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Examining Argumentation Skills of Preservice Science Teachers in Terms of their Critical Thinking and Content Knowledge Levels: An Example Using GMOs*

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ABSTRACT

The aim of this study was to examine the argumentation skills of preservice science teachers on genetically modified foods during an argumentation process. Within case study research methodology, this study was carried out with 20 preservice science teachers identified through convenience sample from science education department. Knowledge Test for GMOs, Watson-Glaser Critical Thinking Appraisal and semi-structured interview questions were used to collect data. Findings showed that the groups with high level genetically modified food knowledge tended to use more qualified rebuttal and evidence. On the other hand, the groups with high level critical thinking skills were apt to exploit more qualified warrant, counter-argument, rebuttal and evidence. The research findings revealed that knowledge level and critical thinking skills are influential on argumentation skills. It was concluded that content knowledge is associated with self-efficacy and motivation in argumentation. However, critical thinking skills are associated with focusing, open-mindedness, understanding opposing ideas, and finding missing parts. In the light of this information, some suggestions was made for the development of knowledge and critical thinking skills for policy makers and educational scientists who have designed a teacher training program.

Keywords: Preservice Science Teachers, Socio-Scientific Issues, Genetically Modified Organisms, Content Knowledge, Critical Thinking Skills, Argumentation Skills.

INTRODUCTION

In many countries' science curriculum, students are targeted to be educated as "scientifically literate individuals" (Barrue & Albe, 2013). In the Turkish national science curriculum, which aims to develop students' science literacy, scientifically literate individuals are defined as follows: Scientifically literate individuals are individuals who research, inquire, have critical thinking skills, make decisions through logical reasoning, solve problems, defend their own opinions, self-confident, open to co-operation, entrepreneurs and life-long learners with an awareness of sustainable development (MNE, 2017). In the last quarter of the 21st

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century in particular, emergent socio-scientific issues (SSIs) such as global warming, cloning, genetically modified organisms (GMOs) and organ transplantation have strengthened the links between science and society. Thus, this issues have been included in the science curriculum as a part of the movement to reform the curriculum and promote the development of scientifically literate individuals.

Teachers have an important role in educating individuals. In schools, the role of science teachers is to develop students' scientific literacy and help them to gain conceptual understanding (Kilinc, Kelly, Eroglu, Demiral, Kartal, Sonmez & Demirbag, 2017). As stated by Sadler and Zeidler (2009), science teachers should improve the learning environment by introducing students controversial scientific ideas and helping them to associate their knowledge with daily-life activities. Furthermore, teachers can assist students' understanding of scientific concepts by enabling them to experience scientific activities carried out in the classroom, which will eventually contribute to the development of scientifically literate learners (Moore, 2008). Although the use of argumentation is recommended in the teaching of SSIs, which has recently been at the higher rank on the agenda of many countries, teaching an SSI is often carried out in the form of lectures or superficial discussions in science undergraduate programs (Kilinc, Demiral & Kartal, 2017). Some studies considered argumentation as a teaching method (Zohar & Nemet, 2002) and other studies examined its effects on cognitive development (Eskin & Ogan-Bekiroglu, 2013).

For preservice teachers, the skills of argumentation are also very important. However, there have only been a small number of studies conducted with preservice science teachers (PSTs) in order to improve their argumentation skills with regard to SSIs. The results of these studies indicated that the PSTs' argumentation skills depends on a number of factors such as the nature of science, content knowledge and epistemology (Sadler & Fowler, 2006; Khishfe, Alshaya, Boujaoude, Mansour & Alrudiyan, 2017; Liu & Roehrig, 2017). On the other hand, these studies did not explain how the PSTs' argumentation skills were influenced by their content knowledge and critical thinking skills, which are likely to be related to the quality of any discussion. Therefore, the purpose of the present study was to understand the nature of the relationship between the PSTs' argumentation skills and their content knowledge and critical thinking skills with regard to one SSI (GMOs). In the following section, theoretical framework of the study was presented at first. Next, some background information about these skills was presented in three sub-sections. The relation between the PSTs' argumentation skills and their content knowledge were explained in the first sub-section. The relationship between the PSTs' argumentation skills and their critical thinking was explained in the second sub-section. In the final sub-section, focus was narrowed on the current findings about the relations between argumentation skills, content knowledge and critical thinking in the context of SSIs. The theoretical framework informs our terminology, methods, analysis and interpretations.

Theoretical framework

Social constructivism is an approach that emphasizes the importance of individual's social interactions in acquiring skills and knowledge (Vygotsky, 1978). According to this theory, the process of argumentation is useful for gaining a deeper conceptual understanding of a specific subject or understanding other aspects of that subject, whether it is carried out in small or large groups (Schunk, 2012). Dialogical communication is indispensable for argumentation and teaching (Kilinc, Demiral & Kartal, 2017). Vygotsky (1978) suggested that an individual's interaction with their environment contributes to their success in learning. The experiences of a person in a learning situation can affect the outcome to a great extent (Schunk, 2012). Learning and thinking also arise in the context of beliefs about cognition, which is a process that varies as a function of personal, social and cultural factors related to an

individual. The beliefs that the individual possesses are also closely related to such factors as self-efficacy (Bandura, 1986) and motivation (Sivan, 1986). That is, individuals who believe that their talents are fixed and unchanging can easily lose heart when they encounter difficulties in daily life because they think that there is not much that they can do to change the situation (Schunk, 2012). Such loss of courage leads to low self-efficacy (Bandura, 1986).

On the other hand, individuals, who believe that they have control over their learning abilities, find it hard to give up when they encounter a problem and instead of changing their strategies, consult additional sources of information or engage in forms of self-regulation (Bandura, 1997). Individuals with high self-efficacy expend more effort in countering arguments and are more likely to respond when they have the necessary skills (Aydeniz & Özdilek, 2016). As can be seen clearly here, self-efficacy affects the efforts made and commitment to advocating points of views during the process of argumentation. In addition, Bandura (1988) defined motivation as a target-directed behavior that is actuated and sustained by anticipating and predicting the outcomes of other people's actions and their self-efficacy in realizing those actions. According to Bandura (1988), experience is very important in the manifestation of these behaviors because if an individual has not previously performed the behavior to be learned, she/he doubts her/himself and this prevents the use of previously-acquired skills. As a result, the individual's motivation decreases. When an individual enters the learning environment, his/her sense of self-efficacy with regard to learning is based on previous experiences, personality traits and social support mechanisms (Schunk, 2012). Argumentation skills are not only justification, rebuttal or evidence but also they involve rather complicated mechanisms such as presenting a claim, justifying claims, being aware of counterarguments, rebuttal of counter arguments, and using evidence (Lin & Mintzes, 2010; Sandoval & Millwood, 2005). To use these skills in the argumentation process, the motivation for the subject should be high (Trend, 2009). Self-efficacy is also important because it can affect motivation, cognition, emotional processes, and ultimately the behavior of individuals (Erika & Prahani, 2017).

Background Information

Argumentation Skills and Content Knowledge

Argumentation skills can be defined as skills in which knowledge is used to justify a decision through the use of scientific, logical and creative thinking (Foong & Daniel, 2013). In the literature, one of the predictive factors for argumentation skills was reported to be cognitive ability. Lin and Mintzes (2010) and von Aufschnaiter, Erduran, Osborne and Simon (2008) studied the connection between argumentation skills, and ‘preliminary information’ and ‘experiences’, which are considered to be factors of cognitive ability. These researchers ascertained that students who were engaged in argumentation used their former experiences and knowledge in the process and those such activities strengthened their existing knowledge and enabled them to evaluate other students’ levels of scientific knowledge. By drawing attention to the scientific knowledge of students, Schunk (2012) and Snyder and Lopez (2009) claimed that students draw on their former knowledge, general abilities, motivations and self-confidence when engaged in an argument.

Some researchers have observed relationship between content knowledge and argumentation. For instance, Sadler and Zeidler (2005b) reported that the students with a high level of knowledge are better at asserting more well-grounded justifications than students with a low level of knowledge. In another study, Sadler and Fowler (2006) reached the conclusion that students with a high level of content knowledge generally presented more detailed justifications in comparison to students with a low level of knowledge. Furthermore, as stated by Zohar and Nemet (2002) and Eskin and Ogan-Bekiroglu (2013), there was a significant

increase in students' knowledge levels if argumentation was used as a teaching method in the classroom.

Argumentation Skills and Critical Thinking Skills

Examining the definitions of the argumentation and critical thinking skills in the literature is useful in revealing the relation between critical thinking and argumentation. Paul and Elder (2001) defined critical thinking as the kind of cognitive ability used in deciding complicated situations. Similarly, Kuhn (1999) defined critical thinking as a cognitive ability used for solving ill-structured problems. In an argumentation process, critical thinking is considered to be a cognitive thinking mechanism used for decision-making and problem solving. Analyzing the relationship between argumentation and critical thinking, it was identified that a critical thinker often deploys critical thinking skills such as using evidence, reasoning, resisting authority, using their own opinions to evaluate knowledge, evaluating the validity and reliability of claims and providing evidence based on the claims (Voss & Dyke, 2001). By using critical thinking ability, an individual can display the following skills during an argument: First, individual can critically question socially-accepted claims, reinforcing them with supporting ideas or refuting them with evidence (Zohar & Nemet, 2002) while taking personal responsibility for this in a motivated way (Braund, Scholtz, Sadeck, & Koopman, 2013). Second, the individual can pay attention to the arguments being made, be eager to respond to group members' comments, and make a contribution towards integrating new evidence into existing knowledge (Driver, Newton & Osborne, 2000). Third, the individual can emphasize the frequently changing nature of scientific knowledge by using new evidence. Finally, the individual can test and evaluate assertions and theories of argumentation (Braund et al. 2013).

In addition to these skills, critical thinking allows individuals to develop valid arguments by using information with strong evidence that involve assumptions, concepts and phenomena. Moreover, critical thinking provides the opportunity for individuals to critically evaluate the strength of the arguments. In a high-quality argumentation process, critical thinking enables individuals to identify the validity of concepts and thoroughly understand the cause and effect relations between these concepts (Saracaloglu, Aktamis & Delioglu, 2011). During the process of argumentation, critical thinking allows cognitive abilities to be used in a more effective, structured and analytical way in order to justify assertions.

Researchers (Jimenez-Aleixandre, Rodriguez & Duschl, 2000; Öğreten & Uluçınar-Sağır, 2014) focused on relationship between argumentation and critical thinking. Jimenez-Aleixandre, Rodriguez and Duschl (2000) have emphasized the important role of critical thinking in defining evidence in addition to choosing, using and evaluating it. According to these researchers, critical thinkers cares about their warrants, which depend on processes of evaluation, judgment, and the situation being discussed while evaluating claims and judging or designing alternative situations. Thus, argumentation facilitates the construction of knowledge in the mind, or, in other words, argumentation acts as a mechanism that both creates and deploys knowledge (Ogan-Bekiroglu & Eskin, 2012). If an individual is able to construct an argument, she/he can also understand the meaning of a concept. Therefore, argumentation is an inseparable part of the thinking process (Kuhn, 1991). Argumentation is a manifestation of thinking, developing, and analyzing arguments can pave the way for new arguments to be made (Ogan-Bekiroglu & Eskin, 2012).

The Relationship between Critical Thinking Skills, Content Knowledge and Argumentation Skills in the context of SSIs

There are some specific features of being a good citizen in a democratic society. One of those features is having critical thinking skills and developing independent ideas (Jimenez-

Aleixandre, & Puig, 2012). Initiating discussions about current social issues such as GMOs (Walker & Zeidler, 2007), the choice of energy sources and climate change (Schweizer & Kelly, 2005) or the use of mobile phones and base stations (Albe & Simonneaux, 2005) can be used in supporting efforts to educate students to be sensitive citizens. SSIs are included in science education programs to support students in becoming the good citizens of the future (Barrue & Albe, 2013). They provide the opportunity for students to develop their own personal ideas and can create a platform for discussion through argumentation in the classroom because of the inherent dilemmas involved in them (Albe, 2008). Studying SSIs also contributes to the development of students' critical thinking skills (Freeley & Steinberg, 2013) and their content knowledge (Mason & Scirica, 2006). Hence, by discussing current social issues in classrooms using argumentation students have the opportunity to use and develop thinking skills including analysis, deduction, explanation, evaluation, interpretation and self-regulation (Facione, 1991). Furthermore, discussing an SSI through argumentation also provides an opportunity for educators to train students who are able to research facts, be open-minded, analytical, systematic and fair, and rely on their own reasoning (Zeidler & Nichols, 2009), while also improving students' content knowledge (Sadler & Donnelly, 2006).

Argumentation can be defined as a process of constructing appropriate reasoning in which individuals are able to assert claims through using logical justifications which can be linked to data, and it has an important role in science education (Driver et al. 2000). However, SSIs, which are controversial issues, require not only scientific but also moral justifications to be made in order for the dilemmas, they raise relating to science and technology to be resolved (Zeidler & Nichols, 2009). These issues enhance students' active participation and require justifications to be made by using scientific data as evidence (Sadler & Zeidler, 2005a). Since studying SSIs develops students' argumentation skills, their inclusion recommended in science education programs and classrooms (Topcu, Sadler & Yilmaz-Tuzun, 2010). Turkey is one of the countries which now including SSIs in science education programs.

This current study contributes the literature on the PSTs' argumentation skills by examining the limitations that was discussed in the previous paragraph. The study is crucial for curricula development, policymakers, and teachers and also for the future of teacher training programs. So, many countries have included SSIs in science education programs in the last decade. Therefore, the aim of this study was to examine the PSTs' argumentation skills with regard to GMOs during a specific process of argumentation. For this reason, we defined the main research problem and sub- problems as follows:

1. How do PSTs' argumentation skills with regard to GMOs differ in terms of their critical thinking skills and content knowledge?

(1a.) What are the differences between the argumentation skills of the PSTs with high-level critical thinking skills and low-level content knowledge, and those with low-level critical thinking skills and low-level content knowledge?

(1b.) What are the differences between the argumentation skills of the PSTs with low-level critical thinking skills and high-level content knowledge, and those with low-level critical thinking skills and low-level content knowledge?

(1c.) What are the differences between the argumentation skills of the PSTs with high-level critical thinking skills and high-level content knowledge, and those with high-level critical thinking skills and low-level content knowledge?

(1d.) What are the differences between the argumentation skills of the PSTs with high-level critical thinking skills and high-level content knowledge, and those with low-level critical thinking skills and high-level content knowledge?

METHODS

a) Study Design

In this study, it was aimed to investigate three variables in the context of SSIs: content knowledge with regard to GMOs, critical thinking skills and argumentation skills.

In order to elicit arguments as a means of empirically comparing argumentation skills, participants engaged in a process of argumentation about an SSI and explicitly asked them to formulate warrants, counter-arguments, rebuttals and evidence in response to a series of related issues. This technique is consistent with other more general investigations of argumentation skills (Acar, 2016 Lin & Mintzes, 2010; Sadler & Zeidler, 2005b; Venville & Dawson, 2010).

In the study, the holistic multiple case study which is a form of qualitative research that is one of the special case study models was adopted to analyze and compare the relationships among the variables (Yin, 2013). In this study, groups with different levels of content knowledge and critical thinking skills are created and each situation is handled holistically. Then the groups are compared.

b) The Study Group

This study was performed with 20 PSTs studying at a science education department. The study group was selected by convenience sampling, one of the random sampling methods used in the purposive sampling model.

For the selection of the teacher candidates taking part in the argumentation, this process was followed:

1. A Knowledge Test about GMOs (KT-GMOs) and the Watson Glaser Critical Thinking Appraisal (WG-CTA) were administered to 209 PSTs.
2. Using both test results, PSTs were assigned from highest to lowest in terms of ranking. To specify the groups, the 27% lower-27% upper formula was applied.

Participants were separated into high and low levels according to their test scores. To decide how to separate the PSTs into high and low level groups, literature was examined about knowledge and critical thinking skills (Sadler, 2003; Sadler et al. 2004). There are five preservice teachers with low-level CT and KT-GMOs in Group-A, five preservice teachers with high-level CT and low-level KT-GMOs in Group-B, five preservice teachers with low-level CT and high-level KT-GMOs in Group-C, five preservice teachers with high-level CT and KT-GMOs in Group-D.

The pseudonyms, gender, grade level and ages of the PSTs selected for the argumentation session as a result of this grouping are given in Table 1 below.

Table 1. *The characteristics of PSTs with different levels of critical thinking skills and GMO knowledge*

Groups	Level	PSTs	Gender	Grade level	Age	Knowledge Test Score	Sub-dimension of critical thinking					Critical Thinking Test Score
							Inference	Recognition of assumptions	Deduction	Interpretation	Evaluation of arguments	
		PST-1	M	3	23	8	5	8	7	10	1	31
	CT (Low)	PST-2	F	1	19	8	3	5	5	7	2	22
A	KT-GMOs (Low)	PST-3	F	2	20	7	4	7	6	11	2	30
		PST-4	F	2	22	7	5	8	8	12	2	35
		PST-5	F	1	20	8	9	6	5	7	1	28
		PST-6	F	1	18	5	8	13	12	18	8	59
	CT (High)	PST-7	M	1	18	6	12	12	7	19	6	56
B	KT-GMOs (Low)	PST-8	F	2	20	8	9	10	11	18	7	55
		PST-9	F	1	18	5	7	11	12	18	5	53
		PST-10	F	2	20	8	10	10	13	16	6	55
		PST-11	M	4	22	16	4	4	8	11	6	33
	CT (Low)	PST-12	F	4	23	15	5	8	6	11	6	36
C	KT-GMOs (High)	PST-13	F	2	21	15	8	8	3	8	8	29
		PST-14	F	4	23	16	2	8	5	9	3	27
		PST-15	F	4	21	15	5	7	7	12	6	37
		PST-16	M	4	22	19	8	10	13	17	6	54
	CT (High)	PST-17	F	4	25	15	13	9	12	18	8	60
D	KT-GMOs (High)	PST-18	M	4	22	17	9	11	12	18	7	57
		PST-19	F	4	21	15	11	9	12	18	6	56
		PST-20	F	4	22	19	11	12	12	19	7	61

c) Data Collection Tools

The following were used as data collection tools: (1) Watson-Glaser Critical Thinking Appraisal (WG-CTA), (2) Knowledge Test about GMOs (KT-GMOs) and (3) the 'Help Somalia' scenario including semi-structured interview questions (Appendix A-B).

Watson-Glaser Critical Thinking Appraisal Test Form-Ym (Wg-Cta)

The WG-CTA test was adapted to Turkish by Çıkrıkçı (1993). She was contacted her via email and written mail and received ethical and legal permission. After the necessary legal permissions had received, the test was implemented. From the results obtained from a pilot application on 210 science teachers, the lower 27% and upper 27% groups were formed and the significance of differences for each item and subscales was analyzed by t-test analysis. In addition, item-total test correlations were used to examine the reliability of the scales and the Kuder-Richardson Formula 20 (KR-20) was used to examine the reliability of the entire scale. At the end of the validity and reliability testing of the WG-CTA, it was decided to remove 23 items from the test. As a result of the pilot study, the critical thinking test was made ready for the actual application in such a way that the *inference* dimension of the test consisted of 16 items, the dimension of *recognition of assumptions* consisted of 14 items, the *deduction* dimension consisted of 16 items, the *interpretation* dimension consisted of 21 items and the *evaluation of arguments* dimension consisted of 10 items. As a general conclusion, it was decided to restructure the WG-CTA and continue the original application with 77 items. The KR-20 value of the test, which was ready for immediate application, was calculated to be 0.732 in the final pilot study.

Knowledge Test for GMOs (KT-GMOs)

Gaskell, Allansdottir, Allum, Corchero, Fischler, Hampel, Jackson, Kronberger, Mejlgaard, Gemma, Schreiner, Torgerseni and Wagner (2006), Sjöberg (2004) and Sönmez and Kılınç (2012) were used in the process of forming a material pool for this measurement

tool. In this test, the options for each question are "I don't know", "right" and "wrong". In order to use the scale in the study, permission was taken from the researchers via e-mail.

The draft scale consisting of 30 questions was applied to 210 university students. According to the results obtained in the pilot study, groups were formed from the lower 27% and upper 27% according to the total KT-GMOs score and the significance of the differences for each question item was analyzed with t-test analysis. In addition to this, the item total correlations were examined for the reliability of the scale items and the KR-20 values for the overall reliability of the test. There was a significant difference according to the level difference between the knowledge of the PSTs in the t-test analysis for the 27% sub-group and the 27% upper-group item mean scores according to the total score order of the respondents to the KT-GMOs [t100=25.261, p<.05]. In other words, the test developed to measure the knowledge of PSTs about GMOs distinguished preservice teachers who knew about the subject from who did not. The item-total correlations ranged for all the items in the test from -0.230 to 0.488 and the t-values were significant (p <.05). Following the statistical process in the pilot application, 10 items were removed from the test and it was decided to continue the actual application with 20 items. The KR-20 value was calculated to be 0.735 in the final pilot application before the actual application.

"Help Somalia" Scenario and Semi-Structured Interview Questions

The group discussion method was used to examine the argumentation skills of PSTs with regard to the issue of GMOs. During the creation of the scenario (Appendix-A) and the scenario-related discussion questions (Appendix-B), we considered the problems and sub-problems, the nature of the research and the work done (Toulmin, 1958; Kuhn, 1991; Sadler, 2003; Lin & Mintzes, 2010; Topcu et al. 2010). As a data collection tool, the scenario was formulated to be the one which people are often confronted and people tend to use their experiences to find more than one way to solve open-ended problems as in real life. For this reason, they use critical thinking skills when solving a problem (Carvalho, Fiuza, Conboy, Fonseca, Santos, Gama & Salema, 2015). Thus, the scenario "Help Somalia" was developed by two researchers in such a way that PSTs could demonstrate their knowledge and critical thinking skills during the argumentation process.

Four discussion questions were prepared for the scenario (Sadler, 2004). In the first question, the researchers aimed to reveal what positions the participants were taking, in the second question why they had taken these positions, in the third question the possibilities of counterarguments, and in the fourth question the ability to refute arguments. The content validity of the questions were consulted with two professors, one assistant professor, and one expert science educator working in the field of science education. Researchers examining the questions indicated that interview questions are appropriate. A pilot interview was conducted with four PSTs to determine if enough data could be collected with these questions during the argumentation process. As a result of the pilot study, the interview questions were considered appropriate and used for the main application.

d) Data Collection Process

209 PSTs were given the KT-GMOs, and then the collected data were sorted and transferred to an Excel file. The scores of the PSTs on the knowledge test and critical thinking scale were grouped from low to high level in terms of both knowledge and critical thinking skills. In accordance with the aim of the present study, out of 209 PSTs, the following were identified by means of the purposive sampling method: those with low-level content knowledge of GMOs and low-level critical thinking skills (5 PSTs); those with low-level content knowledge of GMOs and high-level critical thinking skills (5 PSTs); those with high-level content knowledge of GMOs and low-level critical thinking skills (5 PSTs); those a high-level of content knowledge of GMOs and a high level of critical thinking skills (5 PSTs).

This made a total of 20 PSTs. To examine the argumentation skills of these 20 PSTs, they were divided into five groups, with four people in each group. While the groups were being formed, instead of always putting participants who have similar levels of knowledge and critical thinking skills together, participants who have two different skill levels were also brought together in two groups. With this design, it was aimed to observe the argumentation skills of the PSTs at different levels more clearly. Figure 1 shows the PSTs participating in the argumentation sessions. In this way, it was tried to understand more clearly how argumentation skills vary as the skill levels differ.

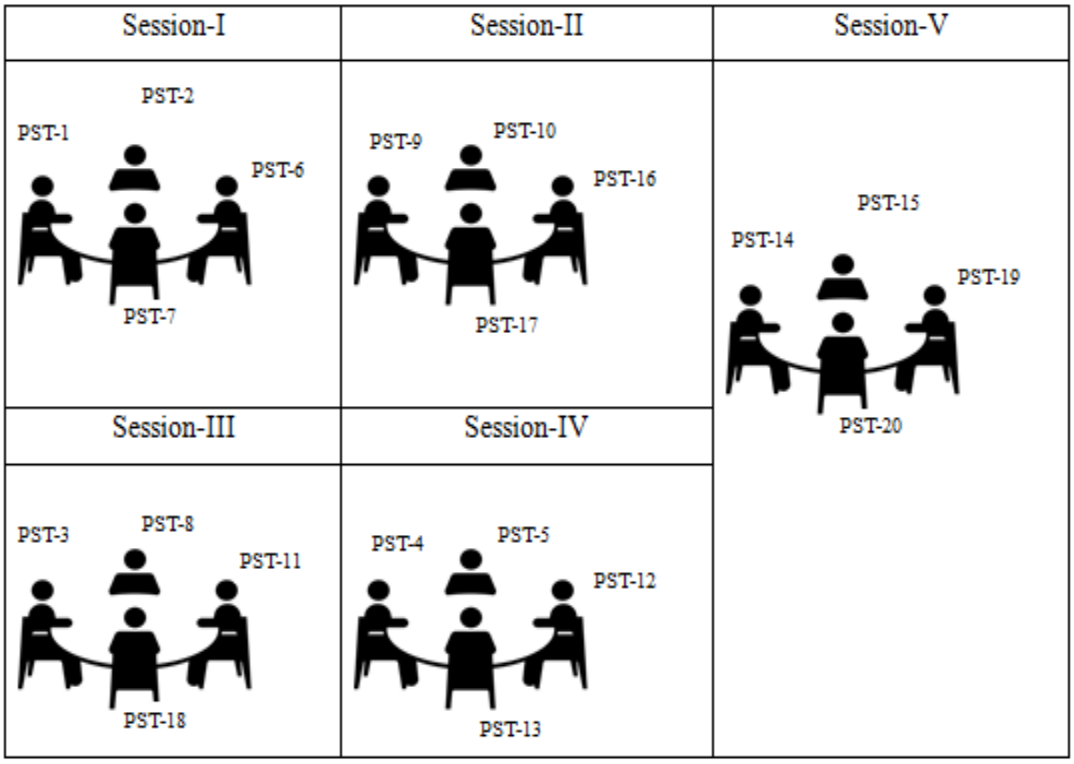

Figure 1. *PSTs seating order at the sessions*

In each session, one of the different levels of content knowledge or critical thinking skills was tested by placing two PSTs side by side. Argumentation sessions were arranged to be about 50 minutes for each of the five groups. In accordance with the nature of the SSI, each discussion group was initially played a video about GMOs. This video was designed to provide evidence that the participants could use during the debate. In putting this video together, we examined discussion programs, documentaries and news about GMOs. Then, we used the Movie Maker program to combine three programs which were most aligned to the nature of the study. It may be imagined that PSTs' knowledge of the subject would be influenced by the video display prior to the discussion. However, the subject of GMO is one that is frequently encountered in everyday life, both in visual and written media. Therefore, it is thought that the video did not actually increase the PSTs' knowledge.

Following the video presentation, each participant in the discussion group was given a text titled "Help Somalia". After the participants had read this, their opinions were sought by asking semi-structured questions aimed at identifying their argumentation skills. Subsequently, the participants presented the reasons why they had put forward their arguments. After the reasons they had presented, they were asked to say whether they were aware of any counterarguments. Finally, they were asked questions about how to refute these counter-claims. In addition, visual and auditory data were noted by the researcher. We took care to establish an environment that allowed free discussion by adhering to the nature of social constructivist theory (Schunk, 2012). The rules were set such as not interrupting

whoever was speaking, using expressions related to the subject being discussed, and not making personal attacks on those advancing an opposing view. It was also wanted to offer encouragement to some of the PSTs who were not able to express themselves well.

e) Data Analysis and Interpretation

Five data analysis and interpretation stages were used as preparation, reduction of data to meaningful parts, naming of parts, combining codes under broad categories and themes, and comparison in data graphs, tables and charts (Creswell, 2012). The data were independently analyzed by two researchers and were combined after each stage. Each researcher's own codes, comments and notes were explained in the meeting of two researchers which held as video conferences. Similarities and differences were focused on. The themes formulated by the two researchers were not carried over into the next stage until they had reached 100% consistency. During the preparation phase, the interviews and discussion observations were put into written form. Each transcript obtained from the discussion was read at least three times. Notes were written in order to create links between raw data, possible categories and themes. Irrelevant expressions were deleted in the process of reducing the data to meaningful parts. It was determined that which of the answers given by the PSTs to the interview questions and the statements expressed at any time during the interview corresponded to the four factors namely skills in using warrants, counterarguments, rebuttals and evidence. At this stage, phrases and spoken expressions were separated, examined, compared and categorized. Then, in the process of combining ongoing codes into broad categories and themes, the codes for the PSTs, which had been dispersed throughout the course of the argumentation process, were combined under four themes. Finally, the PSTs' argumentation skills were evaluated in the four areas.

Warrant (W)

The participants were asked to justify their claims in the second discussion question. One point was given for each warrant. The scale (Table 2) that Sadler and Fowler (2006) developed in their study was used in the process of identifying the quality of warrants.

Table 2. *Warrant quality rubric*

Score	Description
0	No warrant
1	Warrant with no grounds
2	Warrant with simple grounds
3	Warrant with elaborated grounds
4	Warrant with elaborated grounds and a counter position

Counterargument (CA)

The third discussion question was asked to find out whether PSTs were aware of counterarguments. For each counterargument that the PSTs stated for this question, one point was given as the rubric studied by Erduran and Jimenez-Aleixandre (2007). They examined counterarguments in three levels in their study. Level 1 represents the lowest level, and the PSTs on this level were not able to make a claim, or their statements did not have the characteristics of counterargument. Level 2 represents the medium level. PSTs at this level identified a counterargument that was superficially justified. Level 3 represents the highest level. PSTs at this level identified, detailed, and justified counterarguments.

Rebuttal (R)

The participants' rebuttal skills were examined in the fourth discussion question. Since rebuttal skills are advanced skills, two points were given for each rebuttal (Lin and Mintzes, 2010). The scale developed by Erduran and Jimenez-Aleixandre (2007) was used to identify

the quality of rebuttals made. The quality of rebuttal was assessed as follows: a) if the counterargument was rebutted with a superficial warrant, it was categorized as a low-level rebuttal; b) if it was rebutted with a strong warrant, it was categorized as medium-level rebuttal; c) if it was rebutted with a strong warrant and evidence, it was categorized as a high-level rebuttal.

Evidence (E)

Scientific data, past experiences and logical explanations suggested by PSTs were accepted as true and for each piece of evidence, one point was given. In order to examine the quality of the evidence, answers were sought to four questions developed from the studies of Erduran and Jimenez-Aleixandre (2007). These were: a) Does the statement present evidence? Is it [the evidence] realistic?; b) Does the data used as evidence support the warrant?; c) Does the data used as evidence support the rebuttal?; d) What is the source of the data used as evidence? The aim was to identify the quality of the evidence used by answering these questions.

Finally, how the argumentation skills differed as a result of the different levels of content knowledge and critical thinking skills among the PSTs was interpreted by comparing the groups.

f) Trustworthiness

Trustworthiness indicates the credibility of the results. In order to increase the reliability of this study (Creswell, 2012; Lincoln & Guba, 1985), data collection was carried out over five lengthy sessions. All the participants were students of the author, who also interviewed them. The author teaches in first and second-grade physics laboratories and third-grade science laboratories, and is also a class adviser concerned with the official and personal affairs of the participants in the final class. This created a confidence that the participants were able to express their feelings without hesitation. In addition, triangulation of the data is important for research. For this, different types of data sources were used such as questionnaires, face-to-face interviews and interview observations. The researchers planned and organized all phases of this work. In data analysis, in particular, the data were independently analyzed by two researchers, resulting in long discussions about incompatible themes. In this way, the results of the analysis were further clarified and the main reasons were questioned for the relationship between argumentation skills, content knowledge and critical thinking.

FINDINGS

Following the results of the Knowledge Test about GMOs (KT-GMOs) and the Watson Glaser Critical Thinking Appraisal (WG-CTA), argumentation sessions were conducted with 20 of the 209 PSTs. The 20 PSTs were divided into four groups of five individuals (see in Table-1). Comparisons were made between these groups' argumentation skills. Sub-problems 1a., 1b., 1c. and 1d. were individually examined to compare these groups' argumentation skills.

In this section, descriptive findings relating to the PSTs are first given and their argumentation skills are then treated qualitatively.

a) Descriptive Findings

The 20 PSTs separated into four different groups according to their level of KT-GMOs and CT skills participated in discussions. In this process, participants' argumentation skills were examined in terms of warrants, counterarguments, rebuttals, and evidence. The scores for the skills that the PSTs demonstrated in the argumentation process was shown in Table 3.

Table 3. *Argumentation skill score of PSTs*

Groups	Level	PSTs	Warrant	Counter-arguments	Rebuttal	Evidence	Total Score
A	CT (Low) KT-GMOs (Low)	PST-1	2	1	2	1	6
		PST-2	1	1	0	0	2
		PST-3	1	0	0	1	2
		PST-4	1	1	0	0	2
		PST-5	2	1	0	0	3
		Mean	1.4	0.8	0.4	0.4	3
B	CT (High) KT-GMOs (Low)	PST-6	4	3	8	5	20
		PST-7	2	2	2	2	8
		PST-8	2	1	2	1	6
		PST-9	2	2	2	1	7
		PST-10	3	1	0	0	4
		Mean	2.6	1.8	2.8	1.8	9
C	CT (Low) KT-GMOs (High)	PST-11	2	1	2	1	6
		PST-12	3	1	2	4	10
		PST-13	4	1	4	1	10
		PST-14	5	1	2	1	9
		PST-15	1	3	4	1	9
		Mean	3.0	1.4	2.8	1.6	8.8
D	CT (High) KT-GMOs (High)	PST-16	3	3	10	2	18
		PST-17	5	4	6	0	15
		PST-18	2	1	4	1	8
		PST-19	1	3	8	2	14
		PST-20	1	4	6	2	13
		Mean	2.4	3.0	6.8	1.4	13.6

When Table 3 is descriptively examined, the group with the lowest total score appears to be Group-A. On the other hand, Group-D is the group with the highest score. The comparison of argumentation skills between the groups was shown in Figure 2.

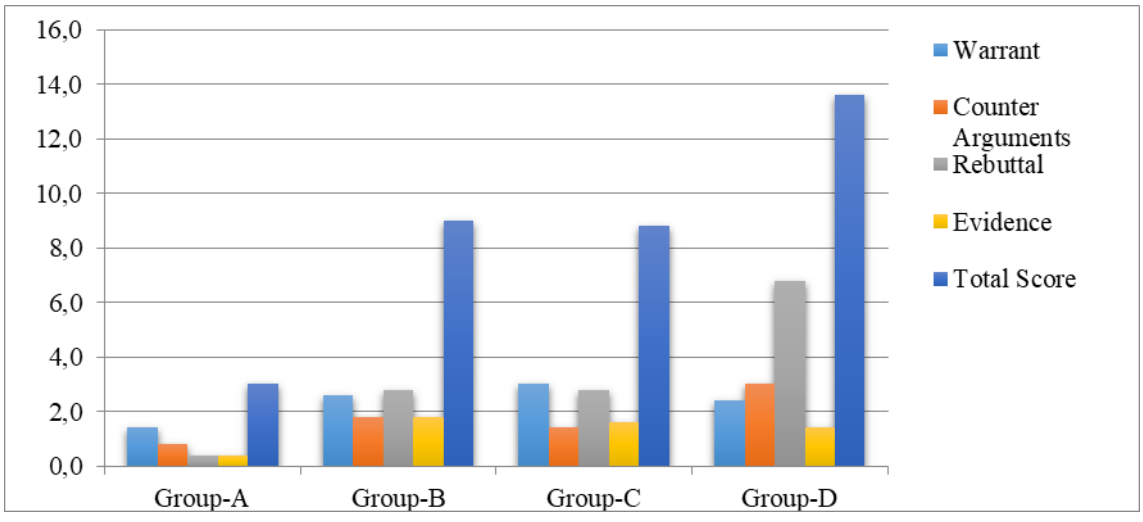

Figure 2. *Argumentation skills score of PSTs*

When Figure 2 is descriptively examined, it is seen that Group D's total argumentation skills, rebuttal and counter-argument skills are higher than the other groups in refuting and counter-claims.

b) Qualitative findings

Comparison of Group-A and Group-B's Argumentation Skills (1a. sub problem)

When argumentation skills of Group-A and Group-B are examined qualitatively, it is seen that there are some differences between skills in using warrants, rebuttals and evidence. Examples of the differences between the groups are given in Table 4.

Warrant skills: When the PSTs' statements were examined, it is clear that there are some differences between two groups. The PSTs in Group-B asserted stronger warrants than the other group in comparison of group warrants. Among the PSTs in Group-B, two PSTs asserted well-grounded, strong warrants, whereas three PSTs asserted warrants with simple grounds. This means that the PSTs' warrants in Group-B were at Level-2 and Level-3. Examining Group-A, it can be concluded that all PST's warrants are simple grounds or no grounds according to examination of Group-A. This means that the PSTs' warrants in Group-A were at Level-2.

Counterargument skills: When the statements of the PSTs are analyzed, some differences stand out between the two groups. Among the PSTs in Group-A, four PSTs made non-detailed, in other words, only superficially justified the counterarguments. And one PST did not use any statement eligible as a counterargument. The counterarguments put forward in the group were mostly at Level 2. It was ascertained that all of the PSTs in Group-B suggested superficially justified counterarguments. All of the counterarguments of the PSTs in this group were at Level 2.

Rebuttal skills: When the statements used for rebuttals by the PSTs are qualitatively analyzed, some differences stand out between these two groups. The rebuttal skills of the Group-B PSTs were more effective than the ones presented by Group-A. Two PSTs in Group-B rebutted the counterarguments by using warrants with simple grounds supported with evidence. One PST in this group had no rebuttal skills. So, Group-B PSTs rebutted partly in the low-high level. On the other hand, only one PST provided statements of rebuttal when the Group-A PSTs are analyzed. This PST rebutted the counterarguments by using warrants that were supported with evidence and simple grounds. The other PSTs in this group did not provide any statements of rebuttal.

Using evidence skills: When the statements used for rebuttals by the PSTs are qualitatively analyzed, some differences stand out between these two groups. In Group-B, four PSTs used data with evidence for the purpose of supporting their warrants or rebuttals. They generally used the statements of scientists in the video as a data source. In Group-A, only two PSTs presented data with evidence but others did not use any evidence. Two PSTs used the opinions of the scientists in the video as evidence in order to support their warrant or rebuttals.

Table 4. *Example statements of PSTs in Group-A and Group-B*

Argumentation skills	Example of PSTs statements
	PST-8: I would not send GMO products because the substances used in the production of GMO products will lead to resistance against medicine such as antibiotics in people who eat the food, and the medicine will not have any effect on the people even if we send it in the days immediately afterwards.
Warrant	PST-1: We cannot say that GM foods are harmful, and as we've seen in the studies, it's not so harmful. Africa is, as I said before, a barren place and its geographical structure has been destroyed. You can only grow plants which are resistant to those geographical conditions in such a destroyed geography. Now, you can pursue a policy like that. Thinking about it economically is also necessary.

Counterargument	PST-5: Someone who is against me might think that a natural diet is better for the health of the community. PST-9: Of course, the people are hungry there and it isn't known when the aid will arrive. Let's send those people natural food, but once this food has been used up, they won't know when the next aid will arrive.
Rebuttal	PST-8: Let's say you've sent GMO products. Assume that you don't have any money one year later and you've caused those people to get sick. What would you do in such a situation? You state that the people may live for another six months through GMO food aid. However, let's suppose that you have sent GMO products and after a year, you don't have any money and you've caused those people to get sick. This situation may cause worse results. That kind of problem may arise. PST-1: You say it's dangerous, but you need to provide evidence. In the video a professor said that more than 410 research studies had been conducted. So it's not like you claimed. No negative results were found in those studies. Has anyone said that they are affected by these animals or GMOs in the last 10 years?
Evidence	PST-6: When we consider the statements of the oncologist in the video, he said that: I can say that fertility has considerably decreased in animals, with increasing miscarriage in areas where excessive planting has been carried out, especially in the last two years. Studies that have considered this point of view have given the obvious result that GMOs are toxic. Therefore, there is evidence supporting their association with cancer. PST-1: You say it's dangerous, but you need to provide evidence. In the video a professor said that more than 410 research studies had been conducted. So, it's not like you claimed. No negative results were found in those studies. Has anyone said that they are affected by these animals or GMOs in the last 10 years?

Comparison of Group-A and Group-C's Argumentation Skills (1b. sub problem)

When the Group-A and Group-C's argumentation skills were qualitatively examined, it can be seen that there are some differences among warrant, rebuttal and the using evidence skills of the two groups. Examples of the differences among the groups are given in Table 5.

Warrant skills: When the PSTs in Group-C are analyzed, it is seen that all PSTs in this group, warrants with elaborated grounds, supported with scientific and logical information. PSTs in Group-C used Level-3 warrants. When Group-A is analyzed, it is found that all PSTs used warrants with no grounds or simple grounds. In this group, all PSTs used Level-2 warrants.

Rebuttal skills: When the PSTs' statements qualitatively examined for rebuttal in both groups, Group-C rebuttals are at a higher level than the Group-A. It is seen that the rebuttal statements of all the PSTs in Group-C manifest quality rebuttals. In this group, three PSTs made high-level rebuttals by using warrants. In Group-A, only PST-1 made a statement of rebut. He tried to use an evidence-based rebuttal, but his warrant was weak. In this group, the other PSTs were not able to make rebuttal statements.

Using evidence skills: When the PSTs' statements are qualitatively examined, some differences stand out between the two groups. All of the five PSTs in Group-C used statements with high quality evidence than Group A. In group B, PSTs used data, which they asserted to show evidence, to support their rebuttals. In comparison with the others in Group-A, PSTs were not able to use statements with high-quality evidence. In this group, one PST used evidence to support his rebuttal while rebutting counterarguments and one PST used

evidence to make her warrant stronger. The difference between the data sources that both groups used for evidence is also noteworthy. While the PSTs in Group-A provided evidence, they used only expert opinions from the video. The PSTs in Group-C, however, used scientific articles and the knowledge they had obtained in university courses in addition to the expert opinions from the video.

Table 5. *Example statements of PSTs in Group-A and Group-C*

Argumentation skills	Example of PSTs statements
Warrant	PST-13: Even if it is said that it's not causing any trouble right now, I think it will create problems in terms of human health since the structure of the DNA has been changed and created by human beings in a laboratory environment. PST-2: My reason is that people would live more healthily.
Rebuttal	PST-14: You say we haven't seen any negative results so far. As you said, GMO doesn't affect human health immediately, it happens in a lengthy process. PST-1: You say it's dangerous, but you need to provide evidence. In the video a professor said that more than 410 research studies had been conducted. So it's not like you claimed. No negative results were found in those studies. Has anyone said that they are affected by these animals or GMOs in the last 10 years?
Evidence	PST-3: GM food may cause a lot of illnesses like thyroid cancer, as the expert in video mentions here. PST-11: According to an expert in the video, growing genetically modified corn in Mexico may affect related species there. However, if GM corn from Mexico is grown in Turkey, there won't be any issue since there isn't any related species to pollinate.

Comparison of Group-B and Group-D's Argumentation Skills (1c. sub poblem)

When the argumentation skills of Group-B and Group-D qualitatively compared, a number of differences were found in the skills regarding warrants, rebuttals and using evidence. Examples of the differences between the groups are given in Table 6. The sub-skills of that stand out as qualitatively different between the two groups are:

Warrant skills: Although Group-B displayed more warrant skills than Group-D, PSTs in Group-D put forward stronger warrants. In Group-D, all PSTs proposed elaborate warrants. Overall, the warrants of Group-D PSTs were at Level-3. Among the PSTs in Group-B, two PSTs asserted well-grounded, strong warrants but three PSTs asserted warrants with simple grounds. This means that the PSTs' warrants in Group-B were at Level-2 and Level-3.

Rebuttal skills: The rebuttal skills of Group-D were more effective than those of Group-B. In Group-B, two PSTs made high-level rebuttals through the use of strong warrants with evidence. Two PSTs made low-level rebuttals, refuting counterarguments with superficial warrants. Only one PST did not use rebuttal statements. In Group-D, four PSTs made high-level rebuttals using well-grounded warrants with evidence.

Using evidence skills: In Group-B, three PSTs used the opinions of the scientists in the video as evidence to back up their rebuttals. One PST used information from scientific journals as evidence to back up their warrants. One PST in the same group did not use any statements with evidence. On the other hand, four PSTs in Group-D used data as evidence to support their warrants or rebuttals. Their evidence sources were the video, their biology lecture notes and science conferences. Only one PST did not use any statement with evidence.

Table 6. *Example statements of PSTs in Group-B and Group-D*

Argumentation skills	Example of PSTs statements
Warrant	PST-20: We are talking about six-month and one year-long processes. You've sent natural goods for six months and fed them. So what? After six months, they'll start dying again, because after six months, people will starve to death. I want them to live longer than just to starve to death. PST-9: If we send GMO processed food instead of natural food, I think that the people there will get harmed through the dissolution of their DNA and gene sequences because we have specific gene sequences. When you insert a different substance, this changes the sequence and has a specific effect.
Rebuttal	PST-9: My friend! You are against the opinion of the professor, which is that "the soil will be destroyed" and you think that's ridiculous. According to the expert in the video, the soil where GMOs are planted isn't destroyed, but it loses productivity. PST-16: For instance, he was not able to provide any clear data and say that was the number. If he had mentioned that he could have changed my ideas, but no one can say that. What they say is: "Therefore, they have found clear connections between them and cancer." That is a very political answer. Kidney cancer is increasing…That is not solely related to GMOs. We consume trans fats....Leave aside the food we consume…The reason is not GMOs. It's not only GMOs that leave toxic substances in my body… Later on, they look for a scapegoat and it gets to be GMOs.
Evidence	PST-8: Even though I am not a mother right now, I am against children being fed with GMO products. In the end, when a woman is pregnant, the baby takes in what the mother consumes and GMO is transferred to it. Moreover, a study showed that GMO caused the stomach walls of mice to get thicker and for them to have problems in the digestive systems. PST-19: My dear friend! You said that we can make people live for six months longer by sending GMO products, but we don't know what results GMO food will produce. Who will answer to the people whose genetic systems have been disrupted as a result of harmful genes due to a problem in the DNA being transmitted to genital genes?

Comparison of Group-C and Group-D's Argumentation Skills (1d. sub problem)

When the argumentation skills of Group-C and Group-D qualitatively compared, a number of differences were found in their rebuttal skills. Examples of the differences between the groups are given in Table 7.

Rebuttal skills: When the statements of the PSTs are qualitatively analyzed, some differences stand out between these two groups. The rebuttal skills of Group-D were more effective than those of Group-C. Analyzing the groups, in Group-C three PSTs made high-level rebuttals through the use of strong warrants with evidence. On the other hand, one PST made a low-level rebuttal by rebutting counterarguments through a warrant with simple grounds. And another PST made medium-level rebuttals by rebutting counterarguments with well-grounded warrants. In Group-D, four PSTs made high-level rebuttals through the use of well-grounded warrants with evidence. In this group, only one PST made medium-level rebuttals by rebutting counter-arguments with well-grounded warrants.

Table 7. *Example statements of PSTs in Group-C and Group-D*

Argumentation skills	Example of PSTs statements
	PST-15: PST-20 has mentioned cancer, she said that GMO may be a possible cause of cancer, but it seems like she's asserting that cancer is a disease that is unlikely to occur. However, today there is no definitive treatment for cancer. Drugs are produced, but they can't directly prevent it because I think that the drugs are only produced in order for the drug companies to make a profit.
Rebuttal	PST-20: PST-19 says that if natural seeds are sown, we can obtain more fruits, but I know from my own life that when, for instance, we go to the highlands in summer, is there anything like local tomatoes? No! On one hand, you plant the seeds that you get from abroad, and on the other hand you plant the local seeds that you get from the farmers, but you can't grow any fruit. You don't produce anything from natural seeds. What does the farmer do as a result? He's not growing anything, and therefore doesn't plant natural seeds.

DISCUSSION and CONCLUSION

The results of the study indicated that the PSTs in Group-B used the warrant, counter-argument, rebuttal, and using evidence skills more effectively than the PSTs in Group-A. When the PSTs' warrant skills were examined, it was found that while three PSTs in Group-B gave detailed warrants and two used superficial warrants, all the PSTs in Group-A stated superficial warrants. When the PSTs' counterargument skills were examined, it was found that in Group-A, two PSTs did not use counterarguments and three of them used non-detailed and superficially justified counter-arguments. However, all of the PSTs in Group-B used superficially justified counter-arguments. Regarding rebuttal skills, four PSTs in Group-A did not make any statements of rebuttal. However, four PSTs in Group-B used weak rebuttal statements with superficial warrants or warrants with evidence. It was observed that a number of differences between two groups in terms of the PSTs skills in using evidence. In Group-A, three PSTs used evidence to support their rebuttals or warrants, but two PSTs did not use any evidence. On the other hand, four PSTs in Group-B used the data as evidence to support their rebuttals, warrants, or both. There may be various reasons for this result. When analyzing the videos of the argumentation process, it was observed that the PSTs in Group-B also expressed skills such as open-mindedness, focusing and understanding the missing parts of the counterarguments.

Because the PSTs in Group-B had high-level critical thinking skills, it was observed two essential behaviors in them. First, in observations made during the argumentation process, it was determined that preservice teachers are good listeners with high-level critical thinking skills. In the argumentation process, they paid attention to opposing ideas in a respectful manner and tried to understand these ideas before stating their own opinions. Similarly, when they noticed that the opposing group had contradictory ideas, they tried to rebut these ideas by attending to the contradictions. Second, critical thinkers were capable of understanding the differences between claims and facts and recognizing inconsistent judgments within counterarguments. These findings suggest that in a socio-scientific context, PSTs' argumentation skills, such as their capacities to use warrant, counterargument, rebuttal and evidence, can be improved by enhancing their critical thinking skills without taking into account their content knowledge. Critical thinkers are individuals with metacognitive skills, who are aware of their own ideas (Paul & Elder, 2001). This feature of critical thinking may have encouraged these PSTs to use more detailed reasoning to support their claims. According to Bandura (1986), there is a close relationship between critical thinking and self-regulation. Critical thinkers not only act according to the preferences of others, but also based

on their own evaluations and standards (Schunk, 2012). These results suggest that focusing on critical thinking skills alone is sufficient to bring argumentation skills to a high level.

The comparison of Group-B and Group-D showed that having content knowledge is vital in order to improve argumentation skills. In terms of argumentation skills (warrant, rebuttal and using evidence), it was observed that Group-D was more effective than Group-B. The analysis of the PSTs' warrants suggested that three PSTs in Group-B gave detailed warrants and two gave superficial warrants. On the other hand, all PSTs in Group-D used detailed and well-grounded warrants. When the differences were analyzed between the two groups regarding the skill of rebuttal, it was observed that four PSTs in Group-B offered a weak rebuttal by using weak warrants or warrants with evidence. However, all of the PSTs in Group-D were able to use statements of rebuttal, and most of their stated rebuttals were advanced. When the evidence used by the two groups was examined, four PSTs in Group-B used data from the video as evidence to strengthen warrants and rebuttals. In Group-D, three PSTs used data from the video, lecture notes and conferences as evidence to strengthen their rebuttals. When the argumentation skills score table was analyzed, it was observed that the evidence skills score of D group was lower than the B group. It showed that the use of evidence of D group was lower than the other group. In fact, in terms of quality, PSTs in group D used their evidence for rebuttal, while some of PSTs in group B used their evidence for rebuttal and others used it for supporting their claims. Accordingly, it can be said that PSTs in group D use effective evidence than B group.

Even without knowledge of GMOs, critical thinkers in a debate may display cognitive skills such as focusing, finding missing parts, being open-minded, understanding counterarguments and having a strategy for discussion. However, these skills alone are not enough to disprove opposing views. Since the PSTs did not know which information was right or wrong, they could not efficiently use all the features of that information, despite being aware of some of these features. The PSTs who have high level of GMO knowledge and critical thinking skills challenged the accuracy of the evidence and information presented by the opposing group in more efficient way. Therefore, they were able to use efficient warrants, rebuttals, and evidence that were all of a higher quality. The PSTs in Group-D had studied GMO in the "Special Topics in Biology" course. However, the PSTs in Group-B had not taken this course. As stated earlier, their high-level of knowledge about GMOs might be due to the PSTs being motivated with regard to the topic and discussion, and their increased self-efficacy.

It was supposed that, there were important relationships among the PSTs' goals, attributions, abilities, motivational behaviors and social behaviors. When faced with obstacles and failures, people who harbor self-doubts about their capabilities make fewer efforts or quickly give up (Bandura, 1988). Conversely, those who have a strong belief in their capabilities exert greater effort when they fail to master a challenge, and this strong perseverance contributes to individuals' accomplishments in their performance. During the argumentation process, the PSTs with high-level content knowledge felt comfortable in contributing to this study and in constructing arguments around this SSI. On the other hand, the PSTs in the low-level GMOs knowledge group were not comfortable when presenting arguments. According to Schunk (2012), people's ways of dividing up the elements of language elements reflect their deep mental structures. Therefore, the PSTs with high-level knowledge had more advanced thoughts with regard to GMOs than the PSTs with low-level knowledge levels. Sandoval and Millwood (2005) stated that coordinating claims and evidence is not an easy cognitive skill. They highlighted the high level of content knowledge needed for students to have an adequate amount of information about the meaning of evidence, what can be used as evidence, and what kind of relationship there is between claim and evidence.

Researchers (Driver et al. 2000; Zohar & Nemet, 2002; Braund et al. 2013) who have investigated the use of critical thinking in the argumentation process have stated that the use of critical thinking skills enables students to critically question socially-accepted claims, strengthen their supporting arguments and their rebuttals with evidence, and consequently increases their eagerness to take personal responsibility in the argumentation process. Furthermore, critical thinking skills enable students to pay attention to an argument and to be eager to respond to other group members, and so contribute to their reasoning when integrating new evidence into their existing knowledge. Finally, they enable students to test and evaluate the claim or theories suggested during an argument.

IMPLICATIONS AND LIMITATIONS

The purpose of this holistic multidisciplinary design was to investigate the relations among the PSTs' argumentation skills, their critical thinking skills and their content knowledge with regard to GMOs. A number of data collection tools were used to understand the argumentation process and underlying sources of these relationships. The findings showed that PSTs with high-level content knowledge were highly motivated to participate in the argumentation process. In addition, PSTs with high-level critical thinking skills were capable of building strategies to refute the statements of the opposing group. However, it was not enough to explain the process of argumentation, which is a very complicated process, with these two factors alone.

As a result of analyzing observational recordings, it was noticed that the process of making an argument is a rather complicated mechanism involving cognitive mechanisms, the teacher's beliefs, language skills and social skills. Hence, efforts to develop PSTs' argumentation skills will not be sufficient if those developing a curriculum incorporate argumentation without understanding the nature of this complex mechanism. In other words, when using new approaches such as argumentation, it is not possible to structure the discussion of the SSI even during the undergraduate period. Therefore, it was recommended to examine the effects of the PSTs' cognitive skills, social skills, language skills and communication skills on their argumentation skills.

In the present study, a measurement tool was used which focused on five dimensions of critical thinking. These five dimensions were as follows: Deduction, awareness of assumptions, interpretation and evaluation of opposing views. In the literature, it was found that it was not yet clear what the limits of critical thinking are. By using other measurement tools designed to measure the PSTs' critical thinking skills, it was aimed to examine the differences in their argumentation skills in different sub-dimensions. There is a need for new studies to examine the relationship between the PSTs' argumentation skills and each sub-dimension.

It was found that low motivation and reluctance among PSTs constituted a strong obstacle to their participation in the argumentation process. Hence, opportunities should be created to keep their motivation high at every stage of the discussion, although these opportunities are limited in crowded argumentation groups and a small number of PSTs will tend to have an active role in the process. However, studies could be conducted in which argumentation environments are more regulated.

As with all scientific studies, this study involves certain limitations. First, as a holistic multiple-case study, it was conducted with a total of 20 PSTs, each consisting of five individuals. Second, the WG-CTA scale included only the dimensions that represented critical thinking. Because many researchers have used this data collection tool, only five dimensions were used in this study. Moreover, the item dimensions in the measurement tool were not included in the SSI.

In this study, the WG-CTA scale measured general critical thinking skills. However, the PSTs' critical thinking skills may depend on the subject discussed, and it was suggested to develop a new critical thinking scale for SSIs. Moreover, this study focused only on the issue of GMOs. Future studies could investigate how the relationship between the PSTs' argumentation skills and their critical thinking skills and content knowledge would change if they focused on other SSI, for instance nuclear energy, global warming and gene therapy.

Finally, it was concluded that the other factors besides critical thinking and content knowledge (communication skills, the nature of science, epistemological beliefs and culture) also influence argumentation skills. Researchers could examine the relationship between these factors and argumentation skills.

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Appendix A: Scenario: Help to Somalia

Somalia is experiencing the driest period of recent years. Because of African countries' unconsciously water-sharing, there were thirst in some areas, in parallel with drying of agricultural products and, finally, the famine. People are trying to survive in internment camps with aid that will come from other countries. The United Nations (UN) is planning to provide food and medicines to these people who suffer from hunger in Somalia under the World Food Program (WFP), with money collected from many countries. Turkey is at the head of the countries participating in this aid campaign. You are the person responsible for the charity campaign. You will make food aid to Somalia with the money to be collected. Approximately 12.000.000 TL (approximately 3.000.000 $) cash was collected from Turkey. You can buy genetically modified food that will be enough for 1 year to the people who need food with this money in your hand, or you can buy natural food for up to 6 months with this money. There is a chance that new money will come from Turkey in the future, but it is not clear when. If you distribute food with GMOs, you will face up to potential risks, or if you distribute normal food, people in the camp will live in hunger for a while again.

Appendix B: Interview Questions

1. As a member of Somali Aid Commission, would you like to send GMO or natural food to Somali? What would you like to do in such a case? (*Taking position skills against a state were evaluated*)
2. What are your reasons to choose the position you take on help? (*Reasoning positions skills are evaluated*)
3. If someone disagrees with the view that you have stated in the first and second questions, then he/she is against some of your views and isn't convinced with some of your reasons. What could be the opposite opinions? (*The skills in creating counter-arguments of the participants are evaluated*)
4. How do you rebut someone who is against your views and how would you convince him? (*Producing supportive arguments to refute claims. The skills of the participants are evaluated*)