the present study.

In addition to the analysis of the PSTs' written argumentations by implementing Sadler and Fowler's (2006) argumentation analysis framework, the variation of argumentation levels within and across socio-scientific issues, the relationships between argumentation quality levels, epistemic belief levels and argumentativeness were described by statistical analyses such as chi-square, Fisher's exact test, Pearson and Spearman correlations.

Specifically, chi-square analysis was used in determining differences within and between socio-scientific issues in terms of argumentation levels. In order to perform chi-square analysis, the frequencies of arguments for each argumentation level at each socio-scientific issue were compared. The results indicated that whether the nature of the distribution of the frequencies of arguments was homogenous or non-homogenous which showed that in cases of homogenous distributions, it was inferred that there was not a significant difference between the compared variables and in cases of non-homogenous distribution, it was inferred that the frequencies of arguments were clustered around some variables and that there was a significant difference as indicated statistically.

Fisher's exact test was used in place of chi-square since sometimes the sample did not meet the assumptions for chi-square analysis such that more than 80 % of the cells of the cross-tables had expected frequencies less than 5 and the sample sizes were relatively small. The interpretation of the results of Fisher's exact test was similar to chi-square such that if the results were significant then there was a difference between the hypothesized variables. Pearson product-moment correlation and Spearman correlations were used in order to describe the relations between the hypothesized variables such that whether there was a correlational relationship between the PSTs' epistemic belief levels, their argumentation levels, and argumentativeness. The results of Pearson product-moment correlation was interpreted such that there was a small correlation when the results were between .10 and .29, a medium correlation for .30 and .49, and a high correlation for .50 and 1.0 (Pallant, 2007). Spearman correlation was used when at least one of the variables was categorical in nature such as epistemic belief levels of the PSTs. Although the PSTs' epistemic belief levels were measured by Epistemic Belief Questionnaire and were continues in terms of numbers, the nature of the variable and the categorization of the PSTs into three epistemic belief levels were categorical and thus Spearman rho correlation coefficient was calculated.

In summary, the participants' written argumentations about socio-scientific issues were analyzed according to the argumentation analysis framework as described and the relationships between the PSTs' levels of argumentations, epistemic belief levels, and argumentativeness were identified by statistical analyses in terms of chi-square analysis, Fisher's exact test, Pearson and Spearman correlations for each of the socio-scientific issues and patterns of argumentation levels were given as descriptive and statistical results.

3.6. Trustworthiness of the Study

The trustworthiness of any qualitative or quantitative study is established by providing reliable and valid knowledge in an ethical manner (Merriam, 1998). Therefore, in order to ensure the trustworthiness of this study, the issues of validity, reliability and ethics were considered by the researcher and they were presented in the following part.

3.6.1. Internal Validity

In the following part, the strategies that the researcher followed in order to confirm the internal validity of this study were presented. Merriam (1998) suggests six basic strategies to confirm internal validity of qualitative studies. Three of them were considered by the researcher in this study: (1) long-term observation, (2) peer-examination, and (3) clarifying researcher's biases.

3.6.1.1. Long-term Observation

Long-term observation is defined as collection of data by repeated observations of a phenomenon over a period of time in order to increase the validity of the findings (Merriam, 1998). In this study, the PSTs' written responses to four different socio-scientific issues in online discussion environment were recorded and observed by the researcher for a period of four weeks. Therefore, this study ensured long-term observations for internal validity.

3.6.1.2. Peer-examination

Merriam (1998) defined peer-examination as asking researchers to comment on the findings of the study. In this study, the PSTs' written responses for the first of the four different socio-scientific issues (i.e. climate change) which corresponded to the 35 % of the total data in terms of written argumentations were independently analyzed by the researcher and two science education researchers who were familiar with the analysis framework. The rest of the data were analyzed by the researcher and the science education researchers peer-reviewed the analysis. Therefore, this study ensured the peer-review for internal validity.

3.6.1.3. Clarifying Researcher Bias

Merriam (1998) identified that to ensure the internal validity, researcher should "clarify the assumptions, worldviews, and theoretical orientation at the outset of the study" (p. 205). In this study, the researcher introduced each socio-scientific issue to the online discussion environment and was the facilitator of the discussions and argumentation among the PSTs. The role of the researcher was to monitor the progress of the discussion without influencing or directing the PSTs towards any kind of argumentation levels. The researcher only promoted the discourse by presenting at least two contrasting viewpoints about the issue in the introduction part of the issue. It is assumed that the researcher did not have an effect on the level of arguments the PSTs generated during argumentation in online discussion environment.

3.6.2. Reliability

The reliability of the qualitative research refers to "the stability of responses to multiple coders of data sets" (Creswell, 2007, p.210). In addition to using validity as a measure of the reliability (i.e. dependability) of the findings of the research, there are a number of ways that researchers use to ensure that the results of their study are reliable (Merriam, 1998). One of these methods is the inter-rater agreement (Creswell, 2007). Thus, inter-rater agreement was used in order to enhance the reliability of the findings of this study.

3.6.2.1. Inter-rater Agreement

For the inter-rater agreement of this study, the researcher first decided for an analysis framework to analyze students' written argumentations. Sadler and Fowler's (2006) analysis framework for analyzing the quality of argumentation was identified and the levels of argumentations of the framework were adapted according to the needs of the present study. The adaptation of the framework was done for the descriptions of level 1 and level 5 argumentations. Level 1 argumentation in Sadler and Fowler's framework is defined as "situations in which participants failed to provide a justification in support of his/her position" (p. 993); however, for the present study level 1 argumentation is defined as situations in which participants did not present any argumentation related to the socio-scientific issue discussed. For level 5 argumentation, Sadler and Fowler defined "Justification with elaborated grounds and a counter-position" and was defined as the level in which "participants were not only able to provide grounded justifications but also recognized positions or evidence contradictory to their own" (p. 994). In this study, the definition of level 5 argumentation is expanded such that participants provided grounded justifications and recognized positions or evidence contradictory to their own as in the original description of the level and also provided counter-arguments to their peers' argumentations as described for the present study. After the definitions of the levels for the analysis framework are described, the researcher gave the PSTs' written argumentations for the first socio-scientific issue (i.e. climate change) which corresponded to the 35 % of the total data in terms of written argumentations to two science education researchers. The researcher and two science education researchers who were familiar with the research and the adapted version of the argumentation analysis framework independently analyzed the PSTs' written argumentations according to Sadler and Fowler's adapted framework. After independently analyzing the PSTs' written argumentations about the first socio-scientific issue (i.e. climate change), the researcher and the two science education researchers established a 94 % inter-rater reliability in analyzing and categorizing students' written arguments in terms of the quality of argumentation. The rest of the data were analyzed by the researcher according to the adapted framework. As for the reliability of the study, Miles and Huberman (1994) recommend an 80% agreement for qualitative data. Thus, the reliability of this study in terms of inter-rater agreement was ensured since above 80% agreement was established for the largest part of total data in terms of written argumentations for the present study.

3.6.3. Ethics

Every researcher studying in social sciences and conduct research involving human subjects is bounded by the ethical regulations and should consider ensuring that his/her research is ethical. Therefore, in this study, the researcher considered three main issues in the study in order to follow ethical regulations and ensure that the study remains ethical. These issues were protecting participants from harm, ensuring confidentiality of research, and deception of participants (Fraenkel & Wallen, 2006). Before beginning the study, the researcher collected consent forms from participants through which participants are informed about the content and nature of the study and the participation is voluntary and participants could leave the study at any time. Specifically, in the consent form, the participants were informed that the issues discussed in the study do not cause discomfort and if the participant feels so, then s/he is free to leave the study at any time. The confidentiality of this study was also ensured since the participants' responses in the study were kept strictly confidential and only the researcher himself and his thesis supervisor and co-supervisor had access to the data collected in this study. The data in this study were used only for scientific purposes. Finally, the participants in this study were not deceived in any way because before the study the participants were informed about the aim and the content of the study in consent forms. In addition, the correspondence address, e-mail and phone numbers of the researcher were provided to the participants in case the participants had questions related to the study.

3.7. Assumptions of the Study

For this study, the following assumptions were made:

1. In order to analyze the nature and the quality of students' written argumentations about socio-scientific issues, the sample of this study was purposefully selected from Science, Technology, and Society course since it was assumed that the participants would constitute a representative sample in terms of understanding and presenting arguments about socio-scientific issues.

2. In this study, the PSTs were administered with an epistemic beliefs questionnaire and argumentativeness questionnaire before the start of the data collection procedure. Thus, it was assumed that the administration of these questionnaires took place under standard conditions without threats to the issues of internal validity of this study. In addition, it was also assumed that the administration of these questionnaires before the actual data collection procedure did not have any effect on the PSTs' level of argumentations about socio-scientific issues.

3. The major data source for the present study was an online discussion forum in which socio-scientific issues were discussed by the participants and written argumentations of the PSTs were collected. Thus, it was assumed that these discussions took place under standard conditions such that the researcher did not promote any kinds of argumentation in students' responses as regards to socio-scientific issues. Besides, it was also assumed that the written introduction of the

socio-scientific issues by the researcher through the online forum system was given without any tendency to a particular viewpoint.

4. All of the participants were in their senior (i.e. fourth) year of elementary science education programs, therefore participants took related science courses and it was assumed that participants had some preliminary knowledge regarding scientific topics related to socio-scientific issues.

3.8. Limitations of the Study

The limitations of this study are following:

1. The number of participants in this study was limited to 30 PSTs who were enrolled in a course of ESE program named Science, Technology, and Society in the fall semester of 2009-2010 academic year. Therefore, the results of this study described only the sample characteristics and could only be generalized to individuals whose credentials and academic experiences were similar to those studied.

2. The nature of this study was qualitative rather than quantitative therefore the results do not represent statistical generalizations and data collection and data analysis parts largely depended on and limited by the researcher's background and capabilities.

3. The data collection procedure took place through an online discussion environment in which participants wrote their argumentations about the related topic. The researcher did not have a chance to ask the participants of this study to confirm the data of this study so the interpretation and representation of the PSTs' statements were limited to the understanding of the researcher.

4. The socio-scientific issues chosen on this study were designed to engage the PSTs in argumentation and write their argumentations about these topics in an online discussion environment. Therefore, the results of this study were limited by the context and design of this study and may not apply to other online discussion environments.

CHAPTER 4

RESULTS

In this chapter, the results of this study were presented in two sections consisting of qualitative and quantitative results. First, qualitative descriptions of the PSTs' written argumentations and frequencies of their argumentations were given in terms socio-scientific issues (SSI) and the levels of argumentation quality. Second, the number of arguments were presented and compared in relation to socio-scientific issues, epistemic belief levels and argumentativeness. In addition, the relation between the PSTs' levels of argumentations and their epistemic beliefs and argumentativeness were described.

4.1. The Levels of Argumentation by Pre-Service Science Teachers During Discussions of Socio-Scientific Issues in Online Environment

This section focuses on the first research question which inquires the levels of the PSTs' argumentation regarding socio-scientific issues. In this section, descriptive results about the levels of argumentation generated by the PSTs in online discussion environment were presented qualitatively for each socio-scientific issue in order to illustrate the nature and the quality of arguments.

During online discussion sessions, the PSTs generated arguments with varying levels of quality for each socio-scientific issue. There were four socio-scientific issues namely climate change, nuclear power, genetically modified foods and human genome project discussed by the PSTs. The levels of the PSTs' written argumentations were described as five levels by argumentation analysis framework used in this study. These levels were defined as:

Level 1- ***No Justification (NJ):***

This level of argumentation was defined such that no argumentation was presented by the PSTs regarding the socio-scientific issue.

Level 2- ***Justification with no grounds (JwNG):***

In this level, justifications were given by the PSTs without grounds such that the PSTs did not support their claims with appropriate data.

Level 3- ***Justification with simple grounds (JwSG):***

For this level, the PSTs presented only one simple ground for their justifications such that claims were supported by a single piece of data.

Level 4- ***Justification with elaborated grounds (JwEG):***

For this level, the PSTs presented more than one ground for the justifications generated. In other words, claims were supported with more than one piece of data.

Level 5- ***Justification with elaborated grounds and counter-positions (JwEG/CP):***

For this level more than one piece of evidence were provided by the PSTs for their justifications as well as they recognized counter-positions to their own claims and provided counter-arguments to their peers' arguments.

4.1.1. Socio-scientific Issue # 1: Climate Change (CC)

The PSTs' levels of argumentations are presented and described in this section for the first socio-scientific issue that is climate change.

Level 1- *No Justification (NJ):*

For this level only 1 argument was constructed by the PSTs during discussions of the climate change issue. The representative quotation written by the PST was given in Table 4.1. In the example quotation, the PST did not provide any argumentation because he did not propose a claim. Instead, he only posed a rhetorical question concerning the climate change issue and the situation of polar bears regarding the fact that polar ice caps are melting due to climate change. Therefore, this argumentation was determined as NJ in which no clearly identifiable argumentation was presented by the PST.

Level 2- *Justification with no grounds (JwNG):*

For this level, a total of 4 arguments were constructed by the PSTs during discussions of climate change issue. Two of the example quotations constructed by the PSTs were given in Table 4.1. In the example quotations, both of the PSTs asserted that climate change was due to humans. In the first quotation, the PST claimed that people were irresponsible and thus no action would be taken until climate change issue starts to effect their environment. In the second quotation, the PST claimed that humans were the reason for climate change but they did not have an idea about climate change and how would it have an impact on the lives of people. However, none of the PSTs presented grounds for their claims and thus their claims were categorized as JwNG.

Level 3- *Justification with simple grounds (JwSG):*

A total of 8 arguments in this level were generated by the PSTs for climate change issue. Two of the example quotations constructed were given in Table 4.1. In the examples, the two PSTs had two opposing views regarding the cause of climate change such that in the first quotation, the PST thought that climate change was due to humans and there would be catastrophic events in a short time period and in the second quotation the PST thought that the issue of climate change was exaggerated. Moreover, both of the PSTs supported their claims by mentioning a single data such as referring to the reports of scientific organizations as regards to the present and future effects of climate change and stating that taking small precautions would be enough in preventing those effects. Therefore, both of these argumentations which included a single ground to support the claims PSTs presented were categorized as JwSG.

Level 4- *Justification with elaborated grounds (JwEG):*

A total of 13 arguments in this level were constructed by the PSTs. Two of the example quotations were given in Table 4.1. In the example quotations, both PSTs asserted that climate change was due to human activity such as excess emission of greenhouse gases into the atmosphere. In both of the example quotations, multiple grounds were presented to support the claims such as overcoming the ability of the atmosphere to compensate for greenhouse gases, melting of the ice in polar regions, increase in the emission of greenhouse gases, efforts to regulate these emissions through international protocols and the stock market involved in these issues. Therefore, the argumentations included several grounds to the claims PSTs asserted and thus were categorized as JwEG.

Level 5- *Justification with elaborated grounds and counter-positions (JwEG/CP):*

The PSTs generated a total of 12 arguments for this level. Two of the example quotations constructed by the PSTs were given in Table 4.1. In the example quotations, both of the PSTs put forward their claims that climate change was due to humans and that the effects were observed in many situations. For their claims, the PSTs provided several supporting data such as melting of arctic glaciers, extinction of many species, disruption of the ecosystem, and politicians who act selfish on these matters. As counter-positions, they mentioned that climate change was not only a water shortage problem as the second PST asserted and even if it was exaggerated, necessary precautions should be taken in order to prevent the issue before it becomes too late. Therefore, these argumentations included multiple grounds in support of the claims and counter-positions and were categorized as JwEG/CP.

Table 4.1 Student excerpts at argumentation levels in climate change issue

Argumentation level	**Student excerpts**
NJ	PST: [In response to the situation regarding climate change which was presented by the researcher] What will be the situation of polar bears [due to climate change]?
JwNG	PST: People are irresponsible and no one is preparing an action plan [as how to prevent climate change]. They will not take action until this problem starts to affect their immediate environment.
	PST: [In response to another PST who asserts that the reason for climate change is humans] I agree to my friend. Although we [humans] are the main reason for this problem [climate change], unfortunately many people do not have an idea about what climate change means, how will it affect us, and they remain silent about it […] As my friend said, climate change occurred because of humans and the solution to it is again with humans.
JwSG	PST: As a result of climate change, many places will be wiped out from the surface of the Earth. For example, according to United Nation's Intergovernmental Panel on Climate Change (IPCC), Maldives will be the first piece of land to be under water if climate change cannot be stopped since the highest point in Maldives is 2.5 m high above sea level. If continues at this rate, climate change will cause Maldives to be history in just 100 years.
	PST: I think that it [climate change] is early to worry. This is extra worries of scientists. I am sure that somehow we will overcome this problem. It would be sufficient to take a few practical precautions for now. We will think the rest later.

Table 4.1 (continued)

JwEG	PST: The reason for climate change is the emission of excess amount of greenhouse gases into the atmosphere and [thus] trapping more heat in the atmosphere. The major greenhouse gas is CO_2. I believe that the contribution of humans to the emission of greenhouse gases is large. Under normal conditions, it is possible for our planet to compensate for such an effect to the atmosphere; however, since humans interfere with the nature more than normal, it is impossible for such compensation. […] United Nations Environment Programme head Achim Steiner reports that the sea levels will rise between 18 to 59 cm. Glacier melting in Antarctica and Greenland should not be ignored. I guess all these indicate us that something should be done. PST: In my opinion, the factors that affect global warming are mainly human-based factors as most of us indicated. The effect of human intervention has been revealed as the effects of climate change have become noticeable in our lives for the last 50 years. Especially, the use of fossil fuels in industries and energy [production] […] Kyoto protocol tries to [control the use of fossil fuels] however in application, there are difficulties. [Countries] could exchange emission […] there is a stock market and trade around the emission of greenhouse gases […] We are talking about point of no return, about extinction of human race. Trade should not have entered this issue.

Table 4.1 (continued)

JwEG/CP	PST: [In response to a PST who asserted that every 15-20 years Turkey and the world face drought and arid seasons] Yes, what you say is true but these do not prove that there is no climate change because the only problem is not the water problem. I wish we had faced the melting of arctic glaciers and extinction of polar bears just for one year. Once a species is extinct then there is no return. Whether you are aware of or not, but every day the number of species which are threatened to be extinct increases. Once upon a time they were pandas, now we know that we can count them in zoos. Today, poor polar bears and tomorrow I wonder which animal. It is a great mystery that how ecosystem will tolerate these extinct species and it is obvious that the problem needs a broader definition than global warming because I think that warming would disrupt the system.
	PST: [In response to a PST who asserted that every 15-20 years Turkey and the world face drought and arid seasons] In fact, I both agree and disagree with my friend. I mean, these events that they tell us would happen in 50 years could happen in 100 years. Humankind, unfortunately, thinks of its own benefit and acts selfish. It is not surprising that politicians use every problem for their benefits. The point I do not agree is that: OK, maybe it [climate change] is exaggerated but we will have the chance to live in comfort and peace when we consider this issue as seriously and early as possible. It is not possible to take time back […] Precaution is taken before the event happens not during.

4.1.2. Socio-scientific Issue # 2: Nuclear Power (NP)

The PSTs' argumentations about nuclear power issue were presented and described in this section.

In this SSI, the first level of argumentation (NJ) and the second level of argumentation (JwNG) were not generated by the PSTs. The argumentation levels generated by the PSTs were at levels of Justification with simple grounds (JwSG), Justification with elaborated grounds (JwEG), and Justification with elaborated grounds and counter-position (JwEG/CP).

Level 3- *Justification with simple grounds (JwSG):*

A total of 7 arguments were generated by the PSTs for this level. Two of the example quotations constructed by the PSTs were given in Table 4.2. In the example quotations, both of the PSTs asserted that nuclear energy should be used. In order to support their claims, the PSTs provided grounds such as insufficiency of renewable energies, spending of a lot of money to meet the energy needs of Turkey and dependency on foreign sources. For each argumentation, the PSTs provided only one supporting data for their claims and thus their argumentations were categorized as JwSG.

Level 4- *Justification with elaborated grounds (JwEG):*

A total of 8 arguments were generated by the PSTs for this level. Two of the example quotations by the PSTs were given in Table 4.2. In the example quotations, the PSTs proposed opposing claims about the nuclear power issue. In the first quotation, the PST who did not support nuclear energy provided grounds for her claims such that nuclear energy is harmful to both human health and to nature, there are safety issues, high costs of licensing and costs of shutting down of these nuclear power plants. In the second quotation, the PST who supported nuclear energy provided grounds for his claims such as natural gas is a limited energy source and it will deplete in the near future which would force us to transfer to other energy sources. In addition, efficiency of renewable energies are no match for nuclear energy and with well-trained personnel, threats would be minimized for nuclear power. Therefore, the PSTs provided multiple grounds for their claims and the argumentations were categorized as JwEG.

Level 5- *Justification with elaborated grounds and counter-positions (JwEG/CP):*

The PSTs generated a total of 19 arguments for this level. Two of the example quotations constructed by the PSTs were given in Table 4.2. In the example quotations, the PSTs who had opposing views about nuclear energy presented their claims. In the first quotation, the PST who supported nuclear energy stated that fossil-based energies are extremely harmful to environment and to human health and thus nuclear energy should be considered as an option. In terms of counter-position, he stated that until new technologies are developed to benefit from alternative energies in terms of efficiency, he would support nuclear energy. In the second quotation, the PST did not support nuclear energy and grounded her claims such that for a country which has natural resources such as sun, wind, and water, nuclear energy should be the last option. In addition, it was not certain that nuclear energy would not be dependent on foreign sources. In terms of counter-positions, the PSTs asserted that until new technologies which provided more efficiency in renewable energies and which reduced the risks of nuclear power had been developed, they would support nuclear power. Therefore, the PSTs' argumentation levels were categorized as JwEG/CP since they provided several grounds for their claims as well as included counter-positions in their argumentations.

Table 4.2 Student excerpts at argumentation levels in nuclear power issue

Argumentation level	**Student excerpts**
NJ	-
JwNG	-
JwSG	PST: [In response to another PST who claims that renewable energies are not enough] I agree with my friend because with renewable sources we could only meet a small portion of our energy needs. We should use nuclear energy. PST: I am in favor of nuclear energy because Turkey meets its energy needs by spending a lot of money. By constructing nuclear power plants this dependence on foreign sources should be reduced.

Table 4.2 (continued)

JwEG	PST: I would like to explain the reasons why I do not support nuclear energy. Nuclear energy is the most harmful energy source among other energy sources today both in terms of society and environment. No new [nuclear] power plant is ordered since 1978 considering economic and health issues. It is not enough to build these power plants; the infrastructure for safety should also be established […] After Chernobyl accident, licensing costs are also added […] Most developed countries shut down these [nuclear power plants] instead of building new ones […] It is nearly impossible to estimate the costs of shutting down these power plants, effects of their wastes on human health and environment. I support the shutting down of these nuclear power plants.
	PST: [In response to PSTs who agree with the use of nuclear energy] I, too, agree with the use of nuclear energy. Right now, more than half of our electricity production is provided by natural gas and as we all know natural gas will deplete after a while and we will have to transfer to other energy sources. Most of us want to use environmentally friendly energy sources; however, when we compare these resources with nuclear energy we can see a significant efficiency difference. As for the harms to environment, under appropriate conditions and when used by well-trained personnel, it is possible to reduce the harms to a minimum.

Table 4.2 (continued)

JwEG/CP	PST: I see myself as a stakeholder in this issue because one of the thermal power plants which provide a large portion of Turkey's electricity is in my hometown. I am talking about Afsin-Elbistan thermal power plant. I want the energy which is produced by fossil fuels to be abandoned […] In this area it is not snowing white. There is a serious decline in soil quality in a 30 km radius around the power plant. The most important statistic is that the cancer incidents are above 300 times Turkey's average. Now, I watch people in their 50s to get lung cancer and I think that this environmental holocaust is worse than Chernobyl. Thus, I want thermal power plants to be shut down. For the increasing energy needs I believe that existing systems are not so clean and if million kilowatts are in question then until new technologies which provide more efficiency in renewable energies are developed, I support building nuclear power plants.
	PST: It is obvious that our country has an energy problem and we are dependent on foreign sources in terms of energy and energy need increases due to increasing population. When this combines with global environmental problems, it becomes a necessity to find alternatives to fossil based energy […] I think that for a country which has sun, wind, water, and geothermal energy, nuclear energy should be the last in the list. Besides, there is no such thing that nuclear energy will not be dependent on foreign sources because we do not have necessary technology to build and operate a nuclear power plant […] shutting down these power plants are much more expensive […] there is a nuclear waste issue […] If in the long run, we cannot deal with the energy problem with renewable resources and if we could reduce the risks to minimum with sufficient technology, then it is possible to rethink nuclear power issue. Right now, I think since we have alternative [energy] resources, it is not worth to take the chance for such a risky thing both for nature and humans.

4.1.3. Socio-scientific Issue # 3: Genetically Modified Foods (GMFs)

In this section, PSTs' argumentations about genetically modified foods and their levels of argumentation quality were described.

In this SSI, the first level of argumentation, NJ, and the second level of argumentation, JwNG were not generated by the PSTs. The argumentation levels generated by the PSTs were at levels of JwSG, JwEG, and JwEG/CP.

Level 3- *Justification with simple grounds (JwSG):*

A total of 3 arguments in this level were generated by the PSTs for genetically modified foods issue. Two of the example quotations constructed by PSTs were given in Table 4.3. In the example quotations, both of the PSTs were against genetically modified foods and they provided single grounds for their claims. In the first quotation, the PST claimed that genetically modified foods were harmful in terms of health, economy, and biological diversity and supported his argumentation with the ground such as genetic change among normal plants and its agricultural effects would be detrimental. In the second quotation, the PST claimed that genetic manipulation of organisms could cause problems to which no solution was known. In order to support his claim, the PST presented a single ground such that consuming genetically modified foods would have unforeseen consequences on human health. Therefore, both of these argumentations were categorized as JwSG.

Level 4- *Justification with elaborated grounds (JwEG):*

In this level a total of 13 arguments were constructed by the PSTs. Two of the example quotations were given in Table 4.3. In both of the example quotations, the PSTs presented their claims such that they were against the use of genetically modified foods and used multiple grounds to support their claims such as harms to human health, differences in taste, shape and quality between these foods and normal crop, decline of agriculture in the country and creation of monopolies were provided for each claim. Therefore, these argumentations were categorized as JwEG.

Level 5- *Justification with elaborated grounds and counter-positions (JwEG/CP):*

The PSTs generated a total of 5 arguments for this level. Two of the example quotations constructed by the PSTs were given in Table 4.3. In the example quotations, the PSTs proposed multiple grounds to support their claims as well as mentioned counter-positions to their own claims. For example, in the first quotation, the PST asserted that genetically modified foods could have unknown harms to humans and to environment and it would be impossible to foresee these effects and thus suggested to be careful until measurable results are produced; however, he recognized that genetically modified foods could also help us solve the famine problem in many countries in Africa. In the second quotation, the PST asserted that use of genetically modified foods is not necessary since natural production is sufficient to meet the demand at least in Turkey and in addition to that corporations which produce these foods think of only their profit. In addition, the PST acknowledged that in the future only option left could be genetically modified foods where technology improved and people became more conscious. Therefore, these argumentations included multiple grounds to support claims and counter-positions and thus were categorized as JwEG/CP.

Table 4.3 Student excerpts at argumentation levels in genetically modified foods issue

Argumentation level	Student excerpts
NJ	-
JwNG	-
JwSG	PST: These genetically modified organisms prevent health, economy and biological diversity […] When farming is performed with these products the pollens of these products fertilize normal plants and cause genetic change. This is called as gene escape and results in species becoming monotype and disappearance of pure races. PST: Genetic manipulation not just in foods but in other organisms could cause problems to which we do not know of any solution […] For example, in obesity people are faced an illness which is transmitted through genes due to their nutritional habits. While just nutritional habits could cause such a manipulation, we could not be sure what kind of effects taking in a constant genetic pool would make but it would never be favorable.

Table 4.3 (continued)

JwEG	PST: I am against genetically modified organisms [...] In the village where my family lives people provides their living from agriculture. At different times in the year, different products such as tomato, pepper, and eggplant in summer and onion and spinach in winter are harvested. These products come as grass or seed. The question here is where these grasses or seeds come from? Very few companies in Turkey sell seeds or grass […] Once crop is harvested from these seeds or grass, we cannot gather seeds from these or even if there is seed it does not germinate in the soil. Similarly, taste, shape and quality of these products as compared to local ones are very different […] The production of local crops are also affected in the fields and gardens in which these crops [genetically modified] are produced […] In the same time, we also put our health into danger by eating these foods.
	PST: Our country has a biological diversity such that we do not need production of such kinds of foods [genetically modified] […] the agriculture of our country will be in the hands of monopolies which produce genetically modified foods; agriculture would have taken another hit. The consumption of genetically modified foods should be stopped.

Table 4.3 (continued)

JwEG/CP	PST: I think that genetically modified organisms could cause unknown harms to environment and to humans. However, this procedure could help us produce crops which we normally could not due to limitations such as area and water. It [genetically modified foods] could help us solve the famine problem. For example, in Africa with this procedure we could produce fast and more foods and overcome the famine problem […] But it is said that at least 10 years is required to assess the outcomes of this procedure. Thus, many countries allowed these kinds of studies under limited conditions. Besides, this unnatural production style could disrupt the balance of the nature. Since it would be impossible to amend the bad results of these practices, we should be careful as the whole world and until the results become measurable, production of genetically modified organisms should be banned.
	PST: I think it is ridiculous to consume genetically modified foods when natural production could meet the demand (in terms of Turkey). Other countries could be insufficient in meeting the demand due to their populations and genetically modified organisms may be needed. In addition, corporations which produce genetically modified organisms think of their profit and ignore human health. Especially since the effects on human health occur after 20-30 years, they are in comfort. I know, maybe in the future the only option in our hands will be genetically modified organisms but at least I hope that technology will have been improved and people will be more conscious.

4.1.4. Socio-scientific Issue # 4: Human Genome Project (HGP)

In this section, PSTs' argumentations about human genome project and their levels of argumentation quality were described.

In this SSI, NJ and JwNG were not generated by the PSTs. The argumentation levels generated by the PSTs were at levels of JwSG, JwEG, and JwEG/CP.

Level 3- *Justification with simple grounds (JwSG):*

In this level only 1 argument was generated by the PSTs. The example quotation was given in Table 4.4. In the example, the PST asserted that he was against human genome project. In order to support this claim, the PST provided a single ground such as with this issue eugenics concept and racism emerged again and posed a serious threat to the society. Therefore, this argumentation was categorized as JwSG.

Level 4- *Justification with elaborated grounds (JwEG):*

For this level only 1 argument was generated by the PSTs. The example quotation was given in Table 4.4. In the example, the PST asserted that human genome project would cause eugenics and racism. In addition, the PST asserted that the possibility of production of biological weapons would produce a great threat to the society in the future. Thus, there were more than one ground to support the claims and thus this argumentation was categorized as JwEG.

Level 5- *Justification with elaborated grounds and counter-positions (JwEG/CP):*

The PSTs generated a total of 13 arguments for this level. Two of the example quotations constructed by the PSTs were given in Table 4.4. In the first quotation, the PST supported human genome project. In order to ground his claim, the PST provided multiple grounds such that the diagnosis and treatment of illnesses such as diabetes, heart diseases and cancer which cause death of millions of people would be easier and people would live a healthier life. As counter-position, the PST acknowledged that human genome project would not be able to provide most of its promises as mentioned in media in a short time and some of them will never come true such as completely finishing illnesses or providing immortality. In the second quotation, the PST did not support human genome project. The PST provided multiple grounds in order to support her claim such that this project will add genetic discrimination to crimes against humanity such as race, religion and ethnicity discrimination. As counter-position, the PST asserted when she could get satisfactory answers to her questions concerning the confidentiality of genetic code, production of new drugs and treatment methods and ethical issues, she could support human genome project. Therefore, these argumentations were categorized as JwEG/CP.

Table 4.4 Student excerpts at argumentation levels in human genome project issue

Argumentation level	Student excerpts
NJ	-
JwNG	-
JwSG	PST: I would like to talk about the unethical side of human genome project. With this project, eugenics concept has emerged again […] In this respect, I think that this project poses a serious threat to societies. I argue that if this project is used by people who do not have goodwill, it will cause a great genetic discrimination. When it is taken into consideration that there are still racist thoughts in the world, I think that this project will bring a big harm to humanity.
JwEG	PST: The starting point is good for this project. The goal is to somehow cure the genes which cause illnesses. But in the end, it will not be like this. I agree with my friend [who claims that this project will cause eugeny]. Eugeny will give birth to racism […] Besides, there is a terrorism issue. Think about it, your whole genetic map is in the hands of others. Production of biological weapons which are specific for a race could be thought of in the future. As a result, I do not support this project.

Table 4.4 (continued)

JwEG/CP	PST: I also think that human genome project will be helpful because, by this way, the diagnosis and treatment of illnesses will be easier. Illnesses such as diabetes, heart diseases and cancer which cause death of millions of people could be pre-diagnosed and prevented. But of course, human genome project could neither completely finish illnesses as exaggerated in media nor is useless. Surely, there had been some benefits to human health and there will be. But, these will never provide immortality as it is supposed. Only, people would live a healthier life or many diseases will be history. But, this project will never be a cure for diseases […] As a result; I could say that thanks to this project many diseases could be prevented and background could be established for new discoveries.
	PST: Our friends shared the benefits of establishing [a gene] database with the human genome project. But, personally I do not support human genome project since my ethical and social concerns outweigh. […] As I mentioned before, scientific studies should be done for the good of humanity. I have doubts that this project will add genetic discrimination to crimes against humanity such as race, religion and ethnicity discrimination. Consequently, I would like to state that I will support human genome project when I could get satisfactory answers to my questions (right now I do not support). Who will know the individual-specific knowledge and how will they use this knowledge? How will the confidentiality of our genetic maps be provided? Is it acceptable in terms of ethics to say that treatment is provided by means of gene therapy? What will be the guarantee that there will not be a market on new drugs and diagnosis methods which will be based on the work on human genome project?

In the following section, distribution pattern of the PSTs' arguments within each SSI and the levels of argumentations are presented and the relations between these variables are described based on total numbers of arguments generated in each SSI and levels of argumentation and chi-square analyses.

4.2. The Variation of Argumentation Levels by Pre-Service Science Teachers Across Socio-Scientific Issues

This section focuses on the second research question which inquires for the variation of argumentation levels generated by the PSTs across SSIs. In order to do so, the results were presented as frequencies of argumentation levels for each of four SSIs and chi-square statistics. Table 4.5 presents the frequencies of argumentation levels of the PSTs across SSIs.

Table 4.5 Frequency of argumentation levels for socio-scientific issues

Argumentation Level	**Socio-Scientific Issues (SSIs)**			
	CC	**NP**	**GMFs**	**HGP**
NJ	1	-	-	-
JwNG	4	-	-	-
JwSG	8	7	3	1
JwEG	13	8	13	1
JwEG/CP	12	19	5	13
Total frequency	**38**	**34**	**21**	**15**

The PSTs generated all 5 levels of argumentation quality for SSIs in online discussion environment. The argumentation qualities generated by the PSTs were at the level and higher than JwSG with no NJ and JwNG levels except for climate change issue. The only NJ generated by one of the PSTs for climate change issue was used as an initiator of the discussion. In other words, the NJ was the first argument generated in order to start the discussion about climate change issue. The next level of argumentation which is JwNG was also generated in the beginning of the discussion of climate change issue. Thus, it could be suggested that the reason for these arguments not to be at higher level argumentation could be that they were the first arguments which served as the initiators of discussions for SSIs in online discussion environment.

As for the frequencies of arguments generated for climate change issue, a total of 38 arguments were generated by the PSTs and the most frequent levels were JwEG and JwEG/CP with frequencies of 13 and 12 arguments, respectively. The rest of the argumentation levels were distributed among NJ with a frequency of 1, JwNG with a frequency of 4, and JwSG with a frequency of 8 arguments. Therefore, for climate change issue, the PSTs generally generated their argumentations around JwEG and JwEG/CP levels such that more than 65 % of the PSTs' arguments in climate change issue were concentrated around JwEG and JwEG/CP levels in which they supported their claims with more than one piece of appropriate data as well as recognized counter-positions to their own claims and provided counter-arguments to their peers' arguments. In addition to the frequency descriptions of the levels of argument, the results of chi-square analysis were also given in order to determine whether there was a difference between argumentation levels statistically. The results for climate change issue showed that the frequency distribution of arguments was not homogenous among the PSTs' argumentation levels which indicated that the PSTs' arguments were clustered around some argumentation levels (χ^2 (4, N = 38) = 13.85, p < .05). Therefore, the results of chi-square analysis confirmed that most of the arguments were generated at JwEG and JwEG/CP levels for climate change issue.

For the next SSI which is nuclear power issue, the PSTs generated a total of 34 argumentations. No argumentation was generated at NJ and JwNG levels. The most frequent argumentation level was JwEG/CP with a frequency of 19 arguments. The rest of the argument frequencies were distributed among JwSG and JwEG with frequencies of 7 and 8 arguments, respectively. For nuclear power issue, the frequency of arguments generated for JwEG/CP level constitutes more than half of the argumentation levels generated for this issue by itself. Therefore, for NP issue, the PSTs generally generated their arguments with higher levels of argumentations (i.e. JwSG, JwEG, and JwEG/CP) in which they provided ground(s) for their claims and considered counter-positions to theirs' and to peers' arguments. The chi-square results for nuclear power issue showed that the frequency distribution of arguments was not homogenous among the PSTs' argumentation levels which indicated that the PSTs' arguments were clustered around some argumentation levels (χ^2 (4, N = 34) = 35.71, p < .05). Therefore, the results of the chi-square analysis confirmed that most of the arguments were generated at JwEG/CP level for nuclear power issue.

The next SSI discussed in the online discussion environment was genetically modified foods and the PSTs generated a total of 21 argumentations with no NJ and JwNG levels. The most frequent argumentation level was JwEG with a frequency of 13 arguments. The rest of the argumentation levels were distributed among JwSG and JwEG/CP with frequencies of 3 and 5 arguments, respectively. Approximately 62 % of the arguments were generated at JwEG level which indicates that most of the arguments about genetically modified foods were generated by the PSTs with claims and multiple grounds to support their claims. In addition, approximately one fourth of the arguments were JwEG/CP which indicated that the PSTs included counter-positions to their own or peers' arguments. Thus, 90 % of the arguments generated for GMFs were clustered at JwEG and JwEG/CP levels. In addition to the frequency distribution of arguments, chi-square results were also presented in order to determine whether there was a statistically significant difference between argumentation levels. The chi-square results for genetically modified foods issue showed that the frequency distribution of arguments was not homogenous among the PSTs' argumentation levels which indicated that the PSTs' arguments were clustered around some argumentation levels (χ^2 (4, N = 21) = 27.33, $p < .05$). Therefore, the results of the chi-square analysis confirmed that most of the arguments were generated at JwEG and JwEG/CP levels for genetically modified foods issue.

For the last SSI which is human genome project, a total of 15 arguments were generated by the PSTs. There were no arguments for NJ and JwNG levels. The PSTs generated only 1 argument for JwSG and JwEG levels, each. Therefore, for human genome project issue almost all of the arguments were at JwEG/CP with a frequency of 13 arguments. Although the total number of arguments for this issue was lower when compared to the total numbers of arguments generated for previous SSIs, the distribution of frequencies of arguments among argument quality levels illustrated that the PSTs mostly generated their arguments for HGP at the highest level of argumentation (i.e. JwEG/CP). In addition to the frequency distribution of arguments, chi-square results were also presented in order to determine whether there was a statistically significant difference between argumentation levels. The chi-square results for human genome project issue showed that the frequency distribution of arguments was not homogenous among the PSTs' argumentation levels which indicated that the PSTs' arguments were clustered around some argumentation levels (χ^2 (4, N = 15) = 42, $p < .05$). Therefore, the results of the chi-square analysis confirmed that most of the arguments were generated at JwEG/CP level for human genome project issue. These results were also summarized in Table 4.6.

Table 4.6 Chi-square results for argumentation quality levels in SSIs

	Socio-scientific Issues (SSIs)			
	CC	**NP**	**GMFs**	**HGP**
χ^2	13.85^{*}(38)	35.71^{*}(34)	27.33^{*}(21)	42.00^{*}(15)

Note. Numbers in parentheses indicate argument frequencies. df = 4, $^{*}p < .05$.

As a result of statistical analyses the first research hypothesis which suggested that the quality levels of the PSTs' argumentations were higher for each socio-scientific issue was accepted.

Besides, presenting the frequencies of argumentation levels for each SSI, the results were also presented in Figure 4.1.

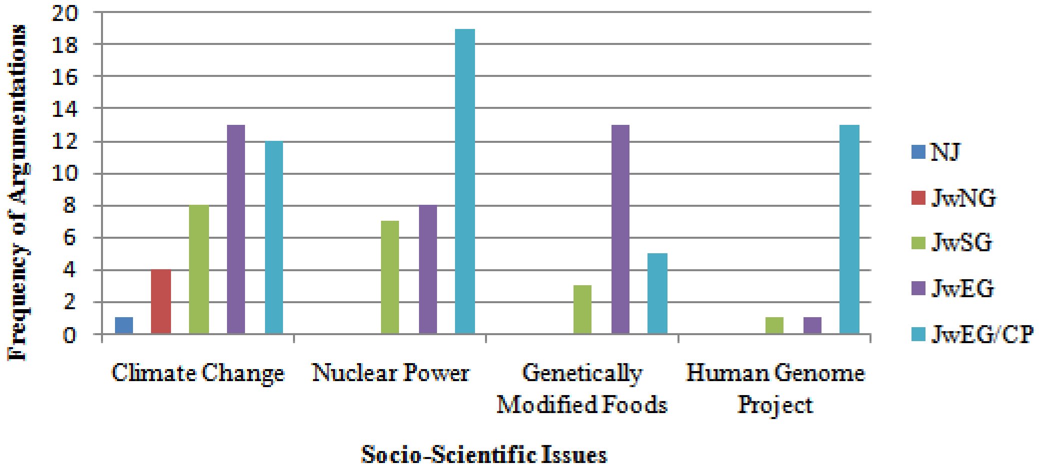

Figure 4.1 Frequency distributions of argumentation levels for each socio-scientific issue.

When each SSI was compared in terms of the frequency of argumentation levels generated by the PSTs, a decrease in the total frequency of argumentations from climate change to human genome project issue was observed as the discussion proceeded. However, among each of the four SSIs, the frequency of argumentation levels showed an increasing trend to accumulate around higher argumentation levels in general as the argumentation level increased from NJ to JwEG/CP. In addition, when the total number of arguments and the levels of argumentations generated by the PSTs were compared, there were only 1 NJ with a percentage of 0.9 %, 4 JwNG with a percentage of 3.7 %, 19 JwSG with a percentage of 17.6 %, 35 JwEG with a percentage of 32.4 %, and 49 JwEG/CP with a percentage of 45.4 % for a total number of 108 arguments which were generated by the PSTs during the four-week online discussions of four SSIs. When the percentages of arguments generated by the PSTs and the levels of arguments are compared, it could be determined that the percentages of argumentation quality levels increase as the levels of arguments increase. The total percentages of argumentation levels generated by the PSTs were given in Figure 4.2.

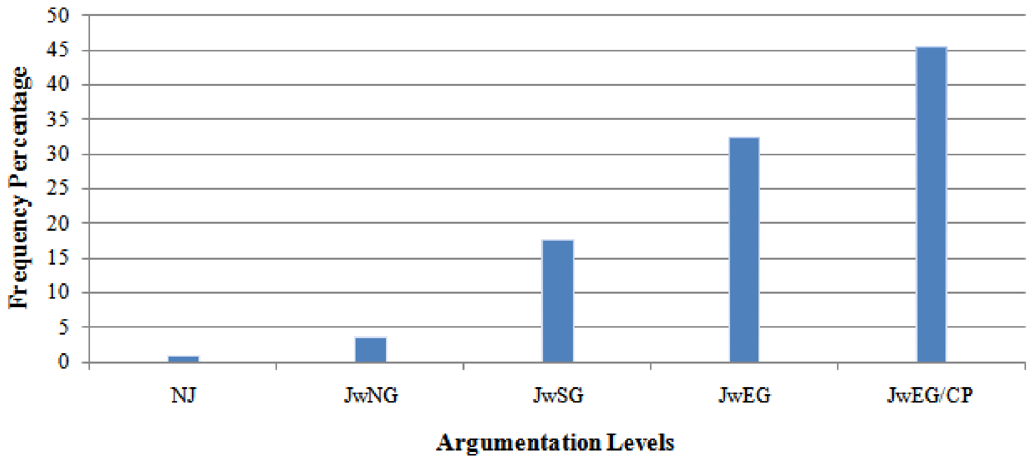

Figure 4.2 Frequency percentages for argumentation levels in total.

As seen in the figure, the PSTs generated most of their arguments at JwSG, JwEG and JwEG/CP levels such that in their argumentations the PSTs provided ground(s) for their claims and considered counter-arguments to their own and to peers' arguments.

In addition to the description of argumentation levels of the PSTs by frequencies of arguments generated for each socio-scientific issue and argumentation quality levels, chi-square analysis was also presented in order to describe the relationship between the PSTs' argumentation levels and socio-scientific issues. The relationship between total frequencies of arguments and SSIs was calculated. The results of the one-sample chi-square analysis between socio-scientific issues and argument frequencies of the PSTs showed that there was a difference between SSIs regarding argument frequencies. (χ^2 (3, N=108) = 13, p < .05) Thus, the results confirmed the difference previously described between SSIs in terms of total number of arguments such that the argument frequencies were not homogenously distributed but decreased from climate change issue to human genome project issue. The relation between SSIs and the PSTs' argumentation levels was also calculated by a chi-square statistic and the results of the analysis indicated that there was a difference (χ^2 (12, N = 108) = 30.56, p < .05) between SSIs regarding argumentation levels of the PSTs given in terms of argument frequencies. In summary, the results of chi-square analysis statistically supported the previous description of the PSTs' argumentation levels based on the frequencies of arguments such that although the number of arguments decreased as the PSTs move along SSIs during four-week discussion environment, they mostly generated higher argumentation quality levels (i.e. JwEG and JwEG/CP) in each of the four SSIs. As a result of the statistical analyses, the second research hypothesis stating the quality levels of the PSTs' argumentation did not show variance across socio-scientific issues was rejected.

In the following section, the variations of argumentation levels of the PSTs in relation to their epistemic belief levels are described. The frequencies of arguments for each SSI in terms of epistemic belief levels, chi-square statistics, Fisher's exact test and correlations are presented in order to describe the relation between these variables.

4.3. The Variation of PSTs' Levels of Argumentations Regarding Their Epistemic Belief Levels

This section focuses on the third research question which inquires for the relationship between the PSTs' levels of argumentations and their epistemic belief levels. The PSTs' epistemic belief levels were measured by the Epistemic Beliefs Questionnaire developed by Kuhn et al. (2000). According to this questionnaire, the PSTs were categorized into three different epistemic belief levels such that absolutists who see knowledge as certain and absolute with facts and expertise as the basis, multiplists who believe that views have equal truth values and multiple answers and evaluativists who believe that viewpoints could be compared and evaluated (Hofer & Pintrich, 1997). The PSTs were categorized into these epistemic belief levels according to a total point calculated based on their answers they give to the questions in the epistemic beliefs questionnaire. A total of 30 PSTs participated in this study and among the participants, 5 were categorized as absolutists which corresponded to 17 % of the participants, 23 as multiplists which corresponded to 77 % of the participants, and 2 as evaluativists which corresponded to 7 % of the participants. Thus, the majority of the participants (i.e. 77 %) hold multiplist points of view regarding their epistemic belief levels.

There were a total of 5 absolutist PSTs and they generated a total of 14 arguments which corresponded to 13 % of the total arguments generated during discussions of all four socio-scientific issues with all levels from "No Justification (NJ)" to "Justification with elaborated grounds and counter-position (JwEG/CP)". The frequency of arguments generated in absolutist level was 1 argument for NJ and JwNG, 2 arguments for JwSG, 7 arguments for JwEG, and 3 arguments for JwEG/CP levels. Therefore, for absolutist level, most of the arguments were generated for JwEG level. The PSTs' arguments were centered at JwSG, JwEG, and JwEG/CP with frequencies of 2, 7, and 3 arguments, respectively. The frequency of arguments generated for JwEG level was 50 % of the total arguments generated by the PSTs at absolutist level (Table 4.7).

For multiplist level, the PSTs generated a total of 90 arguments which corresponded to 83 % of the total arguments generated for all four SSIs. The most frequent level of argumentation was JwEG/CP with a frequency of 42 arguments which is approximately half of the total number of arguments generated. JwEG with a frequency of 28 arguments followed JwEG/CP. The remaining frequencies were distributed among JwNG with a frequency of 3 and JwSG with a frequency of 17 arguments. The pattern of the distribution of arguments indicated that the number of arguments increased as the level of argumentation increased for multiplist PSTs. Therefore, argument quality level for multiplist PSTs indicated that most of the arguments were clustered around JwSG, JwEG, and JwEG/CP levels (Table 4.7).

For evaluativist level, there were 2 PSTs and they generated a total of 4 arguments throughout the discussion of four SSIs. Although the number of arguments generated for evaluativist belief level was small in comparison to absolutist and multiplist epistemic belief levels, all of the arguments generated by the PSTs were at JwEG/CP level. Thus, the distribution pattern of arguments for evaluativist level indicates that the PSTs who have evaluativist beliefs generated their arguments at the highest level of argumentation. The frequencies of argumentation and epistemic belief levels were presented in Table 4.7.

Table 4.7 Frequency of argumentation levels across epistemic belief levels and SSIs

Epistemic Belief Level	**SSIs**	**Argument Level**				
		NJ	JwNG	JwSG	JwEG	JwEG/CP
Absolutist *(N=5)*	CC	1	1	-	1	-
	NP	-	-	2	3	1
	GMFs	-	-	-	2	-
	HGP	-	-	-	1	2
Multiplist *(N=23)*	CC	-	3	8	12	10
	NP	-	-	5	5	17
	GMFs	-	-	3	11	4
	HGP	-	-	1	-	11
Evaluativist *(N=2)*	CC	-	-	-	-	2
	NP	-	-	-	-	1
	GMFs	-	-	-	-	1
	HGP	-	-	-	-	-
Total frequency		**1**	**4**	**19**	**35**	**49**

When the number of arguments generated by the PSTs and their epistemic belief levels were considered, there were 5 absolutist PSTs who generated a total of 14 arguments, 23 multiplist PSTs who generated a total of 90 arguments, and 2 evaluativists who generated a total of 4 arguments. When equal distribution of the frequency of arguments among the PSTs was considered within epistemic belief level categories, then there were 2.8 arguments generated per PST for absolutist level, 3.9 arguments generated per PST in multiplist level, and 2 arguments generated per PST in evaluativist level.

The argumentation levels generated by the PSTs and their epistemic belief levels were also presented for each socio-scientific issue in terms of frequencies of arguments in order to be able to describe the argumentation levels and epistemic belief levels across each SSI. For the first SSI which is climate change, the PSTs generated a total of 38 arguments such that 3 arguments for absolutist level, 33 arguments for multiplist level, and 2 arguments for evaluativist level. The arguments in absolutist level were distributed among NJ, JwNG, and JwEG levels with equal frequencies of 1 argument for each level. The arguments for multiplist level were distributed among argumentation levels except NJ level. The frequency of arguments for JwNG was 3, JwSG was 8, JwEG was 12 and JwEG/CP was 10 arguments. The arguments for evaluativist level were only 2 arguments with JwEG/CP level. Therefore, for climate change issue, the pattern of the distribution of arguments with epistemic belief levels and argumentation levels indicated that absolutist PSTs did not generated many arguments and those generated were distributed between lower level argumentation such as NJ, JwNG and a high level argumentation which is JwEG. For multiplist PSTs, the majority of the arguments were centered on higher level arguments such as JwEG with a percentage of 36 % of all the arguments and JwEG/CP with a percentage of 30 % of all the arguments for a total of 66 % of all the arguments generated in climate change issue. For evaluativist level, all of the arguments were generated at the highest level of argument (i.e. JwEG/CP). In addition to the descriptive results about the PSTs' argumentation levels and their epistemic belief levels, the results were also presented in terms of statistical descriptions. In order to do so, Fisher's exact test was used since the sample for SSIs did not meet the assumptions of chi-square analysis such that more than 80 % of the cells of the cross-tables had expected frequencies less than 5 and the sample sizes were relatively small. The results of the Fisher's exact test analysis indicated that the arguments generated by the PSTs in climate change issue were not homogenously distributed ($P = 12.62$, $p < .05$) among epistemic belief levels. In other words, there was a difference between argumentation levels of the PSTs with regards to their epistemic belief levels. In summary, the pattern of the distribution of arguments across argumentation quality levels for climate change issue with respect to the PSTs' epistemic belief levels showed that as the epistemic belief levels of the PSTs increase from absolutist to multiplist to evaluativist, the frequency of arguments generated by the PSTs also indicated a tendency to increase from lower argumentation quality levels (i.e. NJ) to higher argumentation quality levels (i.e. JwEG/CP) and the statistical results besides descriptive results confirmed that there was a difference between argumentation levels of the PSTs in terms of epistemic belief levels. Table 4.8 summarizes the distribution of arguments generated for climate change issue by giving frequencies of arguments in relation to the PSTs' argumentation levels and epistemic belief levels.

Table 4.8 Frequency distributions of argumentation levels of the PSTs in Climate Change Issue

Argumentation Level	**Epistemic Belief Level**		
	Absolutist	Multiplist	Evaluativist
NJ	1	-	-
JwNG	1	3	-
JwSG	-	8	-
JwEG	1	12	-
JwEG/CP	-	10	2
Total frequency	**3**	**33**	**2**

The next SSI discussed in the online discussion environment was nuclear power issue. A total of 34 arguments were generated by the PSTs for this issue. The frequency distribution of arguments across epistemic belief levels of the PSTs were such that 6 arguments were generated by absolutist PSTs, 27 arguments by multiplist PSTs, and 1 argument by an evaluativist PST. The number of arguments generated by absolutist PSTs was small and was distributed among JwSG with a frequency of 2, JwEG with a frequency of 3, and JwEG/CP with a frequency of 1 argument. The pattern of the distribution indicated that arguments by absolutist PSTs were mostly generated at higher levels of argumentation. Most of the arguments in nuclear power issue were generated by multiplist PSTs and the arguments were distributed among three levels such that JwSG and JwEG with the same frequencies of 5, and JwEG/CP with a frequency of 17 which corresponds to 50 % of the arguments generated for nuclear power issue. Therefore, the distribution of arguments for multiplist level also indicated that the arguments were generated around higher levels of argumentation. For evaluativist level, although only 1 argument was generated, it was in JwEG/CP level. In general for nuclear power issue, most of the arguments generated by the PSTs were at and higher levels than JwSG and were mostly concentrated around JwEG/CP for multiplist and evaluativist levels and around JwSG and JwEG for absolutist level. Besides presenting descriptive results about the PSTs' argumentation levels and their epistemic belief levels for nuclear power issue, the results were also presented in terms of statistical descriptions as Fisher's exact test statistic. The results showed that the distribution of arguments across argumentation levels and epistemic belief levels were homogenous ($P = 5.82$, $p > .05$). In other words, there was not a statistically significant difference between argumentation levels of the PSTs for nuclear power issue with regards to their epistemic belief levels. The frequency distributions of arguments in relation to argumentation levels and epistemic belief levels of the PSTs for nuclear power issue were given in Table 4.9.

Table 4.9 Frequency distributions of argumentation levels of PSTs in Nuclear Power Issue

Argumentation Level	**Epistemic Belief Level**		
	Absolutist	Multiplist	Evaluativist
NJ	-	-	-
JwNG	-	-	-
JwSG	2	5	-
JwEG	3	5	-
JwEG/CP	1	17	1
Total frequency	**6**	**27**	**1**

The next socio-scientific issue discussed in the online discussion environment was genetically modified foods. For this issue, a total of 21 arguments were generated. There were 2 arguments for absolutist level, 18 arguments for multiplist level and 1 argument for evaluativist level. The distribution of frequencies of arguments between argumentation levels were such that for absolutist level, both of the 2 arguments were generated at JwEG level. For multiplist level, the arguments were at levels JwSG with a frequency of 3, JwEG with a frequency of 11, and JwEG/CP with a frequency of 4 arguments. Thus, the most frequent argumentation level was JwEG with a percentage of 52 % of the arguments generated for genetically modified foods issue. There were no arguments generated for NJ and JwNG levels. For evaluativist level, only 1 argument was generated and it was at JwEG/CP level. Thus, in general, the pattern of the distribution of argument frequencies showed that the PSTs generated their arguments at higher levels of argumentations such as JwSG, JwEG and JwEG/CP. In addition to presenting descriptive results about the PSTs' argumentation levels and their epistemic belief levels for genetically modified foods issue, the results were also presented in terms of statistical descriptions as Fisher's exact test statistic. The results showed that the distribution of arguments across argumentation levels and epistemic belief levels were homogenous (P = 3.94, $p > .05$) which indicated that there was not a statistically significant difference between argumentation levels of the PSTs for genetically modified foods issue with regards to their epistemic belief levels. The frequency distributions of arguments in relation to argumentation levels and epistemic belief levels of the PSTs were given in Table 4.10.

Table 4.10 Frequency distributions of argumentation levels of the PSTs in Genetically Modified Foods Issue

Argumentation Level	**Epistemic Belief Level**		
	Absolutist	Multiplist	Evaluativist
NJ	-	-	-
JwNG	-	-	-
JwSG	-	3	-
JwEG	2	11	-
JwEG/CP	-	4	1
Total frequency	**2**	**18**	**1**

The last socio-scientific issue discussed in the online discussion environment was human genome project. There were a total of 15 arguments generated by the PSTs for this issue. For HGP, there were 3 arguments for absolutist level, 12 arguments for multiplist level, and no argument for evaluativist level. For absolutist level, the frequencies of arguments were distributed such that there was 1 argument for JwEG and 2 arguments for JwEG/CP. No other arguments were generated for lower argumentation levels. Thus, for absolutist level, the PSTs generated their arguments at higher argumentation levels such as JwEG and JwEG/CP. For multiplist level, the argument frequencies were distributed such that there was 1 argument for JwSG and 11 arguments for JwEG/CP level. The percentage of arguments for JwEG/CP level corresponded to the 73 % of all the arguments generated for human genome project issue. Thus, for multiplist level, the PSTs generated their arguments at higher levels of argumentation (i.e. JwEG/CP). For evaluativist level, no arguments were generated. In summary, the frequency distribution pattern for absolutist and multiplist levels across argumentation quality levels indicated that PSTs generated their arguments at higher argumentation levels such as JwSG, JwEG, and JwEG/CP. In addition to presenting descriptive results about the PSTs' argumentation levels and their epistemic belief levels for human genome project issue, the results were also presented in terms of statistical descriptions as Fisher's exact test statistic. The results of Fisher's exact test also showed that the arguments were distributed homogenously across epistemic belief levels and argumentation quality levels and thus there was no statistically significant difference between the PSTs' argumentation levels in terms of their epistemic belief levels (P = 3.66, $p > .05$). The frequency distributions of arguments in relation to argumentation levels and epistemic belief levels of the PSTs were given in Table 4.11.

Table 4.11 Frequency distributions of argumentation levels of PSTs in Human Genome Project Issue

Argumentation Level	**Epistemic Belief Level**		
	Absolutist	Multiplist	Evaluativist
NJ	-	-	-
JwNG	-	-	-
JwSG	-	1	-
JwEG	1	-	-
JwEG/CP	2	11	-
Total frequency	**3**	**12**	**0**

Moreover, the results of Fisher's exact test were presented Table 4.12 and the frequency distributions of arguments in argumentation levels generated by the PSTs for all four SSIs in terms of PSTs' epistemic belief levels were presented in Figure 4.3.

Table 4.12 Fisher's exact test results for argumentation quality levels in SSIs with respect to epistemic belief levels

	Socio-scientific Issues (SSIs)			
	CC	**NP**	**GMFs**	**HGP**
P	12.62^{*}	5.82	3.94	3.66

Note. The results are significant $^{*}p < .05$

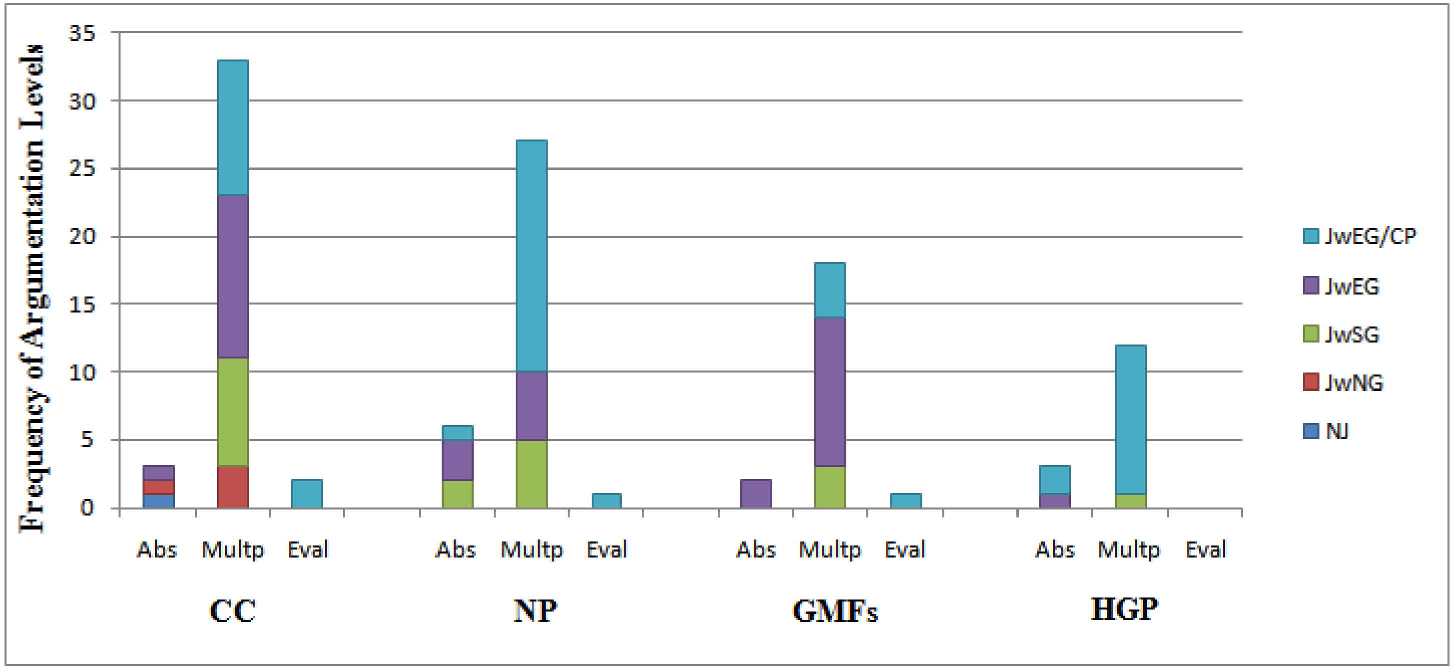

Figure 4.3 Frequency distributions of arguments in argumentation levels across SSIs and epistemic belief levels.

In addition to giving frequencies of arguments generated across epistemic belief levels and argumentation levels of the PSTs, statistical comparisons of the PSTs' argumentation levels and their epistemic belief levels were also computed in order to describe the relations between these variables. In order to do so, chi-square statistics and Pearson product-moment correlation coefficients were presented. For the relationship between the PSTs' epistemic belief levels and the frequencies of arguments generated for each of the epistemic belief levels, chi-square analysis was conducted. The results of the analysis showed that there was a difference between frequencies of arguments generated by the PSTs regarding epistemic belief levels (χ^2 (2, N = 108) = 123, $p < .05$) (Table 4.13).

Table 4.13 Chi-square results of the relationship between PSTs' epistemic belief levels and argument frequencies

	Epistemic Belief Levels		
	Absolutist	Multiplist	Evaluativist
Number of students	5	23	2
Number of arguments	14	90	4
χ^2	123^* (df = 4, N = 108)		

Note. The chi-square result is significant $^*p < .05$

In order to determine the relationship between the PSTs' argumentation levels given in terms of frequencies of arguments and their epistemic belief levels, Fisher's exact test was calculated since some of the assumptions of chi-square was not met such that sample size was small and 80 % of the cells of the cross-table had expected frequencies less than 5. The results of the analysis showed that Fisher's exact test statistic was not significant (P = 13.86, $p > .05$) which indicated that there was a homogenous distribution of arguments between epistemic belief levels and argumentation levels of the PSTs. In other words, although the number of arguments generated for epistemic belief levels indicated a difference between epistemic belief levels, in terms of argumentation levels, there was not a statistically significant difference regarding the PSTs' epistemic belief levels.

When the argumentation levels for each of the epistemic belief level (i.e. absolutist, multiplist, and evaluativist) were compared, the results of chi-square analysis indicated that except for absolutist level, there was a difference between argumentation levels in terms of frequencies of arguments generated for each argumentation level. These results confirmed previous descriptions of the relationship between frequencies of arguments generated for each argumentation level and their epistemic belief levels such that the number of arguments generated for argumentation levels increase as the argumentation levels increase from NJ to JwEG/CP.

In addition to the chi-square analyses and Fisher's exact test results, the relationship between the PSTs' epistemic belief levels, argumentation levels, and frequencies of arguments were also presented in terms of correlation coefficients. First, the Pearson product-moment correlation coefficient between the frequencies of arguments generated by the PSTs and their argumentation levels was calculated. The results showed that there was a large correlation between the numbers of arguments generated by the PSTs in total and their argumentation levels (r (28) = .761, $p < .01$). In order to describe the correlations between the PSTs' epistemic belief levels and their argumentation levels and frequencies of arguments, Spearman rho was calculated since although the results of epistemic beliefs questionnaire were continuous, the nature of the variable was categorical and treated as categorical. Therefore, Spearman rho correlation between the PSTs' epistemic belief levels and the frequencies of arguments was found to be small (ρ (28) = .044, $p > .05$) and the correlation between the PSTs' epistemic belief levels and their argumentation levels was (ρ (28) = .184, p > .05) which is small correlation. Thus, these results show that previous descriptions of the PSTs' levels of argumentations with the frequencies of their arguments and chi-square and Fisher's exact test statistic were also supported by correlation analyses such that as the levels of argumentation increased from NJ to JwEG/CP, the numbers of arguments generated by the PSTs' for that level also increased. In addition, there was a small correlation between the PSTs' epistemic belief levels and their argumentation levels as suggested previously by Fisher's exact test results.

The correlations between frequencies of arguments generated for each SSI and argumentation levels of the PSTs for each SSI were also calculated. The results were presented in Table 4.14. These results also supported previous descriptions of the PSTs' levels of argumentation and the frequencies of arguments given by chi-square analyses.

Table 4.14 Pearson product-moment correlations between the PSTs' argumentation levels and frequencies of arguments

	Socio-scientific Issues (SSIs)			
	CC	NP	GMFs	HGP
Argumentation levels	.719*	.687*	.925*	.992*

Note. The results are significant *p < .01

Besides giving the correlations between the PSTs' frequencies of arguments, argumentation levels, and epistemic belief levels across SSIs, the correlations between the PSTs' argumentation levels and epistemic belief levels generated for each of the four SSIs were also presented. Spearman rho was calculated since epistemic belief levels were treated as categorical variable. The results of the correlation between the PSTs' argumentation levels for climate change issue and their epistemic belief levels was found to be medium correlation, for nuclear power issue to be small correlation, for genetically modified foods issue to be small correlation, and finally, for human genome project issue was found to be a negative small correlation. These results of correlation analysis indicated that previous descriptions of the relationship between the PSTs' epistemic belief levels and argumentation levels for SSIs by Fisher's exact test was also not significant except climate change issue.

Table 4.15 Spearman correlations between the PSTs' argumentation levels and epistemic belief levels

	Socio-scientific Issues (SSIs)			
	CC	NP	GMFs	HGP
Argumentation levels	.35	.17	.22	- .10

Note. The results are significant $^{*}p < .05$

In summary, the results of chi-square analyses, Fisher's exact test and correlation analyses of the relationship between the PSTs' argumentation levels, epistemic belief levels, and frequencies of arguments generated for SSIs indicated that frequencies of arguments generated for different epistemic belief levels were different in terms of argumentation levels except for absolutist level. Moreover, frequencies of arguments were found to be non-homogenously distributed among the PSTs' epistemic belief levels. However, the relationship between the PSTs' epistemic belief levels and argumentation quality levels was not significant and small correlation coefficients were found except for climate change issue. Therefore, as a result of statistical analyses the third research hypothesis which suggested that the quality levels of the PSTs' argumentation increase with their epistemic belief levels from absolutist to multiplist to evaluativist was rejected.

In the following section, the relationship between the PSTs' argumentativeness (i.e. tendency to argue) and their epistemic belief levels and argumentation levels are described in terms of correlation coefficients.

4.4. The Variation of PSTs' Levels of Argumentation Regarding Their Argumentativeness

This section focuses on the fourth research question which inquires for the relationship between the PSTs' levels of argumentations and argumentativeness. The PSTs' argumentativeness was measured by Argumentativeness Scale developed by Infante and Rancer (1982) in which general trait to be argumentative was computed as the difference between values of tendency to approach arguments and tendency to avoid arguments. The minimum score on the approach component was (min. = 26) while the maximum score was (max. = 46). The mean and standard deviation of the scores for approach component were (M = 34.3; SD = 4.9). For the avoidance component, the minimum score was (min. = 14) while the maximum score was (max. = 38). The mean and the standard deviation of the scores for avoidance component were (M = 25.1; SD = 6.0). The minimum and maximum values for the argumentativeness of the PSTs were (min. = -12, max. = 32) with a mean and a standard deviation (M = 9.3; SD = 8.7). The relationship between the number of arguments generated by the PSTs for four SSIs and their argumentativeness scores from argumentativeness scale were compared statistically. In order to do so, frequencies of the PSTs' arguments were correlated to their argumentativeness scores. Pearson product-moment correlation coefficient was calculated. A small correlation (r (28) = .185, p > .05) was found between the total number of arguments generated by the PSTs and their argumentativeness scores. When the correlation was computed between the PSTs' number of arguments and the tendency to approach argument component of their argumentativeness scores, a small correlation coefficient was found (r (28) = .262, p > .05). For tendency to avoid argument component of argumentativeness scale and the PSTs' numbers of arguments a negative correlation coefficient was found (r (28) = -.057, p > .05). In addition to describing the correlation between the total number of arguments generated by the PSTs and their argumentativeness levels with their tendency to approach and avoid arguments, the PSTs' argumentativeness scores were also correlated with their levels of arguments. Pearson product-moment correlation coefficient was computed in order to describe the relationship between these two variables and a small correlation coefficient (r (28) = .034, p > .05) was found. The correlation between the PSTs' levels of arguments and their tendency to approach arguments was r (28) = .162, p > .05 while the correlation between the PSTs' levels of arguments and their tendency to avoid arguments was r (28) = .084, p > .05. Therefore, a small correlation coefficient was found between the PSTs' argumentativeness and their levels of arguments as well as numbers of arguments generated.

In addition to the relationship between the PSTs' total numbers of arguments, argumentation levels and their argumentativeness, tendency to approach and avoid arguments, the correlations between the PSTs' epistemic belief levels and their argumentativeness was also presented. In order to describe the relationship between the PSTs' epistemic belief levels and their argumentativeness, tendency to approach arguments and tendency to avoid arguments scores, Spearman rho was calculated since epistemic belief levels was treated as a categorical variable. The results of the correlation analysis showed that there was a significant medium correlation between the PSTs' epistemic belief levels and their argumentativeness (ρ (28) = .431, p < .05). The correlation between epistemic belief levels and the PSTs' tendency to approach arguments was ρ (28) = .486, p < .05 which also showed a significant medium correlation. The correlation between the PSTs' epistemic belief levels and their tendency to avoid arguments was ρ (28) = - .225, p > .05 which indicated a small negative correlation. These results showed that there was a significant correlation between the PSTs' epistemic belief levels and their argumentativeness which suggested that as the epistemic belief levels of the PSTs increase from absolutist to multiplist to evaluativist, their argumentativeness which is described as the PSTs' predispositions to argue in controversial issues also increased.

The results of the statistical analyses showed that the fourth research hypothesis which suggested that the quality levels of the PSTs' argumentation increase with their argumentativeness and epistemic belief levels from absolutist to multiplist to evaluativist levels was rejected for the first relationship such that small correlations were found between argumentation levels and argumentativeness. However, for the fifth research hypothesis which suggested that the quality levels of the PSTs' argumentation increase with their epistemic belief levels, it was found that there was a significant medium correlation between the PSTs' argumentativeness and their epistemic belief levels and the hypothesis was accepted.

In summary, the results of this study illustrate that the PSTs generated all five levels of argumentation during discussions of four SSIs in online discussion environment. The frequencies of the PSTs arguments within and across each SSI in terms of levels of argumentation, epistemic belief levels, and argumentativeness indicated that the PSTs mostly generated their arguments at higher levels of arguments such as JwEG and JwEG/CP. The total number of arguments generated for each SSI decreased as the discussion proceeded through CC to HGP issues. However, within each SSI, the levels of the PSTs' argumentation were high with respect to their epistemic belief levels such that from absolutist to multiplist to evaluativist levels, arguments were generated around JwEG and JwEG/CP. In addition to the descriptions of the PSTs' argumentations with frequencies of arguments, statistical results in terms of chi-square, Fisher's exact test and Pearson and Spearman correlations also showed that there was a difference between SSIs in terms of the PSTs' argumentation levels. As related to the PSTs' epistemic belief levels and argumentation levels, no difference was found between epistemic belief levels of the PSTs in terms of argumentation levels in general and except climate change issue, in particular. As regards to the PSTs' argumentativeness, argumentation levels, and epistemic belief levels, although small correlation was found between the PSTs' argumentation levels and their argumentativeness, a significant medium correlation was found between their epistemic belief levels and argumentativeness which showed that the PSTs were more predisposed to engage in arguments when their epistemic belief levels were higher.

To conclude, in this chapter the PSTs' argumentation levels, numbers of arguments with respect to their epistemic belief levels and argumentativeness and the relation between these variables were described in terms of qualitative results with participant excerpts of argumentation levels and quantitative results in term of frequencies of arguments and statistical results such as chi-square, Fisher's exact test and correlation coefficients.

CHAPTER 5

DISCUSSION

This chapter presents a discussion of the findings of the present study based on the research questions and suggests implications towards an improvement of science education and recommendations for future research.

5.1. Discussions

Argumentation has been accepted as a relevant and an integral part of science education since one of the goals of scientific inquiry is the students' generation and evaluation of knowledge claims (Jiménez-Aleixandre et al., 2000). Thus, integration of argumentation in science education environments was promoted by many studies (Driver et al., 2000; Jiménez-Aleixandre et al., 2000; Osborne, Erduran, & Simon, 2004). In addition, Bell and Linn (2000) suggested that online discussion environments provided an excellent environment and support for students to engage in argumentation. Besides, socio-scientific issues (SSIs) which are described as controversial issues with scientific and technological relations are argued for inclusion in science education (Sadler, 2004) since incorporation of these ill-structured problems in science learning would create opportunities for students to engage in argumentation (Driver et al., 2000). In a similar manner, in the present study, the aim was to investigate the nature and the quality of the PSTs' written argumentations about four different socio-scientific issues in an online discussion environment and the relationship between the PSTs' argumentations, epistemic belief levels and general traits to be argumentative (i.e. argumentativeness). For this purpose, participants of the present study contributed with their written argumentations to four socio-scientific issues by generating their claims, providing grounds to support those claims, and counter-claims to theirs' and to peers' arguments for a period of four-weeks in total. The analyses of the quality of the PSTs' argumentations were done by an adaptation of Sadler and Fowler's (2006) argumentation quality framework. The results of the study were presented around four research questions in terms of frequency, percentage and statistical results of the PSTs' argumentations such as chi-square, Fisher's exact test and Pearson and Spearman correlations in overall as well as by socio-scientific issues in order to describe the PSTs' nature and quality of argumentations.

One of the remarkable findings of this study regarding the variation of the PSTs' levels of argumentation with respect to different socio-scientific issues was that the PSTs generated all five levels of argumentation across SSIs. The high argumentation quality levels in the whole data are noteworthy. For example, argumentation levels of JwSG, JwEG, and JwEG/CP corresponded to the 95.4 % of all the argumentations generated during four-week discussions of SSIs. This pattern of argumentation quality levels can be regarded as a positive indication that the online discussion environment with the incorporation of socio-scientific issues was effective in promoting argumentation and engaging the PSTs in generation of socio-scientific argumentations with claims, grounds, and counter-arguments. The findings are in parallel with the claims that argumentation in science classrooms could be supported with appropriate context (Lemke, 1990). Moreover, the findings are also in congruence with the literature suggesting that online discussion environments and socio-scientific issues were effective in supporting the PSTs in generation of arguments (Bell & Linn, 2000; Driver et al., 2000).

In terms of the nature and quality of argumentations generated by the PSTs, the results of this study are promising regarding formative assessment practices since PSTs generate their argumentations based on grounds and to include counter-positions. Argumentation quality levels generated by PSTs were analyzed according to an adapted argumentation quality framework developed by Sadler and Fowler (2006). In this framework there were five argumentation quality levels such as NJ, JwNG, JwSG, JwEG, and JwEG/CP. For NJ level participants did not provide any argumentations, for JwNG level participants provided justifications without giving grounds to support their justifications, for JwSG level participants provided a single ground to support their justifications, for JwEG level multiple grounds were provided in support of justifications and for JwEG/CP level counter-positions were also given to their' or to peers' arguments. In this study, PSTs mostly generated their argumentations at higher levels such as JwSG, JwEG, and JwEG/CP. Therefore, the PSTs' uses of grounds in support of their justifications as well as use of counter-positions in their argumentations provide researchers valuable formal assessment tools in order to analyze students' argumentations in classrooms as well as in online discussion environments of socio-scientific issues.

Another remarkable result of this study was related to the frequency and levels of argumentation generated by the PSTs for SSIs. Although the number of argumentations generated by the PSTs decreased as the online discussion was progressing from climate change issue to human genome project issue, the findings illustrated that higher argumentation levels were frequently generated by the PSTs for all SSIs. For example, for climate change issue, 34 % of the arguments were generated at JwEG level and 32 % of the arguments at JwEG/CP level for a total of 66 % of the arguments at JwEG and JwEG/CP levels. For nuclear power issue, 56 % of the arguments were generated at JwEG/CP level, for genetically modified foods issue, 62 % of the arguments were generated at JwEG level, and for human genome project issue, 87 % of the arguments were generated at JwEG/CP level. In addition to higher argumentation levels generated for each SSI, the results also indicated that there was a difference between socio-scientific issues in terms of argumentation levels generated by the PSTs. For example, NJ and JwNG levels were generated only for the first SSI which is climate change and the levels of argumentation for other SSIs ranged between JwSG, JwEG, and JwEG/CP. These results suggested that PSTs' argumentation levels could be influenced from several factors that are both related to PSTs and the online discussion environment. To exemplify, the PSTs had indicated that they were new to the online forum environment in which they write and post their argumentations related to the socio-scientific issues. Although, the researchers introduced the online discussion system with its key features to the PSTs before data collection procedure began, the PSTs might not be accustomed to use such online discussion environments and this could have influenced the argumentation levels of the PSTs negatively especially in the beginning of discussions. Although rare, another factor for argumentation levels to be lower in the beginning of the discussions could be related to the PSTs' direct uses of information obtained from the Internet. The researchers had requested from the PSTs that they should construct their argumentations based on appropriate data in order to support their claims and frame their argumentations around their own points of view; however, sometimes the PSTs could have used information directly form the Internet without proper adaptation and integration of their own points of views. Such argumentations were not considered as high levels. In summary, in the beginning of the discussions of SSIs, lower argumentation levels could have appeared due to several factors related to the PSTs and the online discussion environment itself and as the discussion progressed argumentation levels also increased. In addition, the frequency of higher argumentation levels also appeared in other SSIs and yet in terms of SSIs, argumentation levels varied across issues. The results showed that the argumentation levels generated by the PSTs mostly ranged between JwEG and JwEG/CP levels for all socio-scientific issues which suggest that several factors could have influenced the levels of the PSTs' argumentations. The reasons for the variation of argumentation levels across SSIs could be attributed to several factors such as PSTs' daily life experiences and general knowledge regarding socio-scientific issues, their epistemological orientations and the mass media such as television, newspapers and the Internet. The study by Ozdem (2009) in which the PSTs' argumentations were investigated based on Walton's (1996) argumentation schemes in inquiry-based laboratory environment indicated that the PSTs' argumentations varied across tasks and thus it was suggested that some argumentation schemes could be task-dependent while others were more general and task-independent. In a similar manner, these results implied that the PSTs' argumentation levels could vary according to the discussion topics. In another study by Albe (2008) in which students' argumentations in group discussions about a socio-scientific issue and the relations between scientific knowledge, daily life experience and epistemological and social considerations were investigated, it was found that epistemological nature and the general knowledge used by the students while arguing about a socio-scientific controversy influenced students' argumentations and thus should be considered as important factors. In terms of mass media, the widespread discussions of socio-scientific issues such as climate change, nuclear power, genetically modified foods, and human genome project in televisions, newspapers, and in the Internet place these issues in the daily lives of students. Therefore, as in parallel with the study by Albe (2008), students could have incorporated their daily life experiences into their argumentations and the discussions of these issues in several different environments could have influenced students' high levels of argumentations in these socio-scientific issues. However, in order to understand which contexts and issues promote argumentation in science learning, there is a need for further research which investigates the relationship between students' general knowledge, epistemological nature, daily life experiences and topics of socio-scientific issues (Duschl & Osborne, 2002).

Another finding of the present study was related to the relationship between the PSTs' argumentation levels and their epistemic belief levels. In the present study, most of the participants were at multiplist level in terms of epistemic belief levels and most of the arguments were generated by multiplist PSTs which could be attributed to their large numbers compared to the PSTs in other epistemic belief level categories. The findings of the present study illustrated that except for absolutist level, there was a difference between the PSTs' argumentation levels and their epistemic belief levels which suggested that the PSTs' argumentations were distributed around higher levels for multiplist and evaluativist levels which was also evident by the distribution of the frequencies of arguments. These findings were partly similar to the findings of the study by

Nussbaum, Sinatra, and Poliquin (2008) such that in their study they also found that the PSTs' epistemic belief levels influenced their argumentations such that evaluativists produced more questions and generated alternatives whereas multiplists were less critical and the results for absolutists were less clear cut. Similarly in this study, absolutist PSTs were not significantly different in terms of argumentation levels; however, in contrast to the findings of Nussbaum et al. (2008), both multiplist and evaluativist PSTs generated higher level argumentations in overall. Therefore, the results suggested that more empirical research should be conducted which investigate the relationship between epistemic belief levels and argumentation levels of the PSTs.

The relationship between the PSTs' epistemic belief levels and the quality of argumentations was also described for each of the SSIs in addition to the overall descriptions. The results illustrated that except for climate change issue, the PSTs' levels of argumentations were not different in terms of their epistemic belief levels. These results are similar to the overall descriptions of the relationship between epistemic belief levels and argumentation levels of the PSTs except for the first SSI which is climate change issue. This result was also supported by the statistical analysis such that there was a medium correlation (ρ (28) = .35, $p > .05$) between the PSTs' argumentation levels for climate change issue and their epistemic belief levels. The correlations for other SSIs were small. In the literature, a study which investigated the science-related uncertain issues and epistemological perspectives among children was conducted by Yang and Tsai (2010) such that in their study they found that although children's epistemological beliefs remained consistent across different issues, the criteria which the PSTs used to make judgments about these issues varied with problem contexts. Therefore, the results of the present study showed similarity to the recent findings in the literature. However, in order to better understand the reasons for the PSTs' higher levels of argumentations and epistemic belief levels for different socio-scientific issues, further empirical research should be conducted regarding the relationship between the PSTs' epistemic belief levels, argumentation quality levels and context of socio-scientific issues in which the PSTs' argumentations are analyzed both quantitatively and qualitatively beyond descriptions of the relationship in terms of frequencies, chi-square analyses and correlations.

In the present study, the relationship between the PSTs' general trait to be argumentative (i.e. argumentativeness), their argumentation levels and epistemic belief levels were also described. The results of the present study were worthy of notice since the findings of Pearson correlations regarding the relationship between the PSTs' argumentativeness and total number of arguments and argumentation levels revealed that there was a small correlation between these variables. In addition, the Spearman correlation was also calculated between the PSTs' epistemic belief levels and their argumentativeness. Although there was a small correlation between the PSTs' argumentativeness and argumentation levels, the results indicated that there was a significant medium correlation between PSTs' epistemic belief levels and their argumentativeness (ρ (28) = .431, $p < .05$) which suggested that as the PSTs' epistemic belief levels changed from absolutist to multiplist to evaluativist, their predispositions to argue also increased. The findings of this study were in line with the study of Nussbaum and Bendixen (2003) in which they demonstrated that epistemic beliefs of students are directly related to students' willingness to engage in argumentation such that students who believe that knowledge is simple, certain, and unchanging perceived arguments as anxiety-promoting and they tended to avoid arguments. Therefore, the results of the present study were a confirmation of the findings in the literature regarding the relationship between argumentativeness and epistemic belief levels.

5.2. Implications and Recommendations

In this study, the quality of the PSTs' written argumentations in terms of levels and variations of argumentations across four different socio-scientific issues, the PSTs' epistemic belief levels and their general trait to be argumentative (i.e. argumentativeness) was investigated. The implications of this study were given based on the discussions in five main topics such that first, the online discussion environments with the incorporation of argumentation about socio-scientific issues was effective in promoting argumentation; second, the generation of argumentations by the PSTs about socio-scientific issues in online discussion environments was promising in terms of formative assessment practices; third, the contexts of socio-scientific issues as well as the PSTs' epistemic nature, daily lives and general knowledge were effective in generation of and higher levels of arguments; fourth, the PSTs' epistemic belief levels were related to argumentation levels and this relationship was also evident in specific socio-scientific issues and finally the relationship between the PSTs' general trait to be argumentative, argumentation levels and epistemic belief levels were related to each other.

The findings suggested that in terms of the PSTs' quality of argumentations across socio-scientific issues, the PSTs generated all five levels of argumentation quality with mostly at higher levels such as JwSG, JwEG, and JwEG/CP. In the related literature, it was also indicated that the PSTs' argumentations could also be supported by appropriate contexts (Lemke, 1990) and as regards to this, online discussion environments and socio-scientific issues were shown to be supportive in engaging the PSTs to generate arguments (Bell & Linn, 2000; Driver et al., 2000). These results suggest that learning environments in which the PSTs generate argumentations regarding controversial issues which have scientific and societal ties are important since the PSTs are going to be teachers in the future and are expected to implement these environments in their own teaching of science in their classrooms and other environments. Therefore, these results are informative for science educators and science teacher education researchers in terms of improving science education and providing better learning environments for both science teachers and students.

Another issue investigated in this study was related to formative assessment practices of the PSTs' argumentations. The PSTs generated all of the five levels of argumentation quality for four socio-scientific issues and their argumentations were based on justifications of claims by providing ground(s) to support their claims and counter-positions to theirs' and to peers' argumentations (Sadler & Fowler, 2006). Therefore, development of new formative assessment practices of the PSTs' argumentations generated for socio-scientific issues which are based on levels of argumentations in terms of presence of claims, number of grounds provided and counter-arguments were primarily important for research in science education which focused in measurement and assessment as well as for informing science teachers, researchers and curriculum developers in suggesting alternative measurement practices for discussions of ill-structured problems both in- and out-of-classroom contexts.

In this study, the variation of the quality of argumentation levels generated by the PSTs across socio-scientific issues was also investigated. The findings illustrated that although the frequency of arguments through the SSIs decreased, mostly higher levels of argumentations were generated by the PSTs for all SSIs. In addition, the results also showed that the PSTs' levels of argumentations varied across different SSIs. Regarding the results of this study it was suggested that these results could be due to several reasons such as the PSTs' being new to the online discussion environment, their general knowledge regarding socio-scientific issues, daily life experiences, epistemological orientations and the mass media such as television, newspapers and the Internet regarding these issues. Therefore, the findings of the present study suggested that these factors should be considered in designing, implementing and evaluating science learning environments and are particularly important for science education researchers, teachers, curriculum developers as well as science education policy makers.

Another finding of this study showed that there was a relationship between the PSTs' argumentation quality levels and epistemic belief levels which was clear for multiplist and evaluativist levels as high argumentation levels and was less clear for absolutist level. These results suggested that the PSTs' epistemic belief levels have an influence on their argumentation practices. As the results of the study by Nussbaum et al. (2008) indicated, the results of the present study was also informative for analyzing the PSTs' argumentations in SSI-integrated online discussion environments. The PSTs' argumentation levels and their epistemic belief levels were also described for each SSI. The findings indicated that for the climate change issue which is the first SSI, there was a statistically significant difference between the PSTs' epistemic belief levels and argumentation quality levels defined by Fisher's exact test and Spearman rho correlation. For other SSIs, no difference among argumentation quality levels with respect to epistemic belief levels was found. In the related literature, the relationship between the PSTs' argumentation quality levels and epistemic belief levels were defined (Nussbaum et al., 2008). In addition, socio-scientific issues were argued to offer opportunities to develop students' argumentations (Osborne, Erduran, & Simon, 2004). Therefore, these findings imply that socio-scientific issues could be effective in students' generation and development of argumentations. However, the results of the present study suggest that further research should be conducted towards investigation of the relationship between SSIs and the PSTs' argumentation qualities since the related findings would be important for research in science education which focus in incorporating appropriate contexts in terms of SSIs which promote students' engagement and generation of higher argumentation levels as well as for science teacher educators in better understanding of students' argumentation practices in such contexts and developing appropriate instructional techniques and methods.

Finally, in addition to the description of the PSTs' argumentation quality levels, epistemic belief levels and socio-scientific issues, in this study the relationship between the PSTs' argumentativeness and argumentation quality levels and epistemic belief levels were investigated. The findings showed that although the PSTs' argumentativeness describes predispositions to argue, there was a small correlation between argumentativeness of the PSTs and their argumentation quality levels. In addition, the findings illustrated that evaluativist PSTs generated higher quality argumentations than multiplist and absolutist PSTs. Nussbaum and Bendixen (2003) claimed that PSTs' epistemic belief levels were related to their willingness to engage in argumentation which is a measure of their argumentativeness. Thus, these findings are important for improving science education which incorporates argumentation as a medium to engage students in discussions of scientific and socio-scientific issues because epistemic belief levels of students proves to be an important factor to be considered in science learning environments by science teachers and science education researchers.

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APPENDICES

APPENDIX A

PARTICIPANT PERSONAL INFORMATION SHEET

Dolduracağınız anketlerdeki yanıtları daha kapsamlı değerlendirebilmek için size bir kaç kişisel soru sormak istiyoruz. Bu bölümde ve anketlerde vereceğiniz yanıtların gizli tutulacağını unutmayınız.

1. Adınız ve Soyadınız: ……................................... Öğrenci no: ....
2. Cinsiyetiniz: ○ Erkek ○ Bayan
3. Yaşınız: ……………
4. Bölümünüz: ………………………………………..
5. Sınıfınız: …………..
6. Genel not ortalamanız (GPA): …………
7. Annenizin Eğitim Durumu: ○ İlkokul ○ Ortaokul ○ Lise ○ Üniversite/Lisansüstü (Master/Doktora)
8. Babanızın Eğitim Durumu: ○ İlkokul ○ Ortaokul ○ Lise ○ Üniversite/Lisansüstü (Master/Doktora)
9. Şimdiye dek yaşadığınız bölge aşağıdakilerden hangisi ile tanımlanabilir? ○ Kırsal alan, çiftlik ○ Küçük kasaba (nüfusu 25 000 ile 100 000 kişi arasında) ○ Büyük şehir (nüfusu 100 000 kişiden fazla)

10. Evde bilgisayarınız var mı? ○ Var ○ Yok
11. Lisans eğitiminizde bilgisayar/internet ile ilgili aldığınız dersler nelerdir? (bilgisayarli eğitim uygulamaları, web sitesi tasarlama, vb.) …………………………………………………………………………………… ………...................................... ....
12. Ne kadar süredir bilgisayar kullanıyorsunuz? ○ Bir yıldan daha az ○ Bir – üç yıl arası ○ Üç – beş yıl arası ○ Beş yıldan daha fazla
13. Ne kadar sıklıkla bilgisayar kullanıyorsunuz? ○ Hergün ○ Haftada birkaç kez ○ Haftada bir kez ile ayda bir kez arası ○ Ayda bir kezden daha az ○ Hiç kullanmıyorum
14. İnternete ne sıklıkla giriyorsunuz? ○ Ayda bir kez ya da daha az ○ Haftada bir kez ○ Haftada birkaç kez ○ Günde bir kez ○ Günde birkaç kez

15. İnternette bir gün içinde ortalama ne kadar vakit geçirmektesiniz?

○ 0 – 5 saat

○ 6 – 10 saat

○ 11 – 15 saat

○ 16 – 20 saat

○ 20 saatten fazla

16. İnterneti genellikle hangi amaçlar için kullanırsınız?

(Uygun olanları işaretleyiniz. Birden fazla seçenek işaretlenebilir)

○ İletişim (e-posta)

○ Sosyalleşme (chat programları, sosyal ağ siteleri)

○ Alışveriş

○ Eğitim amaçlı araştırma

○ Bankacılık işlemleri

○ Haber alma

○ Oyun / eğlence

17. Kişisel web sayfanız var mı?

○ Var ○ Yok

18. İnternetin hayatınızdaki yerini / önemini nasıl tanımlarsınız?

○ Çok önemli değil

○ Kısmen önemli

○ Oldukça önemli

19. İnternet kullanımınızla ilgili eklemek istedikleriniz var mı? Varsa nelerdir?

....

....

....

....

APPENDIX B

EPISTEMIC BELIEFS QUESTIONNAIRE

In this scale, there are two statements for each item: one by Robin and the other by Chris. Read these two statements for each item carefully and decide **WHETHER ONLY ONE OF THEIR VIEWS COULD BE RIGHT, OR COULD BOTH HAVE SOME RIGHTNESS**. Circle the answer that you think is right. **IF BOTH COULD BE RIGHT**, that is if your answer for the first question is **BOTH COULD HAVE SOME RIGHTNESS**, then think **COULD ONE VIEW BE BETTER OR MORE RIGHT THAN THE OTHER**. Circle the answer that you think is right. Please answer all of the items carefully.

1.	Robin says warm summer days are nicest. Chris says cool autumn days are nicest.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**

2.	Robin thinks the first piece of music they listen to is better. Chris thinks the second piece of music they listen to is better.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**
3.	Robin thinks people should take responsibility for themselves. Chris thinks people should work together to take care of each other.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**

4.	Robin has one view of why criminals keep going back to crime. Chris has a different view of why criminals keep going back to crime.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**
5.	Robin believes one book's explanation of what atoms are made up of. Chris believes another book's explanation of what atoms are made up of.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**

6.	Robin says the stew is spicy. Chris says the stew is not spicy at all.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**
7.	Robin thinks the first painting they look at is better. Chris thinks the second painting they look at is better.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**

8.	Robin thinks lying is wrong. Chris thinks lying is permissible in certain situations.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**
9.	Robin thinks one book's explanation of why the Crimean wars began is right. Chris thinks another book's explanation of why the Crimean wars began is right.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**

10.	Robin believes one book's explanation of how the brain works. Chris believes another book's explanation of how the brain works.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**
11.	Robin thinks weddings should be held in the afternoon. Chris thinks weddings should be held in the evening.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**

12.	Robin thinks the first book they both read is better. Chris thinks the second book they both read is better.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**
13.	Robin thinks the government should limit the number of children families are allowed to have to keep the population from getting too big. Chris thinks families should have as many children as they choose.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**

14.	Robin agrees with one book's explanation of how children learn language. Chris agrees with another book's explanation of how children learn language.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**
15.	Robin believes one mathematician's proof of the math formula is right. Chris believes another mathematician's proof of the math formula is right.	**Can only one of their views be right, or could both have some rightness?** ○ **ONLY ONE RIGHT** ○ **BOTH COULD HAVE SOME RIGHTNESS** **IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?** ○ **ONE COULD BE MORE RIGHT** ○ **ONE COULD NOT BE MORE RIGHT THAN THE OTHER**

APPENDIX C

THE ARGUMENTATIVENESS SCALE

This questionnaire contains statements about arguing controversial issues. Indicate how often each statement is true for you personally by placing an X next to the statement.

	Almost never true	**Rarely true**	**Occasionally true**	**Often true**	**Almost always true**
1. While in an argument, I worry that the person I am arguing with will form a negative impression of me					
2. Arguing over controversial issues improves my intelligence					
3. I enjoy avoiding arguments					
4. I am energetic and enthusiastic when I argue					
5. Once I finish an argument I promise myself that I will not get into another					
6. Arguing with a person creates more problems for me than it solves					
7. I have a pleasant, good feeling when I win a point in an argument					
8. When I finish arguing with someone I feel nervous and upset					
9. I enjoy a good argument over a controversial issue					
10. I get an unpleasant feeling when I realize I am about to get into an argument					

11. I enjoy defending my point of view on an issue					
12. I am happy when I keep an argument from happening					
13. I do not like to miss the opportunity to argue a controversial issue					
14. I prefer being with people who rarely disagree with me					
15. I consider an argument an exciting intellectual challenge					
16. I find myself unable to think of effective points during an argument					
17. I feel refreshed and satisfied after an argument on a controversial issue					
18. I have the ability to do well in an argument					
19. I try to avoid getting into arguments					
20. I feel excitement when I expect that a conversation I am in is leading to an argument.					