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Prospective Teachers' Written Argumentation Levels about Socio-Scientific Topics

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Argumentation is a process that involves finding solutions to real-life problems by obtaining and analyzing valid, reliable data and using reasoning and supporting it to reach conclusions. Students are expected to demonstrate the capacity to use arguments, data, justifications, and rebuttals and to participate actively in the argumentation process. Socio-scientific issues are suitable topics for expressing opinions. Arguments can be expressed in writing or verbally. In this study, it was aimed to examine the written argumentation levels of 143 pre-service teachers on healthy nutrition, organ transplantation, organic agriculture, and vaccine hesitancy. Four scenarios with related questions were designed by the researchers. These were applied to the teacher candidates who voluntarily participated in the research with the easily accessible sampling model. Written responses were analyzed by different experts according to the argumentation levels as suggested by the relevant literature. The results of the analysis showed that the pre-service teachers' levels of expressing their own views were moderate and above, while the levels of expressing counterarguments in writing, refuting and justifying their claims were low. It shows that pre-service teachers' competencies in critical thinking skills should be developed.

Introduction

One of the aims of science education is to raise scientifically literate individuals (DeBoer, 2000; Hurd, 1998; Kantekin & İrez, 2021; National Science Teachers Association [NSTA] 1982). Scientifically literate individuals have the scientific knowledge to reason about social issues concerning themselves and society, and by using this body of scientific knowledge, they can play active roles in decision-making processes, whereby they contribute their ideas on socio-scientific issues that emerge from science, technology, and social interaction and are of particular concern to society. In contributing their ideas, it is important that they express their knowledge on such topics with properly interpreted, supporting data

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(Howell & Brossard, 2021; Laugksch, 2000). Socio-scientific topics (SST) are by nature controversial, require multifaceted thinking, cannot be inferred from a simple single-type judgment, and include, in a general sense, a moral and ethical dimension (Evagorou & Dillon, 2020; Sadler, 2004; Sadler & Fowler, 2006; Zeidler, 2014). Taking examples from the literature, these SSTs include genetically modified organisms (GMO), nuclear stations, global warming, sex discrimination, and organ donation, to name several (e.g.,Owens, Sadler, & Friedrichsen, 2021; Tidemand & Nielsen, 2017; Türkmen, Pekmez, & Sağlam, 2017;; Zohar & Nemet, 2002). For a topic to qualify as an SST, its content must be related to science, socially meaningful, and of broad public concern (Eastwood, Sadler, Zeidler, Lewis, Amiri, & Applebaum, 2012; Leung, 2020).

The Science Course Teaching program published by the Turkish Ministry of National Education in 2018 includes the following objectives: To improve reasoning skills, scientific thinking habits, and decision-making skills by addressing SSTs. These objectives clearly demonstrate the importance the teacher program attributes to utilizing SSTs as the means to building reasoning, scientific thinking, and decision-making skills in students.

Argumentation is a process that aims to find solutions to real-life problems by gathering and analyzing data, making claims, and using justifications to arrive at conclusions from which informed decisions can be made. In terms of the features defining this process, argumentation involves many concepts, including discussion, reasoning, and thinking action and skills. Based on this understanding of argumentation, it can be asserted that argumentation and learning are two nested processes. Arguments can be presented in two different ways, verbally, where individuals' verbal skills are at the forefront, or in written form, where individuals explain their claims based on evidence and express their opinions, with counterarguments, if any, in writing (Demir, 2017). Fan & Chen (2021), aimed to assist students in improving their ability to write argumentative essays. They find to enhance students' abilities in terms of thinking and argumentation so that they can produce better argumentative essays.

By recognizing the importance of argumentation, its use in science lessons has assisted students in understanding the concept of science and the developmental processes of scientific events (Berland & McNeill, 2009; Simon, Erduran & Osborne, 2006). A review of the literature showed that argumentation is a prominent feature employed to address SSTs (Albe, 2008; Akdöner, 2019; Çiftçi, 2016; Dawson & Carson, 2017; Deniz, 2014; Domaç, 2011; Gürel & Süzük, 2017; Kortland, 1996; Öztürk, 2013; Ratcliffe & Grace, 2003; Sadler & Donnelly, 2006; Sadler & Fowler, 2006; Yaman, 2011; Zohar & Nemet, 2002).

The targeted expectation from argumentation in science education is that students acquire the ability to think and discuss as scientists. To meet this expectation, students must be capable of using claims, data, warrants, and rebuttals related to the determined topics and actively engage in the argumentation process. Teachers' argumentation experiences play a critically important role in their ability to involve students in the argumentation processes. The familiarization with argumentation and the experience applying it in the field of science that teachers gain during their period of being prospective teachers (PT) will make it easier for them to think critically and to foster these skills in students. The most commonly used argumentation model in learning is the Toulmin Model of Argument (Erduran, Simon, & Osborne, 2004; Gray, 2009; Jiménez-Aleixandre, Bugallo Rodríguez, & Duschl, 2000).

The Toulmin Model of Argument includes reasoning components that serve to teach students

how to reach conclusions and generate claims from data (Toulmin, 1958). The model consists of six components: claim, data, warrant, and backing, the main components of the model. and qualifier and rebuttal, the components used to analyze complex arguments (Driver, Newton, & Osborne, 2000; Osborne, Erduran, & Simon, 2004; Simon, Erduran, & Osborne, 2006; Toulmin, 1958).

The argumentation skills of students can be measured by examining the development and quality of their claims, counterarguments, data, backing, and rebuttals (Mason & Scirica, 2006; Sandoval & Millwood, 2005). As the argumentation process requires complex mental configurations, different perspectives on the analysis of arguments have emerged (Demir, 2017; Karışan, 2011; Yalçın, 2018).

In the studies where researchers have used different models to perform argumentation analyses, it has been shown that students tend to create solid arguments when they can form both claims and counterarguments or explain and support their claims with relevant facts (Means & Voss, 1996), or when they can confute counterarguments as well as form certain claims and counterarguments (Erduran et al., 2004; Sadler & Donnelly, 2006). In both situations, it is important that opinions and the main idea behind the opinions are adequately expressed, as this is key to fostering critical thinking skills.

Importance of the Study

Educators bear the tremendous responsibility of raising scientifically literate individuals. In doing this, argumentation has been proven to be one of the most suitable ways to build and improve critical thinking skills, reasoning, and efficient decision-making (Kolsto, 2001; Nussbaum, 2002). Aydemir, Cırıt, Kaya, & Azger (2018), in their study examining PTs' skills at developing arguments, found that teachers' skills were at low levels. Jonassen & Kim (2010) carried out a study on the process students use to create arguments and observed that teachers were weak at pedagogically directing their students to form arguments and, consequently, inadequate at designing learning environments suited for argumentation processes. For the reasons stated above, it is believed to be important that teachers are capable of forming arguments and competent in argumentation processes before starting their professional life, which means that it is essential to measure their argumentation skills and determine any deficiencies they may have in argumentation. In the various studies that have investigated PTs' argumentation levels using different argumentation measurement methods, the scenarios used in determining argumentation levels involved SSTs (e.g., Baytelman, Iordanou & Constantinou, 2020; Chung, Yoo, Kim, Lee & Zeidler, 2016; Karpudewan, Roth, & Sinniah, 2016; Liu & Roehrig, 2017; Macpherson, 2016; Öztürk & Yılmaz Tüzün, 2017; Rundgren, Eriksson, & Rundgren, 2016; Torun & Şahin, 2016). SSTs are well suited to building arguments on account of the dilemmas these topics present. In the present study, the decision to use argumentation scenarios involving SST content was based on the facts that the PTs had experience with SSTs within the scope of the Special Topics in Biology course in teacher training programs and that such topics generally contain information largely accepted by the public (Topçu, 2008). This study aims to determine PTs' level of written argumentation skills by presenting SST-based scenarios.

Method

The present study used the case study approach. This approach involved analysing their levels of written argumentation skills in specific SSTs. Creswell and Clark (2007) describe case studies as a type of research that examines a phenomenon in its natural setting

from multiple aspects. Case studies specifically address the "how" and "why" of a current phenomenon by conducting an in-depth analysis of it within its real-life framework (Yıldırım & Şimşek, 2006). In such studies, information about the existing situation is revealed in detail. The qualitative information obtained will guide the application environments and further research is targeted. In this research, with the aim of collecting data, to understand the situation, to clarify the details of the general situation and to in order to gain a broader perspective and to understand the situation in depth, the opinions of the pre-service teachers on different socio-scientific issues were collected in writing. The data, interpreted using descriptive statistics, were collected in line with the qualitative research methodology to achieve the study's aim. Before collecting the study data, all the participating PTs voluntarily agreed to participate in the study and consented to the data collection process.

Study Group

The sample was determined by the easily accessible sampling method. 143 PT from the departments of Science and Biology Education at a public university in Turkey constituted the study group. Students from these two departments were specifically selected because the SST selected for the purposes of the study are addressed in their respective teaching programs. Since there is no course taken by the 4th graders and the first year of science education department on this subject, the number of pre-service teachers voluntarily participating in the sample is less than the other grades. Table 1 presents the distribution of the study group.

Table1. Distribution of the PTs by year level, department, and gender

	Science Education		Biology Education	
	Female	Male	Female	Male
1st year	-	-	15	2
2nd year	33	5	11	1
3rd year	37	6	11	4
4th year	3	2	8	5
TOTAL	86		57	

Data Collection Tools

Argumentation scenarios prepared on SSTs were used to collect data. In preparing these scenarios and forming the main headings, the literature on SSTs was reviewed. Based on opinions taken from experts on the subject, four argumentation scenarios were created.

The scenarios were designed in such a way as to present dilemmas regarding the topics, to be dependent on scientific knowledge, to create curiosity and attract the interest of the PTs, and to require the application of proper spelling and orthographic rules. There are a set of open-ended questions that aimed to determine the PTs' handling of the components of the Toulmin Model of Arguments, such as claim, counterargument, warrant, and rebuttal. Thus, in accordance with the aim of the study, rather than content, the focus was on argumentation skills, that is, the presence and quality of the argumentation components. The opinions of an expert were taken to confirm the construct and content validity of the scenarios designed by the researchers of the present study. A pilot study involving the scenarios was conducted with ten PT who were not included in the sample group. With the feedback obtained from the pilot study, the scenarios were finalized.

Data Analysis

The content analysis method, an in-depth analysis of written materials containing information about a particular topic (Yıldırım & Şimşek, 2006), was used for the analysis of the written argumentation scenarios. In content analysis, similar concepts are gathered together within the framework of certain relations and themes and are organized and interpreted in a way that can be understood by readers (Yıldırım & Şimşek, 2006). In the study, after examining the responses given to the argumentation scenarios, headings were determined according to the argumentation components (claim, counterargument, data, warrant, and rebuttal), and the responses were then grouped under these headings. The data were analysed by a researcher of the present study and an expert, and any differences in their analysis were compared and resolved to reach a final analysis. For the reliability of the results, consensus and disagreement Miles and Huberman's formula ([(Reliability = number of consensus / (total agreement + number of disagreement)]) was used (Baltacı, 2017). The result obtained from the reliability formula was found to be 0.90. The result shows that the analyzes are reliable and there is a consensus among the respondents.

Before analysing the argumentation skills, different models for evaluating argumentation in the literature were examined. The argumentation levels model developed by Erduran et al. (2004) was selected for use in this study. According to this model, it is important to determine whether or not all augmentation components are present in an argumentation process. The presence and quality of rebuttal differ by argument level. As shown in Table 2, in the argumentation levels model, Level 3, 4, and 5, all of which contain rebuttal, are higher levels than Level 1 and 2.

Table 2. Argumentation levels

Level	Explanation
Level 1	This level includes arguments that consist of counterarguments of a simple claim or of one claim against another.
Level 2	This level includes arguments consisting of data, warrant, or backed claims; however, the arguments do not contain any rebuttals.
Level 3	This level includes a series of claims and counterarguments created with data, warrant, or backing and sometimes with weak rebuttals.
Level 4	This level includes arguments that consist of a claim created by a clearly defined rebuttal. Arguments may involve several claims or counterarguments, but these are not required.
Level 5	This level includes arguments that consist of multiple rebuttals.

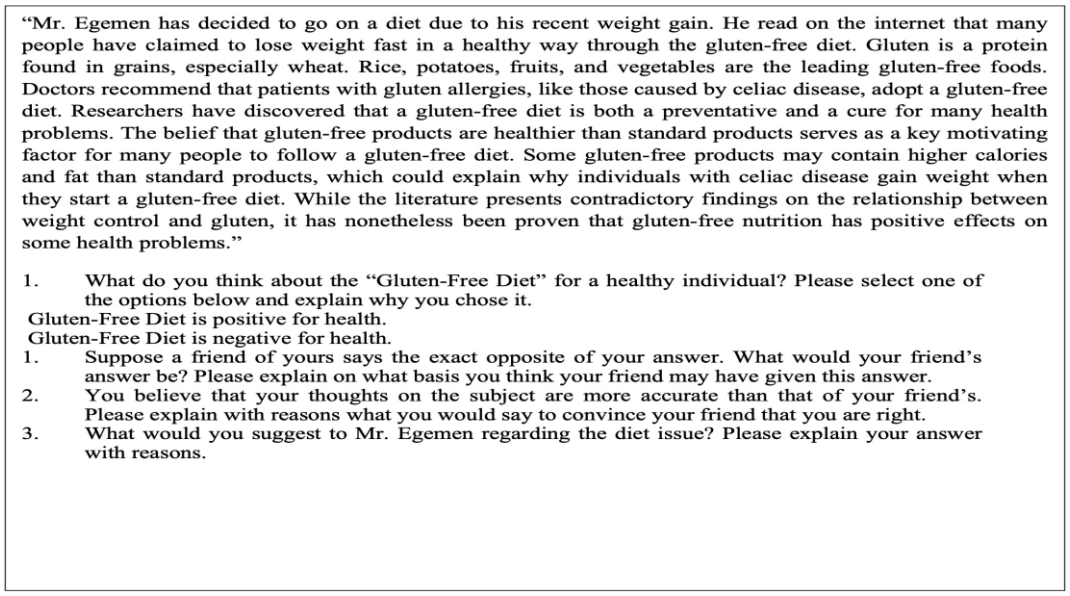
The primary reason that the argumentation levels model was used to analyze the written argumentations in this study was that the model specifically analyzes argumentation levels rather than the scientific accurateness of arguments. Another reason for selecting this model was that it allows for easier analyses when there is a high number of rebuttals. The Achilles' heel of the model is its ambiguity in clarifying the rebuttal content. To address this issue, the model offers a specific solution: assessment of the argument by determining whether or not the rebuttal includes other components, like claim, data, and warrant (Çapkınoğlu, 2015; Demircioğlu, 2011; Soysal, 2012). Overall, the presence of these facilitating factors and the clear hierarchical structure formed in the quality of argumentation in the model design were among the reasons for using this particular model in the study.

Result

In this section, four scenarios, gluten-free nutrition, organic food, organ transplantation, and vaccine hesitancy, were designed in accordance with the Toulmin Model of Argument (1958) are given. Several questions were posed to the PTs to identify their claims, counterarguments, data, warrants, and rebuttals. Their responses to these questions were made in written form. The written responses collected were then analyzed using the Erduran's argumentation levels model (Erduran et al. (2004). The findings obtained from the analyses are presented below.

Scenario 1 "Gluten-Free Diet" Findings

The first scenario is about "Gluten-Free Diet." Figure 1 presents the scenario and its questions.



"Mr. Egemen has decided to go on a diet due to his recent weight gain. He read on the internet that many people have claimed to lose weight fast in a healthy way through the gluten-free diet. Gluten is a protein found in grains, especially wheat. Rice, potatoes, fruits, and vegetables are the leading gluten-free foods. Doctors recommend that patients with gluten allergies, like those caused by celiac disease, adopt a gluten-free diet. Researchers have discovered that a gluten-free diet is both a preventative and a cure for many health problems. The belief that gluten-free products are healthier than standard products serves as a key motivating factor for many people to follow a gluten-free diet. Some gluten-free products may contain higher calories and fat than standard products, which could explain why individuals with celiac disease gain weight when they start a gluten-free diet. While the literature presents contradictory findings on the relationship between weight control and gluten, it has nonetheless been proven that gluten-free nutrition has positive effects on some health problems."

1. What do you think about the "Gluten-Free Diet" for a healthy individual? Please select one of the options below and explain why you chose it.

Gluten-Free Diet is positive for health.
Gluten-Free Diet is negative for health.

1. Suppose a friend of yours says the exact opposite of your answer. What would your friend's answer be? Please explain on what basis you think your friend may have given this answer.
2. You believe that your thoughts on the subject are more accurate than that of your friend's. Please explain with reasons what you would say to convince your friend that you are right.
3. What would you suggest to Mr. Egemen regarding the diet issue? Please explain your answer with reasons.

Figure 1. Gluten-Free Diet Scenario

Table 3 below presents the results of the analysis of the argumentation levels based on the responses given to the first argumentation scenario.

Table 3. Findings on the argumentation levels of the gluten-free diet scenario.

Argumentation Levels	Frequency (f)	Percentage (%)
Level 1	77	53.8
Level 2	42	29.4
Level 3	21	14.7
Level 4	2	1.4
Level 5	1	0.7

As shown in Table 3, 53.8% of the PTs (n=77) were at level 1 and 29.4% (n=42) were at level

2 in the gluten-free argumentation scenario prepared for the topic of health, nutrition, and diet. Only one of the PTs created an argument at Level 5. Most of the arguments to the argumentation scenario 1 were at Level 1 and Level 2. The PTs were able to generate claims, data, and warrants regarding the related argumentation topic but presented simple counterarguments and fell short of establishing rebuttals. Examples of arguments at each level are presented below. Table 4 presents some of the written responses given to the first scenario and their corresponding argumentation level.

Table 4. Examples from each level of the written responses given to the gluten-free diet scenario

Level	Prospective Teacher (PT)	Response
Level 1	PT 33	A gluten-free diet is good for the health. A gluten-free diet has positive effects on some health problems (Claim).
	PT 11:	A gluten-free diet is good for the health because gluten is harmful to human health (Claim).
Level 2:	PT 12:	A gluten-free diet is bad for the health (Claim). It may prevent some diseases, but all types of foods must be consumed in a balanced way for a healthy diet (Data). Since many types of foods cannot be consumed in a gluten-free diet, it is bad in terms of health (Warrant).
	PT 24:	A gluten-free diet is good for the health (Claim). A gluten-free diet should be followed to lose weight because food with gluten stores more energy and does not trigger the desire to eat more (Warrant).
Level 3	PT 31	A gluten-free diet is good for the health (Claim). From the sentence, "Researchers have discovered that a gluten-free diet is both a preventative and a cure for many health problems", I understand that a gluten-free diet is good for the health (Data + Warrant). A gluten-free diet may cause weight gain. Gaining weight can also lead to obesity and other diseases (Weak Rebuttal).
Level 4	PT 2	A gluten-free diet is good for the health (Claim) because I think consuming fruits and vegetables are healthier. Vitamin deficiency can cause some irreversible diseases (Warrant). Furthermore, fruits and vegetables have fewer calories than grains (Data). It is wrong for us to consume only certain foods throughout life. We need grains, too (Counterargument). My friend thinks that grain-based foods are beneficial for us. He loves to consume grain-based foods. Grains are also very healthy (Rebuttal).
Level 5	PT 13	A gluten-free diet is bad for the health (Claim). I think people also need grains. A gluten-free diet is unhealthy since it leads to weight gain (Warrant). First, I would like to know why my friend gave that answer. Maybe, he has a reasonable explanation. It could be because my friend thinks it is healthy and gives more energy, because gluten-free foods provide more energy. It could be because it is preventive and curative of certain health problems. It could be because it creates high-energy motivation (Rebuttal).

As demonstrated in the responses of PT 33 and PT 11 from among the examples given in Table 4, 53.8% of the PTs (n=77) only stated either claims or counterarguments and were unable to present any data or rebuttal to back these claims, which means their responses were at Level 1. The responses of 29.4% of the PTs (n=42) to the questions in the scenario were at Level 2, as they consisted of claims, data, and warrants but had no rebuttals. Of the PTs, 14.7% (n=21) used weak rebuttals in their arguments, meaning they did not provide any data or claims to back their rebuttals, and therefore these arguments were placed at Level 3. Moreover, the arguments they built included a series of backing claims. Only 1.4% rebuttals for the topic of gluten-free diet (Level 4). As in the previous example, the rebuttal consisted of only a few counterarguments and was shaped within the framework of the personal opinions. Only one PT put forward more than one rebuttal (Level 5). In the scenario on healthy eating, the PTs were able to produce simple claims and counterarguments and presented claims, warrants, and data to back their claims. Upon closer inspection of the warrants and data, it was found that the answers expressed the same aspects of the topic using sentences that were similar, if not the same, in meaning.

When the PTs' responses were analysed from a general perspective, it was observed that although they were able to present claims and provide data regarding the SST, they failed to build any relationship between them, instead, stating them in sentences one by one. The PTs' who were able to present a rebuttal had difficulties in building relationships with other argumentation components.

Scenario 2 "Organic Food" Findings

The second scenario given below (Figure 2) is about organic food.

"Miss Özge pays great attention to the nutrition of her young daughter, Öykü. Miss Özge is very picky when it comes to buying chicken for Öykü, who loves to eat chicken. When Miss Özge went to the market to buy chicken, she noticed that there were three types of chicken on the shelf. One of the chickens was raised on a chicken farm and produced with traditional methods, one type was free-range chicken, and the other option was organic chicken. The most expensive type of chicken at the market was the organic chicken, while the cheapest was the chicken raised on a chicken farm. Another option for Miss Özge is the village chickens of Uncle Ali, who sells his chickens at the bazaar. The different options available to Miss Özge prompts her to think."

1. Which chicken would you choose? Please select one of the options below and explain why you chose it.
   - Traditional chicken
   - Free-range chicken
   - Organic chicken
   - Village chicken

1. Miss Özge chose to buy a type of chicken other than the one you would have preferred. What could her choice be?
2. What could be the reasons for Miss Özge to prefer that type of chicken?
3. You think that your choice is the best. How would you convince Miss Özge that your choice is the best one? Please explain."

Figure 2. Organic Food Scenario

Table 5 below presents the results of the analysis of the argumentation levels based on the responses given to the second argumentation scenario.

Table 5. Findings on the argumentation levels in the organic food scenario

Argumentation levels	Frequency (f)	Percentage (%)
Level 1	98	68.5
Level 2	35	24.5
Level 3	10	7
Level 4	-	-
Level 5	-	-

As shown in Table 5, there aren't any arguments for this SST that qualified to be at Level 4 or Level 5. Overall, 68.5% of them (n=98) produced arguments at Level 1, 24.5% (n=35) at Level 2, and 7% (n=10) at Level 3. In this scenario addressing the topic of "organic food," there aren't clearly defined rebuttals or multiple rebuttals. They only wrote their own claims and counterarguments with warrants. Table 6 presents some of the written responses given to the second scenario and their corresponding argumentation level.

Table 6. Examples from each level of the written responses given to the organic food scenario

Level	Prospective Teacher (PT)	Responses
1	PT 38	I would prefer village chicken (Claim). Village chicken is healthier, in my opinion. Organic chicken. Organic chicken is the most expensive, but it is healthier than traditional and free-range chickens (Counterargument).
	PT 119	I would prefer village chicken. I think village chicken is the one that is healthy (Claim). Organic chicken. Everybody prefers organic chicken (Counterargument).
2	PT 28	I would select village chicken. Chicken raised under natural conditions in villages may be healthier compared to others (Claim). Villages offer a good living and feeding environment for chickens. They can find many foods without any additives, which positively affects chickens' health.
	PT 39	Although they label it as organic at markets, I still prefer village chicken, because the organic label may be misleading and I do not trust it(Claim). Organic chicken. The fact that it is expensive could have convinced her that it is really organic, but I think she was deceived. Also, the market could have looked more hygienic (Counterargument). I always say that the best option is village products. Shopping sites like markets are more concerned about money and making a profit than people's nutrition and, therefore, will use the organic label to deceive people. Thus, I suggest buying products from village people who are content with earning their livelihood by selling the products they raise (Warrant).
3	PT 3	I would select village chicken. All the other types outside of village chicken have been processed and placed on the shelves. If there were no village chicken options, I would select organic (Claim + Warrant). It could be organic chicken (Counterargument). We know that chickens on chicken farms are raised in unnatural conditions and in a short period of time. I do not know much about free-range chickens, but I have my doubts about the quality of feed given to them. Frankly speaking, organic chicken is not a reassuring option because it is so expensive (Rebuttal).
4	-	-
5	-	-

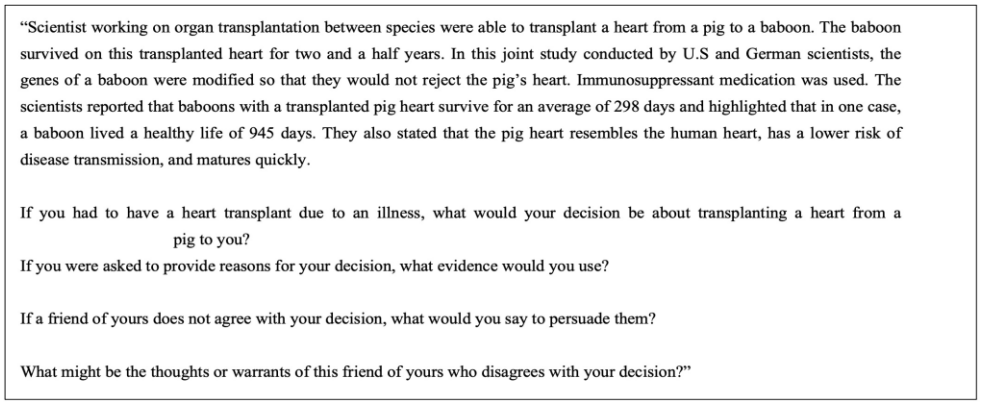
As seen from the examples in Table 6, 68.5% of the PTs' (n=98) presented only claims or counterarguments and failed to produce any arguments that could back or disprove these claims (Level 1). The responses of 24.5% (n=35) to the questions attached to the scenario consisted of only claims, data, and warrants (Level 2). Although there are some counterarguments, they were not considered rebuttals. 7% (n=10) used weak rebuttals in the arguments they produced (Level 3). However, they did not provide any data or claims to back

their rebuttals.

In this scenario that addressed the topic of "Organic Food," a vast majority of the prospective teachers selected the "village chicken." In examining the arguments, they put forward to support this selection, it was determined that they simply used different claims to back their initial claims. The written arguments consisted of simple sentences that fell far short of scientific language. The PTs'were able to produce claims, data, and warrants but lacked the ability to create rebuttals against their claims.

Scenario 3 "Organ Transplantation" Argumentation Findings

Argumentation 3 scenario is about the topic of "organ transplantation." At the end of the scenario prepared about heart transplant. The argumentation 3 scenario is given below (Figure 3).


"Scientist working on organ transplantation between species were able to transplant a heart from a pig to a baboon. The baboon survived on this transplanted heart for two and a half years. In this joint study conducted by U.S and German scientists, the genes of a baboon were modified so that they would not reject the pig's heart. Immunosuppressant medication was used. The scientists reported that baboons with a transplanted pig heart survive for an average of 298 days and highlighted that in one case, a baboon lived a healthy life of 945 days. They also stated that the pig heart resembles the human heart, has a lower risk of disease transmission, and matures quickly.

If you had to have a heart transplant due to an illness, what would your decision be about transplanting a heart from a pig to you?

If you were asked to provide reasons for your decision, what evidence would you use?

If a friend of yours does not agree with your decision, what would you say to persuade them?

What might be the thoughts or warrants of this friend of yours who disagrees with your decision?"

Figure 3.Organ Transplantation Scenario

The PTs' levels regarding the argumentation 3 scenario are presented in Table 7.

Table 7. Findings on the argumentation levels in the organ transplantation scenario

Argumentation levels	Frequency (f)	Percentage (%)
Level 1	111	77.6
Level 2	18	12.6
Level 3	13	9.1
Level 4	-	-
Level 5	-	-

As shown in Table 7, 77.6% (n=111) could produce a simple claim or counterargument, 12.6 % (n=18) put forward arguments that were placed at Level 2, and 9.1% (n=13) used a rebuttal in the argumentation. One PT left the scenario blank. In argumentation scenario 3, a vast majority of the PTs' could not produce any rebuttals but rather, only simple claims and warrants regarding the topic. There are not any arguments that could qualify for Level 4 and Level 5 inclusion. Table 8 presents some of the written responses given to the third scenario and their corresponding argumentation level.

Table 8. Examples from each level of the written responses given to the organ transplantation scenario

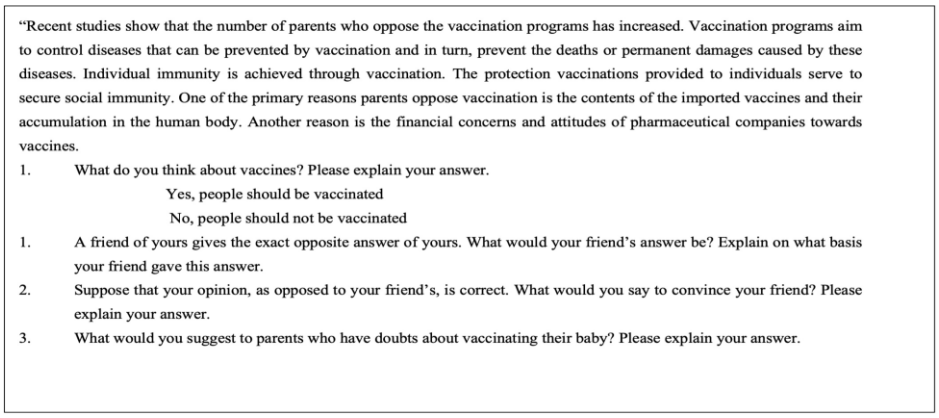
Level	Prospective Teacher (PT)	Response
1	PT 89	I would probably choose not to have a heart transplant from a pig due to my illness. Hopefully, no such thing would ever occur. I cannot explain this with evidence though. I think it would not be logical for me. The fact that it has never been attempted would make me reluctant (Claim). My friend would be okay with the transplantation of a pig heart. He believes that it would help him to regain his health (Counterargument).
	PT 90	I would not want a transplant because this has never been tested on humans (Claim). One might argue that the pig heart resembles the human heart a lot and has lower risks (Counterargument).
2	PT 34	I would accept a heart transplant from a pig. If there was no other heart, I would make this decision to live longer. I would accept it because this heart is less prone to diseases and adapts faster. I would say that I do not want to get sick again, and therefore, I need this (Claim + Warrant). Since it is an animal organ, my friend would think it smells terrible or would find it unclean (Counterargument).
3	PT 48	I would not want a pig heart. For example, parsley has 46 chromosomes, as do humans. We cannot assume though that the genes in parsley and humans are the same. I would say that interaction between species is healthier. I reference the example I mentioned above (Claim + Warrant). My friend would say that I would die if I did not accept the heart. My friend would say that the working principle of the human heart and the pig heart is the same (Counterargument + Rebuttal).
4	-	-
5	-	-

As seen from the examples at Level 1 in Table 8, 77.6% (n=111) put forward only simple claims and were not able to present data, reasons, or rebuttals to back or confute their claims or counterarguments. 12.6% (n=18) produced arguments at Level 2. Their responses to the questions in the argumentation scenario were at the level of claim, data, and warrant. No valid form of rebuttal was encountered in these responses. Overall, 9.1% (n=13) were able to produce weak rebuttals, as demonstrated in the examples given above.

Most of the arguments formed consisted of claims and warrants, and only a few of them included weak rebuttals. It is further seen that in the scenario prepared about organ transplantation, most of them put forward their own claims, constructing them according to their own personal perspective and belief system, presenting them with warrants, and repeating their claims about the topic. This suggests that the PTs may lack knowledge of the related content.

Scenario 4 "Vaccine Hesitancy" Findings

With the argumentation 4 scenario, the PTs'arguments about the vaccine and the rising opposition to the vaccine, popular subjects as of late, were examined. The argumentation 4 scenario is given below (Figure 4).



"Recent studies show that the number of parents who oppose the vaccination programs has increased. Vaccination programs aim to control diseases that can be prevented by vaccination and in turn, prevent the deaths or permanent damages caused by these diseases. Individual immunity is achieved through vaccination. The protection vaccinations provided to individuals serve to secure social immunity. One of the primary reasons parents oppose vaccination is the contents of the imported vaccines and their accumulation in the human body. Another reason is the financial concerns and attitudes of pharmaceutical companies towards vaccines.

1. What do you think about vaccines? Please explain your answer.

Yes, people should be vaccinated

No, people should not be vaccinated

1. A friend of yours gives the exact opposite answer of yours. What would your friend's answer be? Explain on what basis your friend gave this answer.
2. Suppose that your opinion, as opposed to your friend's, is correct. What would you say to convince your friend? Please explain your answer.
3. What would you suggest to parents who have doubts about vaccinating their baby? Please explain your answer.

Figure 4. Vaccine Hesitancy Scenario

The levels regarding the argumentation 4 scenario are presented in Table 9.

Table 9. Findings on the argumentation levels of the vaccine hesitancy scenario.

Argumentation levels	Frequency (f)	Percentage (%)
Level 1	102	71.3
Level 2	27	18.9
Level 3	14	9.8
Level 4	-	-
Level 5	-	-

The analyses showed that 71.3% (n=102) produced arguments related to the topic at Level 1, 18.9% (n=27) at Level 2, and only 9.8% (n=14) at Level 3. Similar to the other scenarios, there were no arguments written at Level 4 and Level 5. Examples from each argument level of this scenario are presented below, followed by their analyses. Table 10 presents some of the written responses given to the third scenario and their corresponding argumentation level.

Table 10. Examples from each level of the written responses given to the vaccine hesitancy scenario

Level	Prospective Teacher (PT)	Response
1	PT 43	Yes, people should be vaccinated. It prevents infectious diseases and aims to prevent permanent damages. Vaccination prevents contagious diseases (Claim). No, people should not be vaccinated. The content of imported vaccines and the accumulation of these contents in the human body (Counterargument).
	PT 22	No, people should not be vaccinated. Since vaccines are imported, we may not know whether or not they would be beneficial for us. It is not wrong to say that other nations are not friendly to us. For this reason, there is a question mark as to how efficient the vaccines imported from these countries would be (Claim). Yes, people should be vaccinated to protect against diseases; my friend would give this answer (Counterargument).

2	PT 91	Yes, people should be vaccinated. It is a useful application for immunity and human health (Claim). The immune-improving characteristic of vaccines has been proved, and it is universal (Data). It is beneficial to human health. The knowledge deficit on the ingredients of vaccines is not going to change these facts (Warrant). Doctors should first be consulted. Since babies have weak immune systems, it would be beneficial for them to get vaccinated (Backing). My friend would say people should not be vaccinated. Due to the lack of knowledge on the ingredients used in vaccines, people should not be vaccinated (Counterargument).
3	PT 138	Yes, people should be vaccinated. I advocate getting a vaccination for immunity. Vaccines are crucial because not everybody has the same living conditions and lifestyles (Claim). To improve our immune system, vaccines are necessary. I would say there are some diseases that can result in death at certain ages; therefore, vaccines are necessary (Warrant). People should not be vaccinated. This could be argued on the basis of the ingredients used in vaccines and the financial concerns of pharmaceutical companies (Weak Rebuttal).
4	-	-
5	-	-

As seen from the examples presented in Table 10, 71.3% (n=102) made simple claims or counterarguments (Level 1), 18.9% (n=27) produced claims with data, warrants, or backed claims but failed to produce any rebuttal in their written arguments (Level 2), and 9.8% (n=14) used weak rebuttals, without any data or claim support, in the arguments they created (Level 3). Overall, for this argumentation scenario on vaccination, a quite popular topic nowadays, most of the PTs put forward their claims or counterarguments regarding vaccination but were not able to offer any rebuttals. Instead, they backed their claims with warrants and data.

All scenarios' findings

In examining argumentation levels for all the scenarios (Table 11), it was determined that they mainly produced arguments at Level 1, putting forward simple claims and counterarguments about the scenarios without any rebuttals and providing only simple counterarguments against their claims. Erduran et al. (2004), in their study, considered the components of the Toulmin Model of Argument when developing their argumentation levels model. In the argumentation levels model, while each argumentation component plays a critically important role, the one component that raises the quality of the argument up to a higher-level argument, that is, Level 3, 4, or 5, is the rebuttal. Based on this, the findings obtained in the present study showed that the prospective biology and science teachers were primarily capable of writing arguments related to the SSTs addressed in this study at only lower levels (Level 1 and 3) (Table 11).

Table 11. Distribution of the written responses given to all scenarios by level

Levels	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Level 1	77	53.8	98	68.5	111	77.6	102	71.3
Level 2	42	29.4	35	24.5	18	12.6	27	18.9
Level 3	21	14.7	10	7	13	9.1	14	9.8
Level	2	1.4	-	-	-	-	-	-

4								
Level 5	1	0.7	-	-	-	-	-	-

In this study, the written argumentation levels on the scenarios of healthy nutrition and diet, organic food, organ transplantation, and vaccination were investigated. The argumentation levels model developed by Erduran et al. (2004) was applied to determine their argument levels. In this model, the most important difference between the levels is whether a rebuttal is present. An argument is said to be a higher-level argument if it contains a rebuttal, as well as claims, data, and warrants (Erduran et al., 2004; Kuhn, 2011). The argumentation levels model designed by Erduran et al. (2004) first mentions rebuttal at Level 3, meaning that Level 3, 4, and 5 can be regarded as higher levels.

According to the study findings on the scenario of healthy nutrition and diet, the arguments of 77 of the PT were at Level 1, 42 at Level 2, 21 at Level 3, 2 at Level 4, and only one at Level 5 (Table 3). In the second scenario on organic food, it was observed that the arguments of 98 of the PT were at Level 1, 35 at Level 2, and 10 at Level 3 (Table 5). For their argumentation levels on the scenario of organ transplantation, it was found that 111 of the PT were at Level 1, 18 at Level 2, and 13 at Level 3 (Table 7). Finally, for their argumentation levels on the scenario of vaccination, it was determined that 102 of the PT were at Level 1, 27 at Level 2, and 14 at Level 3 (Table 9). In examining the overall performance of the PTs' written arguments, it was observed that they largely were capable of only Level 1 and 2 arguments, as they put forward only the components of claim, counterargument, and warrant and failed for the most part to use the rebuttal component seen at Level 3, 4, and 5, in addition to the components of data, warrant and counterargument. Considering all the scenarios, most of the arguments produced by the prospective teachers were at Level 1 and 2, and only a very few were capable of producing arguments at Level 3, 4, and 5. The PTs' levels of written argumentation skills were therefore concluded to be low, as they were clustered at Level 1 and 2 (Table 11).

Discussion and Conclusions

A review of the literature showed that there are many studies on argumentation and its place in science. In a study by Topçu (2008), it was reported that prospective science teachers were able to produce claims about SSTs and backed these claims with data and warrants, but that only a few were able to put forward counterarguments with warrants. Demir (2017) conducted a study with 12 prospective social sciences teachers, who were tasked with working on three different scenarios over a course of five weeks. Demir's study found that the prospective teachers were more successful in creating claims than they were in creating rebuttals. The PTs' written argumentation levels in the present study were mainly at Level 1 for each scenario, meaning that they only contained a simple claim or counterargument. Aydemir et al. (2018), in their study, investigated the argumentation levels of 32 prospective science teachers and found that they had lower-level skills at producing arguments, with most of them only able to produce arguments at Level 2. Gürkan (2018) conducted a study with PTs that examined their written argumentation skills in terms of certain variables on the topics of transplantation and organ donation and found that the PTs had low-level argumentation skills. The results of these cited studies are similar to those of the present study. Moreover, in the present study, as in other similar studies in the literature (e.g., Aymen Peker et al., 2012; Kortland, 1996; Öğreten & Sağır, 2014), it was found that the PTs were able to present claims, data, and warrants but were incapable of putting forward any rebuttal, a component of argumentation considered by many researchers to be a governing indicator of the quality of an

argument (Erduran et al., 2004; Kuhn, 2011). The results of studies where in the argumentation implementation is extended over a long period time and written arguments on different scenarios are collected weekly are also similar to those of the present study, in so far as they showed the written argumentation levels to be low in the first weeks and steadily improving as the weeks progressed.

In contrast to the above-mentioned studies, some studies have found that PTs have higher argumentation levels. Torun and Açıkgül-Fırat (2020), in the study they conducted with prospective social sciences teachers and prospective science teachers to determine argumentation levels, reported that 64% of the participating PTs produced high-level arguments. However, when an in-depth analysis of the components was made, they discovered that the PTs did not use the components correctly, did not use the components in line with the purpose, and failed to build the relationship between them. In the argumentation process, it has been observed that individuals tend to put forward more rebuttals, as well as claims, data, and warrants once they gain more experience in arguments. In the present study, the PTs presented their claims and warrants in short, repetitive sentences that were generally similar to each other. Most of them were incapable of putting forward any rebuttals. It is believed that PTs have insufficient argumentation experience, but that with time and experience, they could present better quality arguments (Kutluca & Aydın, 2017).

The present study used SST scenarios to investigate the PTs' written arguments. Studies in the literature have also used various SST scenarios, including genetically modified organisms (GMO), environmental pollution, climate change, and organ transplantation and organ donation, to investigate written argumentation levels of PTs (Soysal, 2012; Torun & Açıkgül-Fırat, 2020; Yalçın, 2018; Gürkan, 2018). Torun and Açıkgül Fırat (2020). They used scenarios designed on environmental pollution and found that the PTs produced higher-level arguments. Demircioğlu and Uçar (2014) asked prospective science teachers in their study to produce written arguments on nuclear energy. At the end of the process, they found that in addition to the components of claims, data, and warrants, the prospective science teachers produced rebuttals, meaning that they created high-level arguments. In the present study, the most arguments produced at Level 1 (n=111) were on the topic of organ transplantation. The scenario in which the PTs put forward the most arguments at Level 3 or above was the scenario prepared on healthy nutrition and diet (n=24).

The differences seen in the findings from the present study and those reported by other studies on this subject could be attributed to the SST content knowledge of the participating PTs in the present study, the content of the scenarios prepared on these topics, interest in these topics, inability of the topics to motivate the PTs to create arguments, insufficient number of samples, or the fact that a more extended period of time was not allotted for the collection of the written arguments. When the responses of the PTs in the present study were investigated, it was seen that their life experiences, their moral values, and their understanding of ethics were reflected in their responses. The fact that the PTs made use of their experiences to back their claims, were affected by their social surroundings, and disregarded scientific knowledge could explain the simple claims they put forward in their arguments, that is, their low-level arguments, such as Level 1 or Level 2 (Boran, 2014; Dawson & Schibeci, 2003).

The present study's SSTs were limited to healthy nutrition and diet, vaccination, healthy food consumption, and organ transplantation. In future studies on this subject, different socio-scientific topics can be used. The present study, which investigated the quality of written argumentation on specific SSTs, could be restructured so as to investigate the quality of

verbal argumentation. It is recommended that more activities be designed for PTs and professional teachers to improve their argumentation skills. Argumentation exercises can be used more actively in lessons and homework on argumentation can be assigned. For professional teachers, greater attention can be drawn to argumentation through professional development activities, and argumentation can be used more actively in the classroom.

It is further recommended that future studies carry out an argumentation application similar to that used in the present study but with larger sample sizes, and that they be focused on identifying the factors that affect argumentation quality and how they affect it. Furthermore, it is recommended that future studies conduct detailed analyses on the components of argumentation and spread the argumentation process out over a period of weeks so that data can be collected and compared in terms of certain variables. The present study used the argumentation levels model designed by Erduran et al. (2004), but future studies should consider using different models or a model newly developed by researchers to determine argumentation levels.

Note

This paper is extracted from the first author's master dissertation "Relationship between the epistemological beliefs and the written argumentation skills in some socio-scientific issues of teacher candidates" submitted to the Balikesir University of Turkey.

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