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An Examination of Prospective Elementary Science Teachers' Perspective towards Socio-Scientific Argumentation

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ABSTRACT: The purpose of this study was to examine the altering perceptions and opinions of prospective elementary science teachers regarding argumentation while they were engaged in argumentative discourse. The participating teachers were engaged in socio-scientific argumentation for 9 weeks involving a 6 step process on a course "Special Topics in Physics". Two sets of interview questions were addressed to participants at the beginning and end of the process. The data obtained through sets of questions were analyzed by means of inductive content analysis. Argumentation skills included in the sets of questions were analyzed by means of Toulmin's Argument Model. The results achieved showed that the socio-scientific argumentation processes created qualified learning environments in terms of science education. Positive changes occurred in the opinions of the participating teachers with respect to science education. It was also revealed that the participants improved their argumentation skills.

KEY WORDS: argumentation, socio-scientific argumentation, prospective elementary science teachers, science education, perspective

INTRODUCTION

The current developments of science and technology have made science education come into prominence. One of the basic outcomes of science education has been providing students with a broad conceptual perception of the world in which we live and furnishing them with skills to take part in scientific discussions inherently associated in their everyday lives. In several educational systems where knowledge-transmission modes of teaching and learning are adopted, it is stressed that teachers who show didactical teaching display a rhetorical, one-way interaction (Simon & Johnson, 2008).

On the other hand, when the educational systems are oriented by approaches of co-construction of learned phenomena, it is apparent that the teachers' role is a guide; in turn, students are active participants in the learning process (Erduran, Simon, & Osborne, 2004). At the core of a contemporary science education curriculum, carried out in different

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countries, the aim is to advance the students' perception of scientific topics in social life to improve their problem solving and critical thinking skills, and to turn them into scientifically literate individuals (AAAS, 2001; Curriculum Council of Western Australia, 1998; MNE, 2013). In this context, when the aforementioned visions of contemporary science curriculum are taken into consideration, argumentation stands out as an important concept (e.g., Sadler, 2006; Zohar & Nemet, 2002).

REVIEW OF RELEVANT LITERATURE

Argumentation is regarded as a significant component of science education (e.g., Kuhn, 1993; McNeill, 2011; Osborne, Erduran, & Simon, 2004). There are diverse definitions by researchers regarding what constitutes an argument. Argumentation refers to a basic praxis of science educators and in recent years, has been considered as an inevitable broadening goal of high-quality science education (e.g., McNeill & Pimentel, 2010; Aydeniz & Özdilek, 2015). Argumentation also refers to an approach that is used to argue emergent issues (i.e., socio-scientific issues) occurring within individuals' everyday lives.

Argumentation has a critical importance as the basic component of education in terms of scientific knowledge acquisition and students' constructions of social and scientific ideas, as well as ways of thinking and reasoning (Driver, Newton, & Osborne, 2000; Jimenez-Aleixandre & Erduran, 2008). By consensus, argumentation is known to be both an individual and incorporated social interaction in which members of learning communities have an opportunity to generate their arguments (Berland & Reisier, 2009). Through this interaction, individuals produce novel and known arguments, and evaluate such arguments through cognitive processes (Kuhn, 1993). Within social argumentative interactions, two or more individuals generate diverse arguments about a certain topic and they argue to evaluate the validity criterion of these various arguments (Berland & Hammer, 2012; Berland & Reiser, 2009).

It is of chief importance that students are integrated into instructional interactions, not only from a scientific point of view, but also from a socio-scientific perspective for effective science teaching and learning. Sadler & Zeidler (2005a) indicate that socio-scientific topics focus on emergent social issues consisting of an ethical or moral component with a scientific interest. Accordingly, socio-scientific issues (SSIs) have three basic characteristics: they have no clear-cut ultimate solutions, they are inherently argumentative and they also require ethical/moral and emotional reasoning (Zeidler, Walker, Ackett, & Simmons, 2002; Sadler & Fowler, 2006). These SSI components sustain the opportunity to negotiate cutting-edge, everyday issues with others, while thinking in a critical sense (Zeidler & Sadler 2008). In this context, the Toulmin

Argument Model comes into prominence in the process of negotiation through the SSI argumentation.

In science education, within a scientific and socio-scientific context, the Argument Model by Toulmin (1958) has been used by many science education researchers (e.g., Robertshaw & Campbell, 2013; Driver et al., 2000; Zohar & Nemet, 2002). The model allows identification of components of an argument such as claim, data, warrant, backing and rebuttal. According to this model, an argument is comprised of data stating the nature of argumentations independent of the context, justification, backings and rebuttals (Figure 1).

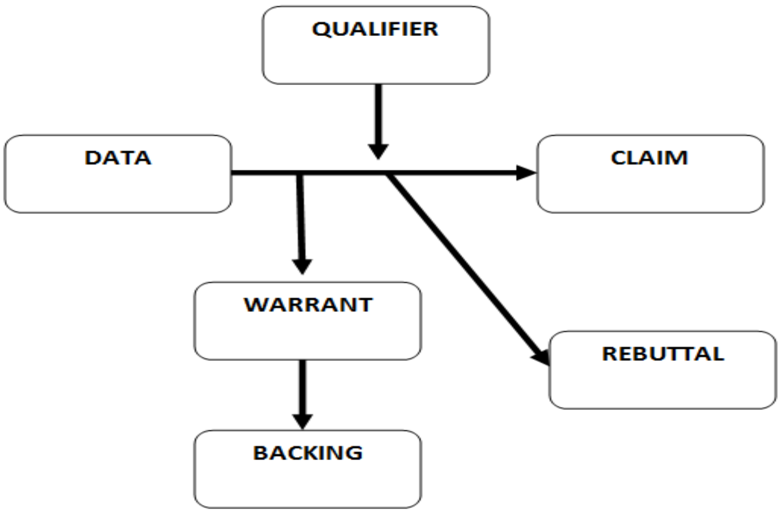

Figure 1. Toulmin's Argument Pattern (1958)

There have been several studies investigating elements that influence socio-scientific argumentation (e.g., Topcu, Sadler, & Tüzün-Yılmaz, 2010), or the effect of argumentative classroom events associated with desired purposes within science education (e.g., Walker & Zeidler, 2007). In these studies, the components characterizing socio-scientific argumentation and their presumable associations, which have been investigated, are:

- knowledge of content (Sadler & Fowler, 2006; Liu, Lin, & Tsai, 2011),
- context of the knowledge of content (Topcu, Sadler, & Tüzün-Yılmaz, 2010),
- comprehension toward nature of science (NOS) (Sadler, Chambers, & Zeidler, 2004; Khishfe, 2012; Walker & Zeidler, 2007),

- epistemological beliefs (Sandoval & Millwood, 2007) and
- reasoning patterns (Sadler & Zeidler, 2005b).

However, there are relatively few studies that deeply examine the altering opinions of students and/or student-teachers about socio-scientific argumentation(e.g., Tümay & Köseoğlu, 2011; Sadler, 2006).

Formal and informal negotiations that are intentional have great effects on students' acquisition of argumentative perceptions in relation to SSIs and their development as scientifically literate individuals (e.g., Sadler & Zeidler, 2005a). Teachers, who encourage learners to generate argumentations pertaining to SSIs, in the field of science education, are crucial as they aid the enhancement of students' conceptual understanding and background knowledge (e.g., Dawson & Venville, 2010). It has been confirmed that teachers are active agents in forming the modes of students' argumentation within scientific and socio-scientific contexts (Simon, Erduran, & Osborne, 2006; Dawson & Schibeci, 2003; Roychoudhury & Rice, 2009; Sadler, 2006). The research on socio-scientific argumentation has shown that being intentionally engaged in fruitful argumentation is only possible in the presence of teachers' incremental perception about argumentation (e.g., Simon et al., 2006; Lin & Mintzes, 2010). Therefore, many studies have shown the importance for teachers to have pre-service and in-service education promoting embedded elements of argumentation (e.g., Erduran et al., 2004; Zeidler, 1997; Driver et al., 2000).

The results of several studies, (e.g. von Aufschnaiter, Erduran, Osborne, & Simon, 2008), signifying the discourse of teachers on a certain negotiation topic, showed that teachers might have a great impact on the patterns of student-generated arguments. In a study conducted by Tümay and Köseoğlu (2011), prospective science teachers who participated in argumentation had their opinions scrutinized at the end of the process. According to the findings, the teachers declared that argumentations could have positive influences on their students in:

- acquiring skills of scientific thinking and questioning,
- scaffolding their conceptual change and meaningful learning,
- developing the views on NOS,
- increasing interest in science courses, and eventually
- encouraging students to contribute to learned phenomena effectively.

In the same vein, Sadler (2006) conducted research in which he explored the perceptions of prospective teachers concerning argumentation. The findings revealed that the prospective teachers considered argumentation as an appropriate cognitive acquisition apparatus for students and a pedagogically scaffolding strategy for teachers to increase the achievement of learners.

Since teachers have a great influence on increasing the quality of the argumentation during a scientific and socio-scientific argumentation, it is important that prospective science teachers gain experience inauthentic argumentation and factors identified affecting their ideas. However, there are few studies in the literature that deeply examine opinions of prospective science teachers about socio-scientific argumentation (e.g., Tümay & Köseoğlu, 2011; Sadler, 2006).

The aim of this study, therefore, is to examine the perceptions and opinions of prospective elementary science teachers who had been engaged in socio-scientific argumentation. The research questions are;

1. what are prospective elementary science teachers' perceptions and opinions on argumentation prior to being engaged in socio-scientific argumentation activities?
2. are there differences regarding prospective elementary science teachers' perceptions and opinions on argumentation following engagement in socio-scientific argumentation activities?

METHODOLOGY

Research Design

A case study approach was employed in this study allowing scrutinizing of a group, system or program connected to each other in their own natural environment where they were materialized (Merriam, 1998). A single case study was used in order to specify what "the socio-scientific argumentation phenomena" denoted from the lens of participants (Creswell, 2007). The case in this study was "how the participants' perceptions and opinions on argumentation differ according to various argumentative discursive events." The study was conducted taking into account bounded *time* and *context* considerations (Stake, 2006), where "time" referred to an allowance for *processes,* in which alterations in participants' opinions and perceptions regarding argumentation, and the expression of "context" related to negotiations 'around' or 'based-on' SSIs, in which participants gained experience (Merriam, 1998; Stake, 2006).

Participants

The sampling strategy for this study was Critical Case Sampling (Patton, 1990), where the focus of the data gathering was on understanding what happened in that critical case (Patton, 1990 p. 174). The Critical Case here is argumentation process. Prospective elementary science teachers (N=21; Males=3, Females=18) from the 3rd grade, enrolled in the Department of Science and Technology Teaching, Faculty of Education, at a public university participated in the study during the fall semester in the 2013-2014 academic year.

The prospective teachers were from different regions of Turkey and so possessed different socio-economic backgrounds and had not participated in earlier argumentation processes. Therefore, the participants were informed about the implementation of the study and invited to participate.

Data Collection Tools

Two distinct, but internally related question sets developed by Sadler (2006) and their completed adaptive forms, were addressed to participants in order to signify their perceptions and opinions on socio-scientific argumentation prior to and following engagement in argumentation. The question sets were submitted to two experts for their examination to substitute for an "external audit" process (Creswell, 2007; Yıldırım & Şimşek, 2008, p. 256). A pilot implementation was conducted previously by 5 participants (25% of the total 21 participants was taken as the criterion; Creswell, 2007) in order to detect whether the questions in the sets were well-organized and intelligible as well as whether:

(a) they denoted the same semantics to all participants, and
(b) to what extent they served for the purposes of the study.

The final form of the question sets was based on experts' views and surface analysis of near verbatim-transcripts of the pilot study. The characteristics of the questions in the sets were as mentioned in Table 1.

Table 1 Characteristic of the Question Sets

	Question Sets	
	Pre-Process (Question Set 1)	**Post-Process (Question Set 2)**
Question 1	Science and its Characteristics	The Impact of the Socio-scientific Argumentation Process on Opinions withinScience Education
Question 2	The Function of Science Teaching	Inclusion of Argumentation in Areas of Science Education
Question 3	The Role of Argumentation in Science	Argumentation in Science Education
Question 4	Teachers' and Students' Roles in Science Education	Argumentation Skill
Question 5	Argumentation Skill	

Implementation

The implementation activities, in which the prospective science teachers were engaged in socio-scientific argumentation, were conducted within a course on “Special Topics in Physics.” The implementation activities lasted for 9 weeks, occupying 2 hours per week and were as detailed below.

Phase I

The participants in the study responded to Question Set 1, which included 5questions in order to determine their pre-process perceptions and opinions pertaining to argumentation and science education. The participants were asked to answer the questions sincerely. Completion of the questionnaire took about 20-25 minutes.

Phase II

A presentation was made about the nature and the perspectives of learning. This interactive presentation aimed at actualizing reciprocal negotiations with the participants through embracing contemporary learning theories, the responsibilities of teachers in creating fruitful learning environments and the desired requirements associated with modern science education. The presentation was in a Question-Answer format in which participants effectively contributed to the negotiation. The rationale for this presentation was seen as: if teachers desire students to advance their perceptions towards science and its sub-fields by prompting them into a higher-quality science learning, it was important to awaken teachers to the various teaching styles rather than just repeating the same teaching mode for a specific topic (Prain, 2006; NRC, 1999; Philips & Soltis, 2004). From this perspective, seen as a prerequisite for teachers, so as to enable them to participate in the argumentation implementations more eagerly, and to internalize the argumentative discursive events, the presentation was seen as empowering.

Phase III

A presentation was made on the meaning of argumentation, which included a video showing an instance of socio-scientific argumentation. The participants were asked to evaluate the discussions in the video by means of Toulmin’s Argument Model. Herein, the aim was to comparatively guarantee that the teachers captured the insights of basic argumentation skills by internalizing the argumentation components displayed in Toulmin’s Argument Model. By means of this implementation lasting 2 weeks, it was expected that the participants would be able to give, to some extent, satisfactory argumentation skills so as to be able to judge the structural components of an argument and the quality legitimizations of an argumentative discourse (Kuhn, 1993, 2010; Zohar &Nemet, 2002).

Phase IV

The participants were engaged in an authentic socio-scientific argumentation implementation activity. In this 3 weeks phase, participants were divided randomly into four groups. The socio-scientific argumentation scenarios (*three different expert opinions were sought to verify whether the scenarios have a scientific base and pose contradictions*), prepared by benefiting from fictional events and by taking current issues into consideration, were argued primarily in small groups and afterwards through whole class discussions by collaboration of the participants and researchers. Every week participants were engaged in thesocio-scientific argumentation and a total of 5 scenarios were considered(an exemplary scenario was as given in Appendix 1). Small group discussions were completed in 15-20 minutes and were followed by a class discussion, in which the groups having opposite or alternative opinions were required to negotiate their arguments in detail.

Phase V

"Question Set II," consisting of 4 questions, was used to deduce participants' post-implementation perceptions and opinions concerning argumentation and science education. The participants were asked to response to the questions sincerely and completion of these took about 20-25 minutes. A general evaluation of argumentation implementation followed and comments on the effectiveness of the implementation were recorded.

Phase VI

An elucidative presentation was made to share outcomes of issues within the presented scenarios, which are scientifically-oriented and placed in socio-scientific contexts.

Data Analysis

The data collected in the research were analyzed by means of interpretative content analysis. This method allowed identification of the underlying conceptualizations of the participants within a qualitative data corpus and the relations between these conceptualizations by means of open, axial and selective coding (Strauss & Corbin, 1990). The responses of the participants to the questions prior to, and following, the argumentation processes were compared and a coding catalogue created, incorporating analytical comparison selections. During this process, coined as *Constant Comparative Method* (Glaser & Strauss, 1967), a coding catalogue was established to ensure the reliability of the analyses and promoting the locating of several untidy codes into emerging themes. For this, an additional researcher participated in the procedures.

The argumentation skills, included in the sets of questions, were analyzed by means of Toulmin's Argument Model (Erduran et al, 2004). The inter-coder reliability (Lincoln & Guba, 1985), which is expected to be beyond 70% for any coding event, was over 80% for the study. In addition, a specific part of the analyzed data was checked by an expert, substituting for an external audit (e.g., Creswell, 2007).

FINDINGS

The findings, illuminating the prospective elementary science teachers' perceptions and opinions regarding argumentation prior to and following socio-scientific argumentation, are presented in two sections as 'Pre-process Assessments' and 'Post-process Assessments'. In general, participants were only able to provide responses to the first stage of the two-stage question sets.

Pre-Process Assessments

Science and its Characteristics

Responses to the questions concerning science and its characteristics confirmed that participants did not comprehend the concept of argumentation in science. The findings inferred from this question were collapsed into six higher-order categories stated item by item. The most definitive quotations from the participants were as displayed in Table 2.

Table 2. Science and its Characteristics

Higher-order category	Excerpt
Hypotheses turn into Theories and Theories turn Into Laws	Science requires verifiable and provable research on a topic. The laws have been obtained at the end of processes. The difference between physics, chemistry and biology and other sciences is that theories are not acknowledged in these sciences, but in the others, theories can be acknowledged. Science is the organized accumulation of knowledge focusing on a specific part of topics related to the universe and its occurrences and figuring out of laws through empirical methods.
The Laws Created After Scientific Processes do not change. They are all Certain	Science is the matter in which ultimate knowledge can be created because it takes its sources from verification and systematic research. Physics, chemistry and biology are more concrete comparatively other scientific disciplines. The laws of science are stable everywhere and they are not changeable.
Evidence integrated Systematically guide Research to its ultimate conclusion.	Science is the process of learning of laws of creation in a systematic manner. It is the culmination of knowledge asserted by research concerning the universe and its […the science's] results are absolute.
Definite Evidence is Acquired by applying Science and its Methods to a specific field of study	Science is the exploration and verification of knowledge. The fields that physics and biology study are different. They are continual studies. Its provability has been testified. If the knowledge is proved, it is considered as scientific knowledge.
The Basic Way to acquire Scientific Information is by Experiment	Science is able to explain nature by means of experiments. There is no science without experimentation. Experiments cannot be conducted in other disciplines. This is a critical difference. Science can explain the environment through experiments.
Science and Technology are the Same Fields	It is […the science] a field which works with technology. One cannot be conceived in the absence of the other. Since technology is not constantly served in other fields, they are scientifically weak.

The Function of Science Education

The second question was concerned with the function of science education. The content analysis conducted on the participants' responses were embedded into two higher-order categories. Most participants stated that science education had importance since it had *interactions* with our *everyday lives (1)*.

> Many things in our lives take their sources from natural sciences. All indispensable technological products in our lives are thanks to natural sciences.
> When science is mentioned, it includes all features of life. All events in our lives are related to science. I would like my students to practice what they learn in their lives.
> …[B]ecause science has a direct, exact relationships with life. Everything we see around us is closely related to physics, or chemistry, or biology. I desire my students to put this course actively into practice for their everyday lives. For instance; they may be able to remember chemistry courses when soap is mentioned.

Another finding obtained in the content analysis for this question indicates that science education is a matter of *Concept Learning (2)*. Furthermore, the participants anticipated that their students need to learn underlying concepts within every aspect during their learning experiences.

> Science education is considerably substantive in making sense of the phenomena and concepts occurring around us and within our bodies. I want students to be educated as individuals who have internalized the topics well and who know how to ask questions.

The Role of Argumentation in Science

From responses to the third question about the importance of argumentation in the pre-process assessments, it is seen that many participants could neither provide any response to the question nor make inappropriate judgments. The responses to this question are categorized in Table 3.

Table 3. The Role of Argumentation in Science

Higher-order category	Excerpt
Linguistic Context	Spoken language should be convenient not only in the discourse within science, but also everywhere in our lives. Besides, during the first years of studentship, in different phases such as when primary and secondary school educations are started, more attention must be paid to spoken language.

Comprehension/ Interpretation/ Teaching	The role of discourse in science is to convey our internal thoughts to people. They learn about our ideas. The role of discourse in secondary school is that others learn aspects of knowledge when we make a scientific speech. Thus, if our discourse is intelligible, they understand it better.

The Role of Teachers and Students in Science Education

The responses to the fourth question related to how science courses and science education were viewed from the participants' perspectives and were embedded into two higher-order categories. Most participants pointed out that

(i) Laboratory implementations are '*sine qua non'* and science education;

(ii) should be actualized in compliance with co-constructive teaching approaches.

> Science education must be completely student-centered. The teacher must only take an active role as a guide. Laboratory studies must be in the foreground since they are more effective in acquisition of outcomes for students.
>
> Laboratory implementation must crucially occupy more emphasis in science education. If the students learn by doing and experiencing […hands-on & minds-on], teaching becomes more co-constructive. Both parties (students and teacher) must be interactive. There must be reciprocal communication.
>
> Science education is possible in the presence of true implementation of laboratory applications. I am of the opinion that theoretical knowledge is also useful. The teacher must be fully-equipped in terms of knowledge acquisition. As students must be receivers of knowledge, co-construction of knowledge in education must be in the foreground.

Argumentation Skills

The last stage of pre-process assessments was that the participants were required to provide arguments in any area they chose by utilizing the nature of argumentation. According to the argument articulations of the participants to this question, it was observed that either many left it unanswered, or they provided baseless argumentations. The argumentations presented, by and large, could not exceed beyond "Claim and Data" according to Toulmin's Argument Model.

> Atomic structure: An atom is comprised of electrons, protons and neutrons. Electrons are negative, protons are positive and neutrons are neutral".
>
> Gravity: This theory was brought forward with the apple falling onto Newton's head. Newton, who questioned why the apple fell on his head, found why a house cannot stand on a tree like an apple and formulated gravity.
>
> Evolution is an ongoing process in which non-living and living organisms have changed over the course of time.

> Big Bang is a theory that advocates the universe came into being as aresult of a very intense hot point. It is a theory, which acknowledges that the universe has a beginning.

Post-Process Assessments

The Effect of Socio-Scientific Process on the Opinions about Science Education

Related to opinions about science education, most participants stated that engaging in socio-scientific argumentation in science education resulted in positive changes in learners' attitudes, behaviors, learning levels and persuasiveness of their arguments. Particularly, the idea of being engaged in argumentation allowing more learning that is meaningful was among the insights of the participants.

> It […argumentation] is important to learn the fundamental knowledge in various topics. Our thinking and thought production power has risen.
>
> I realized that argumentation is beneficial for science teaching. It triggered my eagerness for exploration and curiosity. Knowledge can be transferred to pupils easily through argumentation.
>
> Argumentation must be used in science education. This is because students may be able to find conflicts in questions in her mind by negotiating and correcting her existing misconceptions. It helps her to like science more.

Infusion of Argumentation in Science Education Environment

The second post process question asked whether the participants would implement argumentation in their classes and revealed that many participants agreed to apply it. Examples indicating how participants, who displayed a positive attitude towards argumentation, actualize argumentation are exemplified in the Table 4:

Table 4. **Inclusion of Argumentation in Science Education Environment**

Higher-order category	Excerpt
Assessment and Evaluation Tool	Yes, I will implement it. This is how I can detect the points that students cannot understand or they have misunderstandings. If I detect their level of knowledge, I am able to conceive to what extent they are knowledgeable about the topic and thus help them to correct their misunderstandings.
Formation of Small Argumentation Groups	Yes, I will implement it. Because students generate justifications for their ideas and learn how to advance themselves, I can enable them to exchange ideas through negotiation. This is a more fruitful learning context.

Argumentation in Science Education

The findings collected from the analyses on the place for argumentative attitude in science education are displayed in general terms in Table 5.

Table 5 Argumentation in Science Education

Higher-order category	f	Excerpt
As a goal	12	It must be adopted as the purpose of life. If it is conceived as the purpose, we can practice it in every part of our lives.
As a tool	2	If science education is associated with everyday lives of individuals via argumentation, as both the aim and the means of learning, this can provide a meaningful knowledge base.
Both of them	7	Argumentation must be used as a means of teaching in science education, because brain-storming is possible in various topics. Students learn better and we see how much they learn.

Argumentation Skill

The last stage of post-process assessment consisted of the participants' generation of arguments that were shaped in accordance with knowledge claims among different socio-scientific topics, which took the nature of argumentation into account. The fine-grained analyzed data stressed that the skills of argumentation progress compared with the pre-process stage. It was seen in the argumentation of the participants that 'Justification' and 'Backings' were added to 'Claim' and 'Data'. At the end of the process, the argumentation established by the participants was built on a strong base.

> On the one hand, stem cells should not be produced, because it is not appropriate in our religion. Creation of living things can only be done by God. On the other hand, they should be produced, because organ transplantation may save many people's lives.

[Claim + Justification + Backings + Claim + Justification]

> Stem cells should be produced since every creature has a function in the nature. Once a creature has been extinct, the ecosystem is adversely influenced. It is harmful in turn for all creatures in the long term.

[Claim + Justification + Backings + Backings + Backings]

> GMOs should not be produced. If you place importance on this, biodiversity would be destroyed. Nuclear power plants in Turkey should be established.

[Claim + Justification + Claim]

> Nuclear power plants should be established in Turkey, because their loss would be more than their benefits.

[Claim + Justification]

> I think that stem cells should be developed, because it would be necessary for the health of many people.

[Claim + Justification]

> Production of GMOs should be given more importance, because when the economy develops, the production of crops grown in the country would be facilitated.

[Claim + Justification]

DISCUSSION AND CONCLUSIONS

The aim of this study was to examine the perceptions and opinions of prospective elementary science teachers on argumentation prior to and following engagement in socio-scientific argumentation. Two question sets, within 6 phases, were addressed at the beginning and end of the implementation and interactive presentations, these lasting for 9 weeks, and in which opinions concerning argumentation and science education were explored. The data obtained in the form of written responses to the sets of question were analyzed by means of inductive content analysis. In addition, the argumentation skills in the question sets were examined with the help of Toulmin's Argument Pattern.

The findings obtained from the analysis of the participants' responses to the questions included in Question Set-1 confirmed that they still hold several myths regarding the Nature of Science. When looked at closely, six of the 15 'Science Myths,' identified by McComas (2002), were apparent in the responses of the participants. These were;

- Hypotheses turn into theories and theories turn into laws.
- Scientific laws and types of these ideas are definite.
- The evidence that are brought together carefully result in absolute knowledge.
- Science and its methods provide complete proofs.
- The fundamental way of attaining scientific knowledge is through experiments.
- Science and technology are identical.

The absence of participants citing respectively ‘argumentation’ or ‘discourse’ for this question set should be considered as a significant finding. This finding showed that the participants were unaware of the assertions in the existing literature (e.g., Driver et al., 2000; Erduran, 2014; Duschl & Osborne, 2002) which state that science and argumentation were in reciprocal interaction with each other and scientists argued during knowledge creating processes. One true reason for the participants’ earlier mentioned myths might be considered to be a result of not being exposed to instruction pertaining to the nature and structure of science.

It could be beneficial to look at the responses of the participants to other questions in order to specify the reasons for this case better. While the participants indicated that science education attached importance to learning concepts and reflecting on them in real-life circumstances, they also acclaimed that science education might become more appropriate through in-class, experiential activities. Despite the participants recommending co-constructive teaching methods for science education, particularly through laboratory implementations, they prioritized the learning of concepts as the first goal in their science teaching practices. This fact, in a sense, provided clues as to why the participants held various scientific myths. The participants focused on the context of language and teaching terms when addressing question regarding argumentation. This cautiously confirmed that although the participants adopted co-constructive approaches, they really adopted a rhetorical posture in which they assessed the role of argumentation in a naïve sense. As known, one of the main goals in current science curricula and stressed in related literature was to put emphasis on the dialogistic instead of the rhetoric (AAAS, 2001; MNE, 2013; McNeill, 2011; Osborne et al., 2004). However, the study findings showed that the participants tended to act within a one-way teaching approach. Another striking finding exhibited prior to the process was that participants’ skills of argumentation did not go beyond providing ‘Claim and Data’. This finding was suggested by Kuhn’s (1993) opinion that individuals inherently induced argumentative skills; and it was worthy of note that conventionally-oriented school curricula did not scaffold the advancements of argumentative skills. The existence of mere ‘Claim and Data’ component skills, indicating weak argumentation, pointed to the recognition that held argumentative skills were never sufficient to teach topics through argumentation (e.g., Erduran et al., 2004). As a consequence, the findings obtained prior to the process demonstrated that the participants did not hold necessary comprehension about argumentation and an adequacy in argumentative skills, and despite perceiving science teaching as being favored by learner-centered approaches, they continued to hold a rhetorical stance in science teaching.

The findings obtained from the post-argumentation engagement, Question Set-2 showed the emergence of a positive change in the participants’ ideas towards argumentation. The participants held views regarding science education that it would be more beneficial to teach through reciprocal interactions compared to the pre-process declarations, where the concept of argumentation had been regarded within the context of language and the transmission of knowledge. It was observed that the participants demonstrated a positive attitude toward the infusion of argumentation in science education. It also confirmed that the experiential implementation of socio-scientific argumentation benefited participants in a pedagogical sense (Zembal-Saul, 2009; Sadler, 2006). The participants, as indicated by the findings, recognized that infusing argumentation, particularly socio-scientific argumentation, in science education attached importance to materializing more appropriate learning which, as the participants expressed, scaffolded the improving reasoning skills of learners (Duschl & Osborne, 2002; Simon & Johnson, 2008; Zohar & Nemet, 2002; Bell & Linn, 2000; Driver et al., 2000; Sadler, 2006). Another important finding was that argumentation skills of the participants were augmented compared to the pre-process. While sole ‘Claim and Data’ components had been provided in participants’ arguments prior to process, it was found that ‘Warrants (Justifications) and Backings’ were also included by participants. These findings, as Kuhn (2010), Zohar and Nemet (2002) and Dawson and Venville (2010) reported, showed intentional engagement in argumentation, even in a short period of time, truly increased the individuals’ argumentation levels. Furthermore, Sadler and Fowler (2006) and Sadler and Donnely (2006) advocated that the most outstanding factor scaffolding the development of argumentation skills was enabling learners to justify arguments presented, this only occurring through establishing arguments accompanied with warrants. The increase in the Justifications or Warrants, which participants were able to supply affirmed that their argumentation skills had developed compared with their pre-assessment position.

The findings obtained in this study illustrated that socio-scientific argumentation was able to create resourceful learning environments in terms of science education. Positive changes occurred in the participants’ opinions, with respect to science education, as they engaged in the process. They supposed that quality learning in science education would materialize through argumentation.

Perhaps the most significant outcome from this study was that the participants recognized the value of a co-constructive teaching style before the process, but they still referred to knowledge-transmission modes of learning and teaching. However, their ideas shifted within process. Thus engagement in argumentation might be regarded as having an executive function in leading the participants from a rhetorical posture to a dialogical stance in science teaching and learning.

EDUCATIONAL RECOMMENDATIONS

The results achieved showed that the socio-scientific argumentation might create better qualified learning environments in terms of science education. Positive changes occurred in the opinions of the participants engaged in socio-scientific argumentation and it was detected that they improved their argumentation skills. Recommendations for science education emanating from this study are as follows:

- give more importance to socio-scientific contexts in research in science education with the aim of addressing gaps within existing literature;
- ensure popularization of in-service training programs which include argumentation, socio-scientific argumentation and the reciprocal interaction between the nature of science and argumentation;
- make it possible for prospective teachers to be engaged in oral discursive events more frequently in order for them to be calibrated decision-makers and scientifically literate persons;
- incorporate socio-scientific argumentation in science classrooms;
- put more emphasis on argumentation, especially socio-scientific argumentation, in formal institutions where teachers are educated.

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Appendix 1

SCIENTISTS ARE DISCUSSING

The congress named "Nuclear Power and Environment" and the first of which has been organized this year was hosted in Turkey. Many scientists studying in the field of nuclear energy attended this congress and shared their opinions. During a session in this congress, two speakers, who made a speech, presented two different reports about nuclear energy and the interaction between nuclear power stations and the environment.

Report I

Nuclear power produces electricity in an environment-friendly way without creating carbon dioxide (greenhouse gas), sulfur dioxide and nitrogen oxide,all of which lead to acid rain. Nuclear energy has many advantages based on the fact that the world energy demand is rapidly rising, fossil fuel reserves are bound to be extinct and there are serious problems, which the world is facing. It is observed that in nuclear facilities, there is no smoke emission and the fertile lands are not left to be buried under water. The global environment problem of the world is the rise of carbon dioxide concentration in the atmosphere. No country can isolate itself from this problem. Increasing carbon dioxide concentration results in acid rain and also starts the process of the world's global warming. Excessive fossil fuel usage, which causes this problem, must be restricted. If the electric energy (306544 MWe) produced by nuclear facilities in 1998 had been obtained by firing coal, there would have been nearly more 1600 tons of CO_2 emission. To recap, when nuclear power facilities are compared to fossil fuel facilities, the former is accepted to be nature-friendly. It is observed that thanks to the contributions of many countries such as Canada, South Korea, Taiwan, France and Belgium, which enhanced their nuclear capacity, carbon-dioxide, the other greenhouse gases and poisoning acid rains, are lessened on a vast scale.

Report II

Plutonium emitted as waste while nuclear reactors are working is highly poisonous and causes cancer and its existence in nature is about 250 years. Strontium, another emitted radioactive substance, contaminates vegetables and from there animals' milk and people by rain. It causes leukemia and it has 280 years of life duration. Cesium and Iodine enter the human body from nourishment and cause thyroid gland cancer, failure in child development and genetic disorders. As a result of the nuclear explosion occurring in Chernobyl in 1986, the adverse effects of radiation was encountered in the influenced area for many years. As a result, nuclear power station construction is a process, which takes a long time and it is highly risky. The pulling down of the old plants is also difficult and it is done at a high price. Besides, no formula has been found to store radioactive wastes safely so far. In our world, where many natural events occur, nuclear power stations always bear the risk of accidents.

The scientists in the presentation room were divided into two groups as the supporters and non-supporters of nuclear power station construction after the presentations were completed.

- Do you think that under these circumstances nuclear power stations should be constructed?
- Explain your decision and provide justification.