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Pre-Service Science Teachers' Written Argumentation Qualities: From the Perspectives of Socio-Scientific Issues, Epistemic Belief Levels and Online Discussion Environment

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This study investigated the relationship between pre-service science teachers' written argumentation levels about socio-scientific issues and epistemic belief levels in an online discussion environment. A mixed-methods approach was used: 30 Turkish pre-service science teachers contributed with their written argumentations to four socio-scientific issues. The pre-service science teachers' argumentations were evaluated by an adapted version of argumentation analysis framework developed by Sadler and Fowler (2006) and their epistemic belief levels were measured using the Epistemic Belief Questionnaire by Kuhn, Cheney, and Weinstock (2000). The qualitative as well as quantitative results indicated that: (1) the pre-service science teachers produced high-level argumentations for each socio-scientific issue in an online discussion environment, (2) levels of argumentations increased from climate change to human genome project issue, and (3) higher-level argumentations were produced for higher epistemic belief levels (i.e., multiplist and evaluativist).

Keywords: Epistemic belief levels, online discussion environment, socio-scientific issues, written argumentation.

INTRODUCTION

Argumentation has been an essential component of discourse practices employed by individuals as well as by groups of individuals in societies (Voss & Van Dyke, 2001). In addition 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 Newton, & Osborne, 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). Argumentation is especially important and should be promoted in science education since it plays a central role in scientific inquiry and in establishing theories, models and explanations of scientific phenomena in science classrooms (e.g., Driver et al., 2000; Jiménez-

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State of the literature

- Argumentation in science education has been an important research theme in terms of students' discussions and epistemic belief levels about scientific and socio-scientific issues.
- Socio-scientific issues are controversial topics that provide contrasting viewpoints and a discussion opportunity for students to produce, justify and counter argumentations of their own and their peers. Socio-scientific issues are, therefore, important in science education research to investigate students' learning processes in such discussion contexts.
- Online discussion environments provide students a medium to write and see all argumentations of their own and their peers. Online environments have been studied in science education to support students' argumentations.

Contribution of this paper to the literature

- This study contributes to the research about socio-scientific argumentations by investigating the relationship between pre-service science teachers' written argumentations and their epistemic belief levels about socio-scientific issues.
- This study describes the implications of the integration of online discussion environments in pre-service science teachers' written argumentations about socio-scientific issues.
- The contribution of this study to the related literature is the investigation of the pre-service science teachers' written argumentations in the perspective of socio-scientific issues, epistemic belief levels and use of online discussion environments that were studied separately but not together in the literature.

Aleixandre, Rodríguez, & Duschl, 2000; Osborne, Erduran, & Simon, 2004).

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 justifications of argumentations (Sampson & Clark, 2008). In these studies, several frameworks were developed to analyze and evaluate the quality of student-produced argumentations in a variety of contexts (e.g., Kelly & Takao, 2002; Sandoval, 2003; Sandoval & Millwood, 2005; Schwarz, Neuman, Gil, & Ilya, 2003; Toulmin, 1958; Lawson, 2003; Zohar & Nemet, 2002). However, many of the argumentation frameworks were only applicable to the specific contexts in which a particular study was conducted. In the present study, pre-service science teachers' argumentations were investigated in contexts where socio-scientific issues were presented through an online discussion environment and the pre-service science teachers contributed to with their written argumentations.

One of such contexts in which students' argumentation are investigated is socio-scientific issues. Socio-scientific issues are defined as social issues with conceptual and technological relations to science and are controversial in nature (Sadler, 2004). Socio-scientific issues are argued to be integrated in science education and in argumentation practices in science learning environments since the inclusion of such issues into science education provides opportunities for students' argumentations (Driver et al., 2000). Moreover, socio-scientific issues are especially important in students' decision-making processes. Thus, students' argumentation is an important part of decision-making (Patronis, Potari, & Spiliotopoulou, 1999) especially in the context of socio-scientific issues (Kolsto, 2001).

In this perspective, a variety of studies investigated students' generation of argumentations about socio-scientific issues (e.g., Acar, Turkmen & Roychoudhury, 2010; Simonneaux & Chouchane, 2011; Gresch, Hasselhorn, & Bögeholz, 2011). In one of the studies, students' argumentations about socio-scientific issues were found to be poor but improved after the incorporation of findings from decision-making research such as value-focused decision-making and common heuristics (Acar, Turkmen & Roychoudhury, 2010). In another study, the critical analysis of the controversial issues by the students improved their argumentation frequency (Simonneaux & Chouchane, 2011). In addition, Gresch, Hasselhorn and Bögeholz (2011) indicated that socio-scientific issues and decision-making processes in science classrooms enable students to participate in discussions of these controversial issues more productively. These results indicated that the students' argumentations and decision-making processes in science classrooms were better with the inclusion of socio-scientific issues.

Students' epistemic beliefs and assumptions about knowledge are also effective in reasoning and justifications of argumentations about controversial issues (King & Kitchener, 1994). Epistemic beliefs are defined as beliefs and assumptions regarding the nature of knowledge and knowing (Mason & Scirica, 2006). Epistemic beliefs were studied by many researchers and through a variety of models such as developmental sequence of students' epistemologies (e.g., Baxter Magolda, 2004; Belenky, Clinchy, Goldberger, & Tarule, 1986; Perry, 1970 as cited in Hofer & Pintrich, 1997) and of their influence on students' justifications and reasoning (e.g., King & Kitchener, 2004; Kuhn, 1993). The results of these studies have shown that students' epistemic beliefs and assumptions about knowledge

influence their thinking and reasoning processes and justifications about ill-structured problems (King & Kitchener, 1994) and argumentation skills (Kuhn, 1993). In addition, research on students' scientific and socio-scientific argumentations was mainly in offline discussion environments such as science classrooms (e.g., Duschl & Osborne, 2002; Jiménez-Aleixandre et al., 2000). On the other hand, related research on students' argumentations in online environments illustrated that these environments improved students' generation of high quality argumentations (Clark et al., 2007, Lin, Hong & Lawrenz, 2012, Noroozi, et al., 2012). Therefore, in the present study, an online environment to which pre-service science teachers would be able to contribute with their written argumentations about four different socio-scientific issues (i.e., climate change, nuclear power, genetically modified foods, and human genome project) was utilized in order to promote the pre-service science teachers' argumentations about socio-scientific issues as well as to describe the pre-service science teachers' levels of argumentations in relation to epistemic belief levels in an online discussion environment.

Purpose of the study

The purpose of this study is to explore pre-service science teachers' written argumentation levels about socio-scientific issues in relation to their epistemic belief levels in an online discussion environment. In the literature, pre-service science teachers' argumentations were investigated in classrooms, laboratories or in online contexts as well as in relation to their nature of science understandings or epistemic belief levels. However, the implications of these different aspects on pre-service science teachers' written argumentations have not been investigated together in a study. In this perspective, the significance of this study is the consideration of these aspects in the analysis of pre-service science teachers' written argumentations. The research questions that are addressed in this study are:

(1) What are the levels of the pre-service science teachers' argumentations regarding each socio-scientific issue (i.e., climate change, nuclear power, genetically modified foods and human genome project)?

(2) What is the variation of the pre-service science teachers' levels of argumentations across socio-scientific issues?

(3) What is the relationship between the pre-service science teachers' levels of argumentations and their epistemic belief levels?

METHODOLOGY

In this study, a mixed methods approach with qualitative and quantitative analyses was used to describe the relationship between pre-service science teachers' written argumentations about socio-scientific issues and epistemic belief levels in an online discussion environment.

Participants

Thirty pre-service science teachers (10 male, 20 female) at a large public university participated in this study voluntarily. All of the participants were in their last year of the four-year undergraduate elementary science teacher education program. In addition, pre-service science teachers had completed several science courses (e.g., physics, chemistry, mathematics, and biology) as part of their teacher education program and were assumed to have basic understanding of natural phenomena. Besides, pre-service science teachers were enrolled in Science, Technology, and Society (STS) course, in which they were provided with scientific, technological, and societal issues and the interrelation of these issues with each other.

During data collection the researchers used a participant personal information questionnaire to determine the participant demographics. The participant personal information questionnaire included 19 questions investigating the characteristics of the pre-service science teachers' personal background, use of computers and the Internet. According to the answers to these questions, the age range of the participants was from 21 to 28 years of age with an average of 23. The participants' characteristics related to their use of computers and the Internet was such that 63.3 % used computers and they were familiar with them for more than five years. The 86.6 % of the participants were using the Internet for several times a day while 6.7 % of the participants were in the Internet once a day and several times a week. None of the participants used the Internet with a frequency of once a week or once a month or less.

Design of the Study

In this study, pre-service science teachers' epistemic belief levels were measured using Epistemic Beliefs Questionnaire developed by Kuhn et al. (2000) before pre-service science teachers' argumentations were collected during the online discussion as part of Science, Technology, and Society (STS) course. The pre-service science teachers could login with their student IDs and passwords and write and post their argumentations about the socio-scientific issues under discussion as well as respond to their peers' argumentations. In the online discussion environment, the researchers introduced four socio-scientific issues namely climate change (CC), nuclear power (NP), genetically modified foods (GMFs), and human genome project (HGP), in the order given. Each of these socio-scientific issues was

Table 1. Points-of-views in Socio-Scientific Issues

Socio-scientific Issues	Argument 1	Argument 2
Climate Change	Climate change is due to increased human activity that accelerated with the Industrial Revolution from 18th to 19th century resulting in production of goods and use of fossil fuels (i.e. primarily coal) and thus causing environmental pollution and ultimately destruction.	According to some other scientists the recent warming of the Earth had nothing to do with human activity and 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.
Nuclear Power	Nuclear energy has 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 greenhouse 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.	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 in case of an accident due to possible radioactive fallout and its devastating effects on living and non-living components of the environment. Moreover, the issue of nuclear weaponry poses a threat in terms of international relations
Genetically Modified Foods	Genetically modified foods are 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.	Altering the genetic makeup of organisms to be used as foods by humans have the probability of causing some unknown diseases and could have devastating effects for the balance in nature in terms of diversity of species. In addition, corporations which produce genetically modified organisms are 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 to the environment.
Human Genome Project	Human genome project would provide novel treatments for some currently incurable genetic diseases as well as it would help 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.	Altering human genetic material could create unknown effects and most importantly it is unethical to change human genetic code in order to create stronger or more intelligent humans. In addition, access and use 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.

discussed by the pre-service science teachers for a period of a week. The pre-service science teachers contributed to the online discussion with their written argumentations on a voluntary basis. The researchers did not give any instructions about written argumentations other than providing the pre-service science teachers with two contrasting arguments in each socio-scientific topic in the beginning of each discussion session and requesting the pre-service science teachers to write their argumentations with scientific justifications.

The researchers chose these socio-scientific issues since these topics had an importance nationally as well as internationally in terms of the impact on human life and environment. In addition, these issues were also related to and were part of the participants' daily lives through media such as televisions, newspapers, and the Internet and through courses in schools that introduce

science, technology and society and the relationship between these issues. Each socio-scientific issue was presented to the pre-service science teachers with two contrasting arguments. The pre-service science teachers could decide and take up their own positions related to the issue and construct their argumentations in support of their positions as well as counter the argumentations of their peers. These contrasting argumentations were given below for each socio-scientific issue (Table 1).

Data Analysis

Quantitative and qualitative data analysis methods were used to determine the pre-service science teachers' argumentation levels for the four different socio-scientific issues. Sadler and Fowler's (2006) argumentation framework was adapted for analyzing the pre-service science teachers' written argumentations. In this framework, pre-determined argumentation levels were used and the analysis of argumentations was based on justifications provided by the pre-service science teachers. As the pre-service science teachers' argumentations were more based on justifications and counter-positions, the level of the argumentation is determined to be higher.

In this study, Sadler and Fowler's (2006) argumentation analysis framework was adapted such that descriptions of the first (i.e., Level 1) and the last levels (i.e., Level 5) of argumentations were changed. Level 1 argumentation in the framework (i.e., No Justification, NJ) for this study was defined as "argumentations in which the pre-service science teachers did not present any argumentation related to the socio-scientific issue discussed" and for level 5 argumentation (i.e., Justification with Elaborated Grounds and Counter-Positions, JwEG/CP) the definition was expanded to include situations where "the pre-service science teachers provided grounded justifications and recognized positions or evidence contradictory to their own argumentations and/or provided counter-arguments to their peers' argumentations". The argumentation levels described in the Sadler and Fowler's (2006) argumentation analysis framework is given with the excerpts of pre-service science teachers' argumentations (Table 2).

The pre-service science teachers' epistemic belief levels were measured by a 15-item Epistemic Beliefs Questionnaire developed by Kuhn et al. (2000). 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?' with two possible answers as 'Only one right' and 'Both could have some rightness'. The following question to be answered in the same pair depended on the answer given to 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.

The reason for this instrument to be chosen by the researchers is that 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 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). To this end, Kuhn et al.'s (2000) epistemic beliefs assessment which specifically considered the students' beliefs about knowing and knowledge was implemented. Based on the answers given to the questionnaire, the pre-service science teachers were categorized into three epistemic belief levels as absolutist (Only one right), multiplist (One could not be more right than the other), and evaluativist (One could be more right). In order to determine the pre-service science teachers' general levels of epistemological levels, a total score for epistemological understanding for each pre-service science teacher was calculated. The scoring and epistemic belief levels of the pre-service science teachers was determined according to Kuhn et al. (2000) such that for each judgment domain the pre-service science teachers were categorized as absolutists, multiplists, or evaluativists when responses to two of the three items for the particular domain represented the level, scoring 1, 2 and 3 points, respectively. In cases where no patterns emerged across three items, multiplist level was assigned. Thus, the scores for each pre-service science teacher could range from 15 (absolutist in all domains) to 45 (evaluativist in all domains). The scores ranging from 15 to 25 were identified as absolutist, 25 to 35 as multiplist, and 35 to 45 as evaluativist levels of epistemic belief.

RESULTS

The Levels of the Pre-Service Science Teachers' Argumentations in Socio-Scientific Issues

The findings regarding the first research question are that the pre-service science teachers produced all five levels of argumentations across socio-scientific issues and high argumentation levels in the whole data are noteworthy. To illustrate, argumentations at levels of Justification with Simple Grounds (JwSG), Justification with Elaborated Grounds (JwEG), and Justification with Elaborated Grounds and a Counter-Position

Table 2. Argumentation Analysis Framework

Score	Description	Excerpts
0	No justification (NJ)	What will be the situation of polar bears [due to climate change]?
1	Justification with no grounds (JwNG)	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.
2	Justification with simple grounds (JwSG)	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.
3	Justification with elaborated grounds (JwEG)	I am against genetically modified organisms [...] In the village where my family lives people provide 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 [genetically modified] crops are produced [...] At the same time, we also put our health into danger by eating these foods.
4	Justification with elaborated grounds and a counter-position (JwEG/CP)	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.

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

(JwEG/CP) according to the Sadler and Fowler's argumentation analysis framework corresponded to 95.4 % of the total argumentations produced during four-week discussions of socio-scientific issues. The results were presented as frequencies of argumentation levels for each of the four socio-scientific issues (Table 3).

The pre-service science teachers produced argumentations either at or higher levels than Justification with Simple Grounds (JwSG). No Justification (NJ) and Justification with No Grounds (JwNG) levels was only observed in the beginning of the discussion about climate change issue. Therefore, it could be suggested that the reason for these argumentations not to be at higher levels could be that they were the first argumentations that served as the initiators of discussions for socio-scientific issues in online discussion environment.

In addition to the frequency descriptions of the levels of argumentation, a chi-square analysis was also performed in order to determine whether there was a statistically significant difference between argumentation levels (Table 4).

The results of chi-square analysis are significant for each of the socio-scientific issue. The results indicated that the frequencies of the pre-service science teachers' argumentations distributed non-homogeneously for

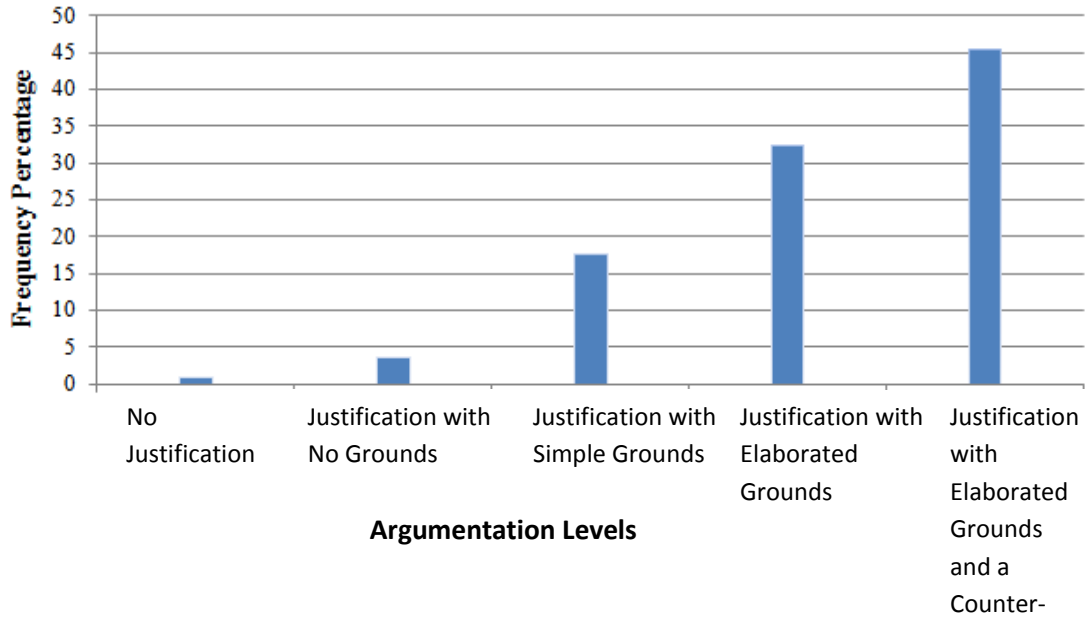

Figure 1. Frequency percentages for argumentation levels in total

Table 3. Frequency of argumentation levels for socio-scientific issues

Argumentation Level	Socio-Scientific Issues			
	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**

Note: *CC: Climate Change, NP: Nuclear Power, GMFs: Genetically Modified Foods, HGP: Human Genome Project*

Table 4. Chi-square results for argumentation quality levels in socio-scientific issues

	Socio-scientific Issues			
	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).*

each socio-scientific issue. The results of the chi-square analysis could be interpreted as the pre-service science teachers' argumentations were at higher argumentation levels.

The Variation of the Pre-Service Science Teachers' Argumentations across Socio-Scientific Issues

When each socio-scientific issue was compared in terms of the frequencies of the levels of argumentations produced by pre-service science teachers, a decrease in the total argumentation frequency from climate change to human genome project issue was observed. However, between each of the four socio-scientific issues the frequency of argumentation levels showed an increasing trend to accumulate around higher argumentation levels as the argumentation levels increased from NJ to JwEG/CP. Moreover, when the total number of argumentations and the levels of argumentations were compared, there was only one argumentation at NJ level, four argumentations at JwNG level, 19 argumentations at JwSG level, 35 argumentations at JwEG level and 49 argumentations at JwEG/CP level for a total number of 108 argumentations. The total percentages of argumentation levels produced by the pre-service science teachers are given in Figure 1.

Chi-square analysis between the pre-service science teachers' argumentation levels and socio-scientific issues also showed that the frequencies of argumentations produced by the pre-service science teachers' were different between socio-scientific issues ($\chi 2$ (12, N = 108) = 30.56, p < .05).

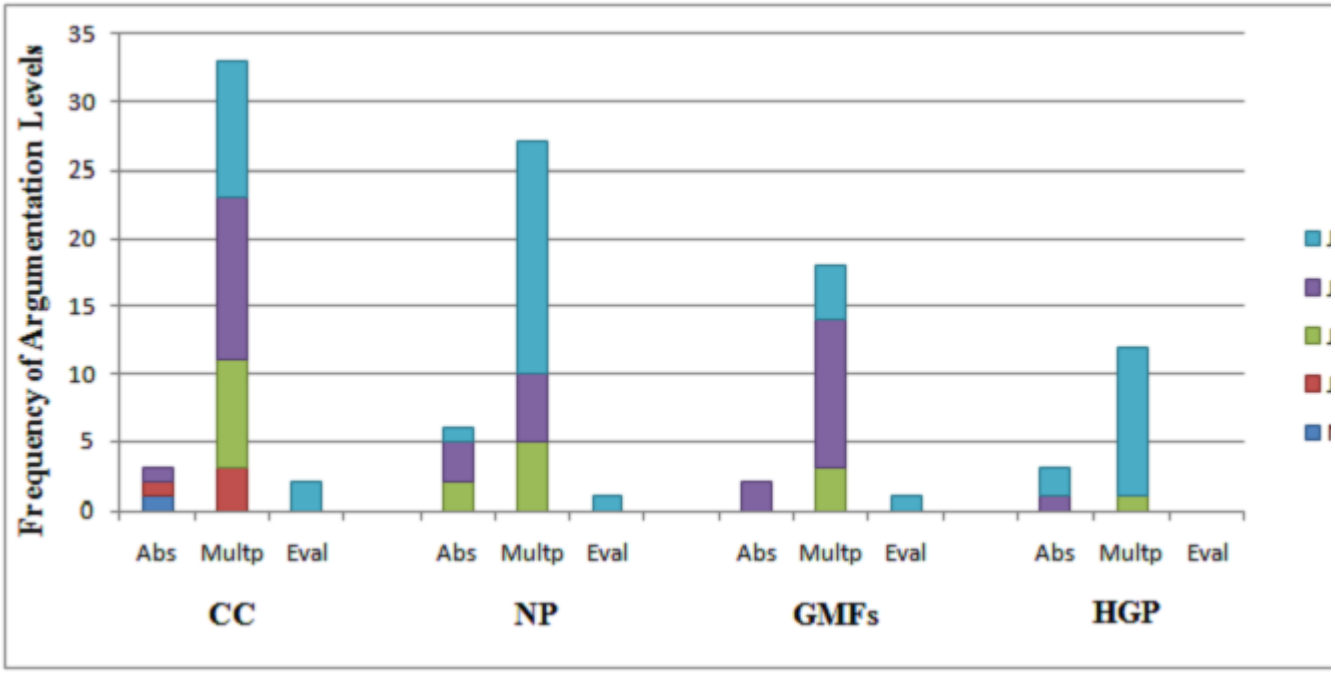

Figure 2. Frequency of argumentation levels across epistemic belief levels and socio-scientific issues

Table 5. Spearman correlations between the pre-service science teachers' argumentation levels and epistemic belief levels

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

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

The Relationship between the Pre-Service Science Teachers' Argumentation Levels and Epistemic Belief Levels

In terms of epistemic belief levels of the pre-service science teachers, there were 5 absolutists, 23 multiplists and 2 evaluativists in total. The frequency of argumentation levels for each socio-scientific issue in terms of epistemic belief levels were given in Figure 2.

As seen in Figure 2, the distribution of the argumentation levels with respect to epistemic belief levels and socio-scientific issues indicated that most of the higher-level argumentations such as JwEG and JwEG/CP were produced as the discussion progressed from climate change to human genome project issue and by the pre-service science teachers who were at multiplist and evaluativist epistemic belief levels. .

The relationship between the pre-service science teachers' argumentation levels and epistemic belief levels were also described by Spearman rho correlation. Spearman rho correlation between the pre-service science teachers' epistemic belief levels and argumentation levels was found to be a non-significant small correlation (ϱ (28) = .184, p > .05) (Table 5).

In summary, although the descriptive analyses of the relationship between the pre-service science teachers' argumentation levels and epistemic belief levels in socio-scientific issues showed that higher argumentation levels were produced as pre-service science teachers' epistemic belief levels were higher, Spearman correlation coefficients were small and not statistically significant.

DISCUSSION

The purpose of this study was to explore the pre-service science teachers' written argumentation levels about socio-scientific issues in relation to their epistemic belief levels in an online discussion environment. In order to describe the relationship between these issues, three research questions that addressed the pre-service science teachers' levels of argumentations in terms of socio-scientific issues, variation of the levels of argumentations across socio-scientific issues and the relationship between the levels of argumentations and epistemic belief levels were determined by the researchers.

The results of this study showed that the pre-service science teachers produced high argumentation levels for all socio-scientific issues in online discussion environment and the levels of their written

argumentations increased from climate change to human genome project issue. Although fewer argumentations were produced as the online discussion progressed from climate change to human genome project issue, the results illustrated that higher levels of argumentations are frequently produced by the pre-service science teachers for all socio-scientific issues. In the beginning of the online discussions of socio-scientific issues, lower levels of argumentations could have appeared due to several factors that are both related to the pre-service science teachers and to the online discussion environment itself; however, as the discussions progressed, the pre-service science teachers' argumentation levels also increased.

The results showed that the argumentations produced by the pre-service science teachers were mostly ranging between higher levels of argumentation such as Justification with Elaborated Grounds (JwEG) and Justification with Elaborated Grounds and a Counter-Position (JwEG/CP) for all socio-scientific issues. Several factors could have influenced the levels of the pre-service science teachers' argumentations. Among these factors are the pre-service science teachers' different backgrounds, daily life experiences and general knowledge regarding socio-scientific issues as well as mass media such as television, newspapers and the Internet. In this regard, the study by Albe (2008) showed that higher levels of argumentations about socio-scientific issues could be due to the students' daily life experiences where students incorporate their experiences in their argumentations as well as provide counter examples obtained from their relevant environments to the socio-scientific issues in question. In this perspective, the four socio-scientific issues (i.e., climate change, nuclear power, genetically modified foods, and human genome project) chosen by the researchers for this study were common issues in the media as well as related to the pre-service science teachers' daily lives. Specifically, at the time of this study, nuclear power and genetically modified foods issues were being actively discussed in the society. In terms of mass media, widespread discussions of socio-scientific issues in televisions, newspapers and in the Internet have an important place in the daily lives of students. Moreover, a recent study by Evagorou and Osborne (2013) showed that students' different backgrounds could have an effect in important ways in their collaborative engagement within a socio-scientific issue. Therefore, in parallel with the study by Albe (2008) and others, the pre-service science teachers' daily life experiences, the discussions of such issues in the media and the pre-service science teachers' different backgrounds would have contributed to their argumentations about socio-scientific issues in this study. However, in order to determine the contribution of different contexts and issues to the pre-service science teachers' argumentations, there is a need for further research that investigates the relationship between students' general knowledge, daily life experiences and knowledge of socio-scientific issues.

The results of this study also showed that the pre-service science teachers' argumentations were mostly at higher epistemic belief levels (i.e., multiplist and evaluativist levels). Although the relationship between the pre-service science teachers' epistemic belief levels and the levels of argumentations did not reach statistical significance, descriptive results suggest that the epistemic belief levels of the pre-service science teachers have an effect on the pre-service science teachers' levels of argumentations such that the pre-service science teachers at multiplist and evaluativist levels produced higher levels of argumentations than those at absolutist level. To illustrate, the pre-service science teachers at multiplist level acknowledge that there could be more than one equally valid explanation for a phenomenon and evaluate each one of them in their argumentative reasoning. Similarly, the pre-service science teachers at evaluativist level tend to evaluate issues so that there is only one valid explanation among alternatives. Thus, they could be argued to be more predisposed to defend their reasoning with many elaborated grounds and try to discredit alternative explanations by providing counter-examples. These results were also similar to the study by Nussbaum, Sinatra, and Poliquin (2008). They also found that the pre-service science teachers' epistemic belief levels have an influence on students' argumentations such that evaluativist students produced more questions and generated alternative explanations whereas multiplist students were less critical of argumentations and the results for absolutist students were mixed. Similarly, in this study, the pre-service science teachers at absolutist level were not significantly different in terms of argumentation levels; however, in contrast to the findings of Nussbaum et al. (2008), the pre-service science teachers who are at multiplist and evaluativist levels generated higher-level argumentations.

An online discussion environment where the pre-service science teachers contributed with their written argumentations to the discussions of the four socio-scientific issues was implemented in this study. The results of this study indicated that the pre-service science teachers' argumentations about socio-scientific issues in online discussion environment were at high levels for all socio-scientific issues. Although pre-post analyses or control group design was not implemented in the present study, the findings of high levels of argumentations produced by the pre-service science teachers for all socio-scientific issues in online discussion environments are in congruence with the literature suggesting that online discussion environments and socio-scientific issues are effective in supporting the pre-service science teachers' production

of argumentations (Bell & Linn, 2000; Driver et al., 2000). Moreover, several studies indicated that online discussion environments were supportive for students' argumentations (e. g., Clark et al., 2007, Clark & Sampson, 2008, Noroozi, et al., 2012). In a recent study by Lin, Hong and Lawrenz (2012), the researchers investigated the students' argumentations about socio-scientific issues in an asynchronous online discussion environment. The results showed that the students' argumentation skills were better in online environment compared to paper-and-pencil practice. Similarly, in the present study, an asynchronous online discussion environment was implemented in the pre-service science teachers' written argumentations about socio-scientific issues and the levels of the pre-service science teachers' written argumentations were found to be at high levels of argumentations for all socio-scientific issues. However, further research that controls for online and offline environments as well as for socio-scientific issues as different contexts should be conducted to clearly describe the relationship between online and offline environments, socio-scientific issues and levels of argumentation.

In a recent review by Deng, Chen, Tsai and Chai (2011), the researchers suggested that students' epistemologies of science can be enacted through students' use of argumentative resources to construct and justify scientific claims. In addition, in the study by Ozdem, Ertepinar, Cakiroglu and Erduran (2013), the researchers indicated that the pre-service science teachers supported their argumentations with scientific grounds in inquiry-oriented laboratory environments that provided the pre-service science teachers with opportunities for critical discussion. These studies from the literature and the results of the present study indicate that the pre-service science teachers' argumentations and epistemologies are closely related as well as specific environments that provide the pre-service science teachers with opportunities to discuss are effective in supporting the pre-service science teachers' argumentations.

In summary, specific contexts such as socio-scientific issues, use of an online discussion environment and the pre-service science teachers' epistemic belief levels that are important for the pre-service science teachers' written argumentation levels about socio-scientific issues were explored and the relationship between these concepts were described in this study. The results of this study indicated that the pre-service science teachers produce high levels of argumentations about socio-scientific issues in online discussion environments and the levels of the pre-service science teachers' argumentations are related to their epistemic belief levels.

As regards to future research in science education, further empirical studies with quantitative and qualitative methodologies should be conducted in order to better understand the relationships between the pre-service science teachers' epistemic belief levels, argumentation levels and the context of socio-scientific issues in online discussion environments.

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