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The Observation of Pre-service Teachers' Argumentation Skills on Different Socioscientific Issues

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ABSTRACT

In this study, it was aimed to determine the argumentation skills of pre-service science teachers studying at the 4th grade in different socioscientific issues. The study was designed in accordance with the case study. In the study involving 8 teacher candidates, the data were obtained by observation method. For data analysis, descriptive analysis was performed. The data in the argumentation process were evaluated both in terms of quantity and quality. In terms of quantity, it was seen that teacher candidates had more codes and frequencies in biotechnology and health themes, and less in environment and energy themes. When the argumentation process was examined qualitatively, it was seen that the pre-service teachers could not form arguments by paying attention to all components. It was also concluded that the participants formed better arguments on socioscientific issues such as global climate change, genetically modified organisms, nuclear energy, organ donation and stem cells, medicine-alternative medicine. It was found that the participants were able to form arguments at a lower level on socioscientific issues such as cloning, euthanasia, space pollution and pandemic vaccine. From this point on, it can be stated that the argument attributes are affected by the subject context.

Keywords: Argumentation, teacher candidate, socioscientific issues, observation.

Öğretmen Adaylarının Farklı Sosyobilimsel Konulardaki Argümantasyon Becerilerinin Gözlenmesi

ÖZ

Bu çalışmada fen bilgisi öğretmenliği 4. Sınıf düzeyinde öğrenim gören öğretmen adaylarının farklı sosyobilimsel konularda argümantasyon becerilerinin tespit edilmesi amaçlanmıştır. Çalışma, durum çalışmasına uygun olarak tasarlanmıştır. 8 öğretmen adayının yer aldığı çalışmada veriler gözlem metodu ile elde edilmiştir. Veri analizi için betimsel analiz yapılmştır. Argümantasyon sürecindeki veriler hem nicelik hem de nitelik olarak değerlendirilmiştir. Nicelik olarak bakıldığında öğretmen adaylarının biyoteknoloji ve sağlık temalalarında daha fazla, çevre ve enerji temalarında ise daha az kod ve frekanslara sahip olduğu görülmüştür. Argümantasyon süreci nitelik olarak incelendiğinde öğretmen adaylarının tüm bileşenlere dikkat ederek argüman oluşturamadığı görülmüştür. Ayrıca katılımcıların küresel iklim değişikliği, genetiği değiştirilmiş organizmalar, nükleer enerji, organ bağışı ve kök hücre, tıp-alternatif tıp gibi sosyobilimsel konularda daha iyi düzeyde argümanlar oluşturduğu sonucuna ulaşılmıştır. Katılımcıların klonlama, ötenazi, uzay kirliliği ve pandemik aşı gibi sosyobilimsel konularda daha düşük düzeyde argümanlar oluşturabildiği tespit edilmiştir. Bu noktadan hareketle argüman niteliklerinin konu bağlamından etkilendiği ifade edilebilir.

Anahtar kelimeler: Argümantasyon, öğretmen adayı, sosyobilimsel konular, gözlem.

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1 | INTRODUCTION

Today, living conditions are changing very rapidly and human beings are faced with many dilemmas due to the effects of scientific processes on society. When considered ethically, morally and socially, the effects and interventions of science in human life and the diversity of these dilemmas also increases (Zeidler & Sadler, 2008). In other words, the obtained scientific knowledge also prepares the ground for new problems, dilemmas and solutions. Human beings, who are among the key concepts of problem, solution and dilemma, enter the decision-making process by considering the above dimensions. One of the main goals of science education is to enable students to make conscious decisions in their lives and to use their scientific understanding in the discussion processes they may encounter in their daily lives (Dawson & Venville, 2010). Waste control and renewable products (Kortland, 1996), genetic engineering applications (Sadler & Zeidler, 2005a, 2005b; Zohar & Nemet, 2002), nuclear power (Zengin Kırbag, Kececi, Kirilmazkaya, & Sener, 2011), hydroelectric power plants (Ozturk & Leblebicioglu, 2015; Yavuz Topaloglu & Balkan Kiyici, 2017), gene therapy, cloning (Concannon, Siegel, Halverson & Freyermuth, 2010), global climate change (Topcu, Sadler & Yılmaz Tuzun, 2010) are the concrete examples of such issues. The aforementioned issues are seen as controversial issues on which studies are carried out both in social and scientific grounds every day. Socioscientific issues (SSI) have been conceptualized in the recent past, draw attention by researchers and are frequently used in daily life (Sadler, 2003). They are scientific situations that involve social dilemmas related to science and affect the society in which students will have mutual dialogue, conflict and debate (Zeidler & Nichols, 2009). In addition to the issues mentioned above, pandemic vaccines, seal hunting, biotechnology applications and space pollution can be shown as examples of socioscientific issues (Yaman, 2012). It can be said that these controversial issues are generally of a universal nature. However, these issues can be local, as well as universal (Atasoy, 2018). For example, topics such as "İğne Ada, Akkuyu, Sinop nuclear power plant projects, green road project in the Black Sea, Cerattepe mine operation project, illegal electricity usage, base stations" are also socioscientific issues in our country. (Capkinoglu, 2015; Evren Yapicioglu & Kaptan, 2018; Furuncu, 2016). Discussions could not be put to an end in any of the issues given as examples and dilemmas continue. In fact, as scientific developments increase, it is thought that the variety and number of socioscientific issues will increase over time (Karakaya, 2015).

These controversial issues on the agenda are also reflected in science education and the curriculum, because the main purpose of science education is to help students gain skills rather than providing scientific knowledge on the axis of research inquiry-based approach (MoNE, 2018). In addition, the present curriculum focuses on values education as well as developing skills in students. Socioscientific issues play a key role in providing students with many skills as well as values education. To give a specific example, while contributing to a mental skill such as critical thinking, socioscientific issues also focus on values such as global citizenship awareness (Lee et al., 2013; Zeidler, Applebaum & Sadler, 2011). However, it is stated that socioscientific issues also provide a basis for students to gain argumentation skills (Wu & Tsai, 2011). It can also be said that socioscientific situations are the process of reaching a decision within the context of argumentation (Sadler & Zeidler, 2005a; Zeidler & Sadler, 2008). From this point of view, it is possible to say that socioscientific issues and the argumentation process are key concepts associated with it. Argumentation can be expressed as a written or verbal process in which there is a mutual exchange of ideas about the validity of a claim, using data, reasoning, support and rebuttal to convince people, and criticizing, discussing and reviewing the opposing claim (Berland & Reiser, 2011; Driver, Newton, & Osborne, 2000; Toulmin, 2000). In order to raise individuals who have developed argumentation skills and are science literate, first of all, teachers should have this developed skill (Evren Yapicioglu, 2016), because the teacher acts as a guide that guides this process in the discussion environments where students present their claims based on valid data (MoNE, 2018; Ozcan, Aktamıs, & Higde, 2018). The use of argumentation in science lessons is thought to provide students with high-level cognitive skills, ability to use language, understanding the nature of science, being science and technology literate, having creative and critical thinking, and questioning skills (Jimenez-Aleixander & Erduran, 2007). Asserting that argumentation should be used especially in socioscientific issues, Lin et al. (2014) state that the most appropriate science subjects for the nature of argumentation are socioscientific subjects. It can be said that the argumentation process, which is dealt in the context of socioscientific issues, plays a key role in raising science literate individuals (Zeidler & Sadler, 2011). Science teachers have an important role in raising science literate individuals. However, it is thought that another group that is as important as teachers is pre-service teachers. When the socioscientific issues mentioned above and the

pre-service teacher dimension of argumentation skill are examined, there are many studies in the literature where teacher candidates and socioscientific issues are discussed together such as (Barret, 2007; Bell, Matkins, and Gansneder, 2011; Cansız, 2014; Cenk, 2020; Cirit Gul & Apaydin, 2021; Demircioglu & Ucar, 2014; Es & Varol, 2019; Halverson, Siegel & Freyermuth, 2009; Kutluca, 2012; Kutluca & Aydin, 2017; Liu, 2014; Matkins & Bell, 2007; Ozturk, 2011; Ozturk & Yenilmez Turkoglu, 2018; Sadler & Zeidler, 2005b; Surmeli & Sahin, 2012).

It is possible to talk about many argumentation models (Lawson, 2003; Sandoval, 2003; Schwarz et al., 2003; Toulmin, 2003) and analytical frameworks (Sadler & Fowler, 2006; Toulmin, 2003; Zohar & Nemet, 2002) in the literature. It can be argued that Toulmin's (2003) argumentation model is generally used in both national and international literature (Aktamis & Higde, 2015). Based on Toulmin's argumentation model, Erduran, Simon, and Osborne (2004) also created a framework that presents the argumentation skills to be used in small group discussions and student-teacher dialectics. The theoretical framework in question has been the reference point in many studies. The argumentation model, suitable for using with socioscientific issues, can clearly reveal the quality of the argumentation. For this reason, it is believed that selecting the argumentation model developed by Erduran et al. (2004) based on Toulmin's (2003) argumentation model would be appropriate in this study. On the other hand, literature review on socioscientific issues, the key concept in this research, shows that the studies on socioscientific issues in Turkey conducted with pre-service teachers have generally focused on participants' level of knowledge (Ayvacı, Bulbul & Turker, 2019), participants' attitude (Cebesoy, Donmez Sahin, 2013), identification of opinions (Sabıc, 2017; Tekgoz & Ercan Yalman, 2020; Turkmen, Pekmez & Saglam, 2017) and the argumentation process (Ozturk & Yenilmez Turkoglu, 2018; Yaman, 2012). When the studies are examined as research design, it can be said that studies are generally carried out with a quantitative approach (Genc & Genc, 2017). Unlike most studies in the literature, qualitative data were obtained by making long-term observations in this study. The observation technique is thought to help obtain rich and multidimensional results. As a matter of fact, the effectiveness and importance of argumentation practices in the socioscientic issues as small group discussions or class discussions are mentioned in the literature. (Maloney & Simon; Walker & Zeidler, 2007) Because in each discussion environment, the participants can find the opportunity to criticize the socioscientific issue discussed and gain a different perspective (Liu, 2014). In addition, when the literature is examined, it is noteworthy that in general, the studies on socioscientic issues are shaped around a single subjects such as GMO, nuclear energy etc. However, there is a limited number of studies examining the quality of arguments by addressing more than one socioscientific issue (Turkoz, 2019; Tuskan, 2020; Urhan, 2016). For example, Turkoz (2019) examined the argument quality of pre-service teachers on three different socioscientific issues such as glucose tolerance in pregnancy, raw and processed milk and nuclear power plants. Turkoz's (2019) study is similar to the current research since it addressed different socioscientific issues as well. However, studies questioning the quality of arguments in a wider range do not exist in the literature. In this context, the present study is considered to be important because it addressed nine different socioscientific issues. In other words, the discussion skills of the teacher candidates were observed over and over again in many subjects and tried to reveal qualified results in this study. From this point of view, in the present study, it was aimed to observe how the argumentation skills of science preservice teacher candidates in socioscientific issues are different in other socioscientific issues. The study conducted in line with this purpose included two starting points or sub-objectives.

RESEARCH QUESTIONS

1. What is pre-service teachers' argumentation skills in regards to socioscientific issues?
2. Do pre-service teachers' argumentation skills change according to the context of the subject?

2 | METHOD

In this study, it was aimed to examine the argumentation skills of pre-service science teachers and to determine how the argumentation skills of pre-service teachers would change according to the subject context. Thus, the study was conducted according to a case study, one of the qualitative research approaches. Yin (2012) defines case studies as a type of assessment in which the researcher analyzes a situation, action, process and people in depth. Yildirim and Simsek (2016) mentions that while describing the characteristics of the case studies, it is necessary to carry out the research with relatively smaller working groups in order to obtain detailed and in-depth

information. The rationale for conducting this research according to the case study can be based on the above definitions. To put it more clearly, the situation investigated in this study is considered to be suitable for the case study, since it presents rich and explanatory information in its natural context in a small group. For this reason, observation was used to examine the non-verbal behaviors of the study participants.

PARTICIPANTS

Pre-service teachers had received their high school education in provincial centers in the Mediterranean region (Mersin, Adana, Antalya, Osmaniye, etc.) and were presently studying at a state university in the Mediterranean Region at the time of the study. The sample of this study consists of 8 4th grade teacher candidates (3 male, 5 female) studying in Faculty of Education, Science Education Department. The study was conducted within the scope of an elective course named “Special Topics in Science”. For this reason, the number of students choosing the course constitutes the research group. Before taking the elective course in which the study was conducted, pre-service teachers had taken courses such as "Nature of Science”, “History of Science” and “Evolution", courses that could have shaped their opinions and decisions on socioscientific issues. In this context, it can be argued that the participants have had prior knowledge on socioscientific issues, both due to the department they studied in and due to the previous courses they took.

DATA COLLECTION

Socioscientific issues -based training was conducted with the teacher candidates for nine weeks and the process was recorded via camera. In the implementation process, the entire socioscientific issues were handled with the argumentation process. The preservice teachers tried to produce arguments in each socioscientific issue in this process. Different methods and techniques (6 thinking hats, station, cornering, etc.) were used while making presentations with socioscientific issues. The socioscientific issues and application process discussed within the scope of the research are presented in Table 1.

Table 1. Socioscientific Issues Examined Within the Scope of the Research and Application Process

Week	Subject	Argumentation Question	Data collection tool
1	Global climate change	Is global climate change beneficial or harmful for the environment? Why?	Classroom observation (video recording)
2	Genetically modified organisms	Is GMO useful or harmful? Why?	Classroom observation (video recording)
3	Nuclear energy	Should nuclear power plants be built? Should nuclear power plants not be built? Why?	Classroom observation (video recording)
4	Space pollution	Should Space Pollution be cleaned or not? Why?	Classroom observation (video recording)
5	Cloning	Should cloning be used on humans or not? Why?	Classroom observation (video recording)
6	Organ donation and stem cells	Should organ donation be supported or not? Why?	Classroom observation (video recording)
7	Euthanasia	Should euthanasia be practiced or not? Why?	Classroom observation (video recording)
8	Pandemic vaccine	Should pandemic vaccine be administered or not? Why?	Classroom observation (video recording)
9	Medicine – Alternative Medicine	Should alternative medicine be supported or not? Why?	Classroom observation (video recording)

Data were collected from pre-service teachers with observation records. Data were collected over nine different socioscientific issues. These issues are global climate change, genetically modified organisms, nuclear energy, space pollution, cloning, organ donation, euthanasia, pandemic vaccine and medicine-alternative medicine.

Observation, which is used as a data collection tool in the research process, is a data collection tool with strengths since it examines non-verbal behaviors under natural environmental conditions for a long time (Yildirim & Simsek, 2016). Unstructured observation type was used in the study. In this type of observation, the researcher should observe in a more natural and open-ended manner rather than using predetermined categories and classifications. The aim is to allow the categories and concepts necessary to analyze and describe observation data to emerge while research is being carried out rather than being based on previous data or concepts (Punch & Oancea, 2013). For this reason, it is thought that the classroom observation method is an appropriate data collection tool for prospective teachers to reveal the researcher structures in the classroom and the discussions they will make among themselves.

For data analysis, firstly, the preservice teachers' speeches in the camera recordings were transcribed. After the transcripts were created, descriptive analysis was used. Transcripts were reviewed by two field experts. The transcripts are divided into codes and themes by two experts and researchers (4 people in total). At this stage, four people in the analysis process carried out the analysis independently. Then, the harmony between the analyzes was tried to be determined. Inter-coding (transcoding) is based on the acceptance of two or more encoders of codes used for the same sentences in a transcript (Creswell & Plano Clark, 2011). When the codes of the experts in the analysis process were compared, it was defined as consensus if codes similar to the same sentence were given, and disagreement if different codes were given. According to the calculation formula proposed by Miles and Huberman (1994), the compliance was determined as 83%. It was tried to reach consensus by coming together on the codes and themes where there was a difference of opinion. The second compliance percentage calculated in this way was determined as 92%. In addition, the quality of the arguments was analyzed to evaluate the data created by the participants on socioscientific issues in a versatile way. Pre-service teachers' argumentation quality was determined by evaluating the transcripts obtained from the observation data. "Argumentation Quality Rubric" (Sadler & Fowler, 2006), presented in Annex 1, was used to determine pre-service teachers' argumentation quality.

Based on the general summary of the data analysis process, it can be argued that both quantitatively and qualitatively analyses were performed on the arguments developed while trying to identify the argumentation skills that the participants used in answering the research questions. The quantity of the arguments was analyzed with the descriptive analysis method and the quality of the arguments was analyzed with the "Argumentation Quality Rubric" (Sadler & Fowler, 2006).

Key concepts such as validity, reliability, credibility and transferability were taken into consideration in the study. Lincoln and Guba (1985) state that each of the concepts of "credibility, transferability, consistency and verifiability" are important in qualitative research. The applications for each of these concepts are explained in detail below.

In order to ensure validity and reliability, the above-mentioned analysis process was carried out first. The fact that more than one person takes part in the analysis process is important in terms of not causing the researchers' subjective assumptions or misunderstanding the data (if any). In order to ensure validity, reliability and verification, participant confirmation was used as the second method. In the participant's confirmation, the researchers presented the data to the participant and asked them to express their opinions on the accuracy of the collected data. There are two key concepts (credibility and transferability) that are as important as validity and reliability in qualitative research. Merriam (1998) states that explaining the process to the reader as transparent as possible in qualitative research will help to ensure transferability. The research process has been explained to the reader in detail in order to ensure credibility and transferability. In addition, from time to time, examples from the natural data of teacher candidates were presented in the findings section to ensure credibility and transferability. Considering the applications made during the analysis process, it is thought that the study is appropriate in terms of validity, reliability, credibility and transferability.

RESEARCH ETHICS

The issues that the researcher should behave ethically towards the participants can be listed as conscious consent, freedom of the participants, respecting for the private life of the participants, not deceiving and harming the participants (Hammersley ve Traianou, 2017). In this study, attention was paid to both legislative ethics and

applied ethical principles. Within the scope of legislative ethics, approval for this study was obtained by the Social and Human Ethics Committee (26/08/2020-36) of the university where the present study was conducted. In the applied ethics part, firstly, the participants were informed about the research. When the researchers explained the purpose and scope of the study to the participants, the prospective teachers stated that they could be involved in the study voluntarily. In this sense, it can be said that the conscious consent principle is taken into consideration. In addition, codes such as P1, P2 were given to the participants in order not to damage the privacy of the participants.

It was emphasized by the researchers that the participants could easily express their opinions and should not have grade concerns in this process. In addition, itt was stated that when participants talked about religious, political, cultural issues in the argumentation process, the researchers would not make any intervention. Researchers also have an ethical responsibility to the reader. The research content was described in as much detail as possible and the data was adhered to during the reporting process of the research. As a result of all these actions, it can be said that ethical rules are adhered to.

Mention of the role of researchers is also important for the comprehensibility of the process. The first author in this research participated in the classroom environment as an observer. The role of the researcher is known by the participants. The second author is the lecturer who is conducting the course named “Special Topics in Science”. In order for the second researcher not to manipulate the process and affect the research results, the participants were guaranteed that the statements in the argumentation process would not be associated with the scoring of the course. Both researchers did not take an active role in classroom practices and the argumentation process and so did not interfere with the situation.

3 | FINDINGS

The data obtained from the observation records of the pre-service teachers were evaluated both in terms of quality and quantity. First of all, the records of prospective teachers were evaluated in terms of frequency of repetition. Afterwards, the data were evaluated qualitatively. The frequency of repetition of the information obtained from the observation records is presented in Table 2.

Table 2. Themes and Codes Obtained from Observation Records

Category	Code	Sub-code	%
Biotechnology (168)	Genetically modified organisms (50)	Genetic engineering (16)	9,5
		Conducting research (14)	8,3
		Increasing efficiency (12)	7,1
		Durability (12)	7,1
		Immune system (11)	6,5
		Technology 11	6,5
		Embryo (10)	6
	Stem cells (30)	Increase in resource consumption (9)	5,4
		Hereditary diseases (9)	5,4
		Treatment methods (9)	5,4
	Cloning (54)	Subject creatures (8)	4,8
		Trivialization of living things (8)	4,8
		Organism community (7)	4,2
		Domestication (7)	4,2
	Pandemic vaccine (34)	Commercial purposes (7)	4,2
		Bio-factories (4)	2,4
		Tube- baby (3)	1,8
		Expert opinion (18)	13,2
		Empathy (14)	9,6

Health (136)	Euthanasia (52)	Religious perspective (13)	10,3
		Laws (12)	8,8
		Awareness (11)	8,1
		Active ingredients (10)	7,4
	Transplantation (46)	Scientific methods (9)	6,6
		Treatment methods (8)	5,9
		Conscience (8)	5,9
		Information pollution (7)	5,1
		Right to life (7)	5,1
	Medicine- Alternative Medicine (48)	Hope (6)	4,4
		Miracle (5)	3,7
		Herbal medicines (5)	3,7
		Psychology (3)	2,2
Environment (92)	Space pollution (41)	Danger (17)	18,5
		Human-made (13)	14,1
		Waste (12)	13
		Scientific research (11)	12
		Fossil fuels (9)	9,8
		Wars (8)	8,7
	Global climate change (51)	Pollution (8)	8,7
		Mechanization (7)	7,6
		Costly measures and solutions (7)	7,6
Energy (57)	Nuclear energy (57)	Risks (9)	15,8
		Accidents (9)	15,8
		Radioactive substances (9)	15,8
		Energy requirement (8)	14
		Nuclear waste (8)	14
		Safe waste storage (7)	12,3
		Alternative energy sources (7)	12,3

When Table 2 was examined, four different categories were formed in line with the data obtained from the observation records of the pre-service teachers. These categories are biotechnology, health, environment, and energy. According to the answers given by the teacher candidates, genetically modified organisms, cloning, stem cell, pandemic vaccine were included in the biotechnology category. Euthanasia, organ transplantation, medicine-alternative medicine subjects are included in the health category. Global climate change and space pollution are included in the environmental category, while nuclear energy is under the energy category. In general, the codes in the biotechnology category were repeated 168 times, and the codes in the health category were repeated 136 times. The codes in the environmental category were repeated 92 times. The codes in the energy category were repeated 57 times. Looking at Table 2, it can be said that both codes and frequencies are less in environmental and energy categories.

It can be said that the codes created in the observation records according to the data show similarities in some subjects but differ in other subjects. The codes on which teacher candidates refer to are shown with the colored letter "X". Different colored "X" letters are defined for different subjects. These data are presented in Figure 1, Figure 2 and Figure 3.

In the biotechnology category created within the different socioscientific issues, the subject of genetically modified organisms is indicated with the letter ' X " in red, the subject of pandemic vaccine with the letter " X " in blue, the subject of cloning with the letter " X ' in orange, and the subject of stem cell with with the letter " X ' in green. When the socioscientific issues in the environmental category are examined, the issue of global climate change is represented by the letter " X " in purple, and codes related to the subject of space pollution are represented by the letter 'X' in pink. The subject of euthanasia in the health category is represented by the gray letter "X", organ

transplantation is represented by the letter "X" in turquoise, and the subject of medicine-alternative medicine is represented by the yellow letter "X". The codes determined in line with the answers of the teacher candidates are represented by the letter "X" in that color, in which socioscientific issues they are repeated. Since there is only one socioscientific issue in the energy category, all the codes specified are repeated codes related to the nuclear energy issue. For this reason, a separate figure has not been prepared for the energy category. The similarities of the codes in the biotechnology category are shown in Figure 1.

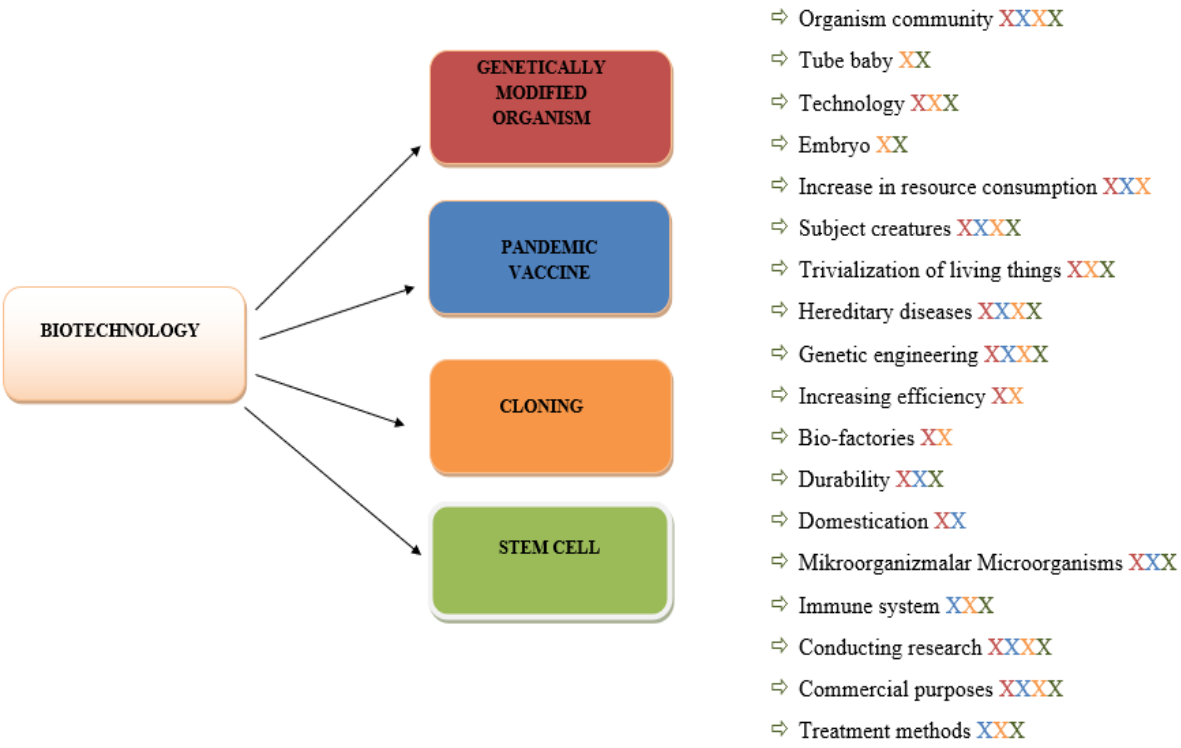


Figure 1. *Similarities of the Codes in the Biotechnology Category*

Genetically modified organisms, pandemic vaccine, stem cell, cloning are included in the biotechnology category. It has been determined that the codes of organism group, living things, hereditary diseases, genetic engineering, research and commercial purposes, which are included in the codes repeated for these issues, are common in all socioscientific issues in the biotechnology category. While test tube baby and embryo codes have been used in cloning and stem cell issues, increasing efficiency, bio-factory codes have been used in genetically modified organisms and cloning issues. It has been determined that the domestication code was repeated in genetically modified organisms and pandemic vaccines issues. Technology code has been determined to be commonly repeated in cloning, stem cell, and genetically modified organisms, issues. The code of trivializing living things has been commonly repeated in genetically modified organisms, cloning, and stem cells. It has been determined that durability and microorganisms, codes are commonly repeated in genetically modified organisms, pandemic vaccine, and stem cell issues. Immune system and treatment methods codes have been found to be commonly repeated in pandemic vaccine, cloning and stem cell issues. The similarities of the codes in the environmental category are shown in Figure 2.

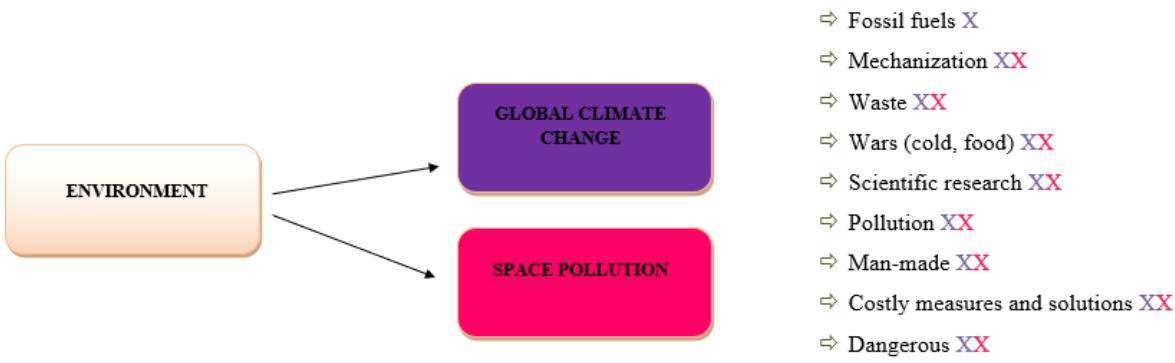


Figure 2. *Similarities of the Codes in the Environment Category*

Global climate change and space pollution issues are included in the environmental category. It has been determined that mechanization, waste, wars (cold, food, water), scientific research, pollution, human made, costly measures and solutions, danger codes, which are among the repeated codes for these issues, are common in all socioscientific issues within the environmental category. It can be said that the fossil fuel code is stated only on global climate change. The similarities of the codes in the health category are shown in Figure 3.

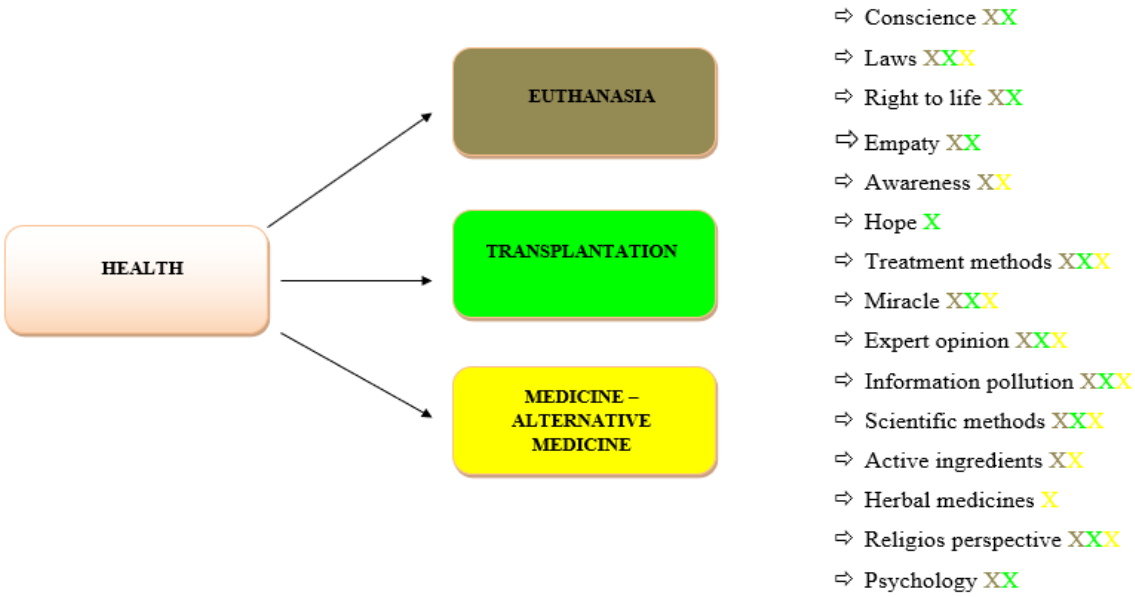


Figure 3. *Similarities of the Codes in the Health Category*

Subjects of euthanasia, organ transplantation and medicine-alternative medicine are included in the health category. It has been determined that the treatment methods, expert opinion, miracle, laws, information pollution, scientific methods and religious perspective codes included in the codes repeated for these issues are common in all socioscientific issues in the health category. It has been determined that the conscience code, the right to life code, the empathy code and the psychology code are common in euthanasia and organ transplantation issues. The awareness code repeats itself jointly on organ transplantation and medicine-alternative medicine issues. Hope code is specified only in organ transplantation. It has been determined that the active ingredients code is reproduced jointly in euthanasia and medicine-alternative medicine issues. The herbal medicines code has been mentioned only in the subject of medicine-alternative medicine.

When the results are examined in general, it is noteworthy that some codes are common to all subjects in that category. For example, codes such as the organism community in the biotechnology category, test subject organisms, hereditary diseases, genetic engineering, research, commercial purposes have been repeated jointly on GMO, pandemic vaccine, cloning and stem cell issues. In addition, in the environmental category, mechanization,

waste, wars (cold, food), scientific research, pollution, man-made, costly measures and solutions, hazard codes, global climate change and space pollution have been mentioned jointly. In addition, codes such as laws, treatment methods, miracle, expert opinion, information pollution, scientific methods, religious perspective in the health category are common in euthanasia, organ transplantation and medicine-alternative medicine issues.

It was observed that some of the arguments that the teacher candidates presented on different socioscientific issues were in a similar direction, and some common codes could emerge in different weeks, albeit on different subjects. Some quotations are given below in order to support the findings shown in Figure 1, Figure 2 and Figure 3.

P1: Global climate change is one of the important problems of today. I think that measures should be taken and solutions should be sought. We can turn to renewable energy sources. We can use clean energy sources We can do awareness raising activities. (Global climate change - solutions, renewable energy code)

P8: I don't think there is a place where nuclear waste could be stored. It seems very counterintuitive to me to take this to another field. If we are going to use electricity, we must apply to cleaner ways. For example, it can be efficient if we install wind energy in certain areas. For example, I think that if we meet some of our energy from wind, some from bio-diesel, some from boron and some from solar energy, we will already be able to meet most of our energy. For example, the city of Çanakkale is windy most of the year. We should install wind energy there or is there boron in Eskişehir? We must use boron as energy. Or we must benefit from Black Sea for wave energy. Although it may seem costly during the installation phase in the first place, it can pay for itself in the long run. Moreover, I believe it can be more beneficial because it is clean energy. Also, I don't think we are a very suitable country for nuclear energy. (Nuclear energy - solutions, renewable energy code)

P5: A car brand makes a claim that the exhaust gases of the car we produce are not harmful. In order to test this, they set up a system in which the monkeys they selected as subjects were closed in a glass bowl and diverted the gases from the exhaust of the vehicle they produced into the glass bell and they say the monkeys will not be harmed by this. Of course, the monkeys suffer from this. Subject creatures should not be used in such experiments. Ultimately, exhaust gases harm nature. They harm living things. (Global climate change - subject creatures code)

P4: Animals are used as live subjects for cloning. Considering that we are in the group of vertebrates, I think that cloning can also be done on humans. And it is really sad that animals are used in such experiments. I do not lean towards the cloning of people either. I don't think so. (Cloning – subject organisms code)

Striking results, not seen in the tables, but observed by the researchers in the classroom environment and confirmed in the observation records, were also obtained. For example, it was observed prospective teachers could make clear decisions as a result of discussions on some socioscientific issues, but abstained from some socioscientific issues. While the teacher candidates provided clear ideas on nuclear energy, global climate change, organ donation and stem cells, cloning issues, they were observed to abstain from euthanasia, medicine-alternative medicine, space pollution, genetically modified organisms. Among the different socioscientific issues, the teacher candidates were able to make the most arguments about nuclear energy, while the least argument was made about the pandemic vaccine.

When the data obtained from pre-service teachers were examined, the findings in the argumentation process were also examined in terms of quality. In this part, the discussions that the teacher candidates had in the classroom, which is their natural environment, were evaluated and their argument levels were tried to be determined. In other words, it was examined whether the argument components existed in the discussions of the prospective teachers. The argument levels of the teacher candidates in different socioscientific issues are presented in Table 3.

Table 3. Argument Levels Obtained from the Observation Records of Pre-Service Teachers

	Global climate change	Genetically modified organisms	Nuclear Energy	Space pollution	Cloning	Organ donation and stem cell	Euthanasia	Pandemic vaccine	Medicine-alternative medicine
P1	All components	Claim and proof	All components	Claim and proof	Claim and proof	Claim and proof	There is a claim	All components	All components
P2	Claim and proof	All components	All components	All components	Claim and proof	All components	Claim and proof	There is a claim	Claim, proof and support
P3	All components	Claim and proof	Claim, proof and support	All components	All components	Claim and proof	Claim and proof	Claim and proof	Claim, proof and support
P4	Claim and proof	All components	Claim and proof	Claim, proof and support	Claim, proof and support	Claim, proof and support	There is a claim	Claim and proof	All components
P5	Claim, proof and support	Claim and proof	There is a claim	Claim, proof and support	Claim and proof	Claim, proof and support	Claim and proof	Claim, proof and support	Claim, proof and support
P6	Claim, proof and support	Claim, proof and support	All components	Claim and proof	All components	Claim and proof	All components	All components	Claim, proof and support
P7	Claim and proof	All components	Claim and proof	None	None	None	There is a claim	Claim, proof and support	Claim and proof
P8	Claim, proof and support	All components	All components	All components	Claim, proof and support	Claim, proof and support	All components	All components	Claim, proof and support

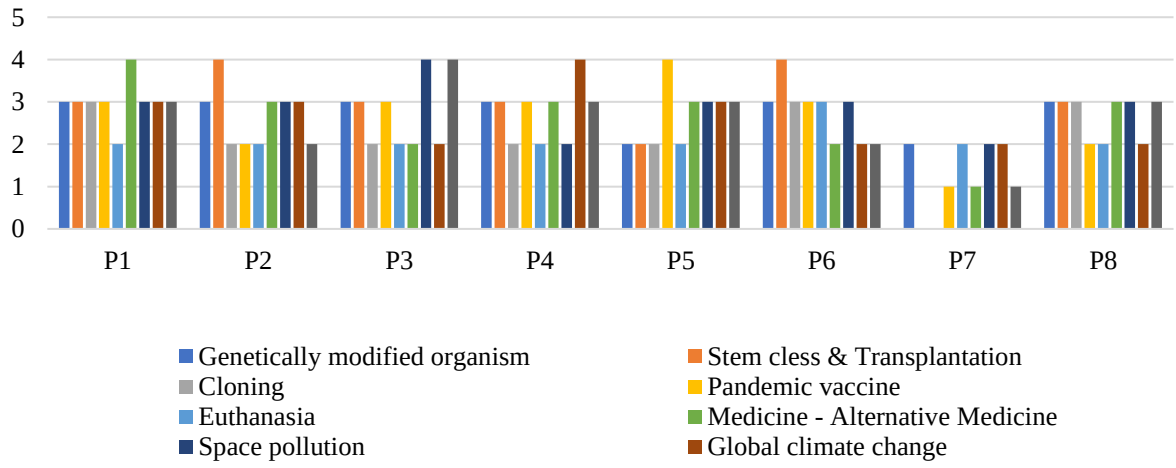
During the argumentation process, it was observed that the pre-service teachers had the power to use all the components (claim, evidence, supportive, rebuttal) in some subjects, while it was determined that no arguments could be formed in some subjects. For example, while P3 created arguments that included all components on global climate change, space pollution and cloning issues, he created arguments on GMO, nuclear energy, organ donation, stem cell, euthanasia, pandemic vaccine and medicine-alternative medicine, but he created arguments that did not include all components. In addition, it was determined that P7 could not create any arguments on three different socioscientific issues. Below are excerpts about the cases in which there are complete components and not all argument components are presented.

P3: I am not in favor of cloning. There are points where I am indecisive or where my claim can be refuted. Scientifically, I think that having one more of the same living thing and applying cloning events on humans will have bad consequences. It *can become a weapon that powerful states can use in case of war. So, I think this situation means trivialization of human. I think that no matter what the creature is cloned, it will not exactly reflect the characteristics of the cloned human being. Because, while the human grows and personalities begin to form, the environment is of great importance as well as genetic factors. In identical twins, individuals can be affected by different environmental conditions and have completely different thoughts and emotions. The point where I am indecisive is that a leader like Atatürk can be born again as a result of cloning. But someone like Hitler can appear, too and I think this is not a situation that can be put at risk. (Cloning-argument containing all components)*

P3: I am not in favor of leaving a person's being alive or being killed to other people's wishes and preferences. It is impossible for me to support this topic. Life is a very precious thing and every human being demands immortality. I can't approve of doing something to someone else that I don't want done to myself (euthanasia-argument lacking all components).

Chart 1 presents the data obtained from the analyses of participants' argument quality based on the "Argumentation Quality Rubric".

Chart 1. Quality of Argumentation



The eight participants included in the study formed arguments on nine different socioscientific issues. According to Chart 1, pre-service teachers generally produced arguments of above average quality. Evaluation of arguments based on specific subjects shows that pre-service teachers produced better quality arguments on topics such as genetically modified organisms, stem cell and organ donation and global climate change, compared to others. Their arguments on cloning and euthanasia were found to be of moderate quality. Based on the examination of pre-service teachers' arguments, it was concluded that the argument quality of the participants P1, P3, P4, P6 was at a higher level with a more homogeneous distribution. P7 was found to produce low-level arguments.

It can be argued that no significant change was observed in participants' argument levels over time according to the interpretation of the data in Table 3 and Chart 1. However, when examined in the context of specific subjects, a qualitative difference was observed in the level of arguments. In addition, considering the components that make up the argument, it can be stated that the participants were partially more successful in presenting the argument components such as claim, data, justification and supporting points, but they were not as successful in presenting rebuttals.

4 | DISCUSSION & CONCLUSION

In this study, the results obtained through observation were categorized in terms of both quantity and quality. In terms of quantity, four different categories were obtained: "biotechnology", "health", "environment" and "energy". These categories were divided into some codes within themselves. It was concluded that the categories created were similar to some studies in the literature. (Demiral, 2014; Tekin, 2018)

When the category of "biotechnology" was examined, it was concluded that the participants generally dealt with scientific studies that closely affected living things. While the teacher candidates created many of the codes related to the biotechnology category related to the genetically modified organisms (f: 50) and cloning (f: 54) subjects, they created less code about the pandemic vaccine (f: 34) and stem cell (f: 30) In other words, it can be said that the participants reached more codes and frequencies in genetically modified organisms and cloning than other issues. This can be explained by the fact that genetically modified organisms and cloning issues are related to genetics and technology. In addition, it is thought that the fact that the participants took the biotechnology course one year (3rd grade) before experiencing the argumentation process within the scope of this study can be related to this result. When the literature is examined, it has been concluded that genetically modified organisms and cloning are often associated with biotechnology in some studies (Babacan, 2017; Tekin, 2018; Topcu, Mugaloglu, & Guven, 2014; Ture, 2018).

When the category of "health" was examined, it was concluded that the code mostly repeated by pre-service teachers was "expert opinion". Participants emphasized the importance of obtaining expert opinions on socioscientific issues with health content. Studies containing the code of expert opinion (Babacan, 2017; Demiral, 2014; Demiral & Turkmenoglu, 2018) are available in the literature. In addition, according to the observation records of the teacher candidates, euthanasia, medicine-alternative medicine, organ donation were discussed in the "health" category. It was noteworthy that teacher candidates approached the subject from a religious, moral and psychological point of view on health issues. This situation was reflected in the codes (Table 2).

When the category of "environment" was examined, it was seen that the codes created focused on the causes of environmental problems. It has been observed that the most repetitive code in the environmental category is the "danger" code. When the different socio-scientific issues covered in the environmental category are examined, it has been determined that these issues are space pollution and global climate change. When the literature is examined, it is seen that according to the researchers (Barraza, 1999; Ozsoy, 2012; Shepardson, Wee, Priddy, & Harbor, 2007; Ozata Yucel & Ozkan, 2014), the frequently repeated code in the environmental category is "pollution". For example, in the study conducted by Polat (2013), the word association test was applied to the students regarding the environment and as a result, it was concluded that the frequency of repetition of the pollution code was between medium and low levels. This situation may be related to the fact that the individuals to whom the research was applied may have been affected by local problems, and that the participants have different age levels and different levels of field knowledge. In the codes created within the scope of the environmental category, teacher candidates stated that man-made products, machines create a serious pollution and that high costs are required to solve this pollution. n other words, the impact of socioscientific issues on human, economy and nature has been revealed clearly in this part of the research. In the literature, it can be said that there are similar studies (Taspinar, 2011; Ture, 2018) expressing the effects of socioscientific issues on humans.

When the arguments formed by the teacher candidates about nuclear energy in their observation records were examined, it was thought that it would be more correct to evaluate the frequently repeated words in the "energy" category. When the codes created under this category were examined, it was observed that the opinions of the

teacher candidates and the content of the discussions on nuclear energy were generally negative. In the argumentation process, it was stated by the participants that the geography they are in and the people of the region will be exposed to more risks in case of a possible danger. It was thought that the region where the research was conducted could be effective in obtaining this result. As a matter of fact, it was seen in the classroom discussions that the participants had advanced knowledge about the nuclear power plant being built in the Akkuyu region of Mersin and so they offered various solutions. In some studies in the literature (Tonus, 2012; Ozturk & Leblebicioglu, 2015; Simmons & Zeidler, 2003; Walker & Zeidler, 2007), it has been stated that individuals are affected by environmental factors in their decision-making and argument-making processes. The mentioned environmental factors are listed in a more descriptive manner by Wiyarsi and Calık (2019). It was stated by the researchers that the geography, context and interaction with the participants in the socioscientific issues studies can affect the results of the study. In the studies of Kılınc, Boyes, and Stanisstreet (2012), there were results supporting this view. In the related study, data about nuclear power plants was collected from teacher candidates in Sinop, Mersin and Kırşehir. In the findings obtained from Sinop and Mersin, it was seen that the participants expressed more negative opinions against the nuclear power plant. This situation can be explained by the effect of environmental factors on research findings. In this category, it has been determined that repetitive codes are generally “risks, accidents” codes in the arguments formed by pre-service teachers. In the study conducted by Iseri (2012) with prospective teachers, it was aimed to measure the risk and benefit values in nuclear energy. As a result of the mentioned research, it was stated that the damage that nuclear power plants can cause to living life carries a very high risk. On the other hand, it has been stated that nuclear energy accidents cannot be compensated and in this case there is a high risk. Similarly, in the study conducted by Tekgoz and Ercan Yalman (2020), codes such as environment, health, risks and threats emerged while examining the opinions of science teachers about the nuclear power plant. In this context, it can be said that the codes emerging in the study are compatible with the literature. In addition, it is thought that the reason why the code that the teacher candidates often repeat is the "risks" in the study may be due to the accidents experienced in the past and the very high damage to the environment. Also, the teacher candidates offered solutions such as "safe waste storage" and "turning to alternative energy sources" despite the problems related to nuclear energy.

Different socioscientific issues were dealth with in the classroom for nine weeks in this study. However, although the topics differ every week, it has been observed that some codes and themes are similar and repeated (Figure, 1, 2, 3). For example, in the biotechnology category, the "test organisms" code is specified under four subjects (GMO, pandemic vaccine, cloning, and stem cell). Another example is that the "empathy" code in the health category is common in both euthanasia and organ transplantation. Based on this, it can be said that some socioscientific issues are related to each other. Socioscientific issues are open-ended situations, both scientific and social which include dilemmas. (Sadler, 2003). For this reason, it can be thought that it is a natural situation for the subjects to be interconnected. In the study conducted by Sadler (2003), it was stated that some socioscientific issues were related to the conceptual structure of science and technology.

After the findings regarding the argumentation process were discussed in terms of quantity, they were also examined qualitatively (Table 3 and Garphic 1). It was observed that the pre-service teachers could not form an argument by paying attention to all components. It has been observed that pre-service teachers are partially more successful in forming claims, evidence and finding support, but they are not very successful in the rebuttal part. In the relevant studies in the literature, it was stated that most individuals had difficulties in the refutational part in the argumentation process and could not complete all the components (Cirit Gul, & Apaydın, 2021; Erduran, Simon, & Osborne, 2004; Jimenez Aleixandre, Rodriguez, & Duschl, 2000; Kortland, 1996; Sahin Kalyon, & Tasar, 2020). In the study conducted by Kortland (1996), it was stated that the students directly supported the situations claimed about the current problems, and the participants were limited in presenting opposing claims and rebuttal. The researcher stated that this situation may stem from inexperience in forming arguments and their lacking of knowledge about socioscientific situations. Fakhriyad and Masfuah (2021) reported that participants can create scientific knowledge thanks to data and evidence in daily life and emphasized that the participants can be successful in argument components such as the claim, data, justification and supporting points for this reason. The findings of Fakhriyad and Masfuah (2021) can be used to explain the finding in this study that the participants were partially successful in the argumentation process in creating claims, evidence and finding supporting points. Similarly, inadequacies in presenting rebuttals can be explained by Kortland's (1996) aforementioned findings.

When the qualitative results about the argumentation process are handled in the context of the subject, striking results have been reached (Graphic 1). The components of the arguments created for the socioscientific issues which were selected according to the results provided by the teacher candidates are different from each other. It was concluded that teacher candidates formed better arguments on socioscientific issues such as global climate change, genetically modified organisms, nuclear energy, organ donation and stem cells, medicine-alternative medicine while they formed lower arguments on socioscientific issues such as space pollution, cloning, pandemic vaccination and euthanasia. Socioscientific issues are universal, scientific, social and current issues (Dawson & Venville, 2009). For this reason, it has been observed that in the face of socioscientific situations and problems that are more visible, in social media, news sources, and daily life, pre-service teachers produce more and more qualified arguments and can present more logical components. For example, while global climate change is a frequent issue in the media, space pollution is a socioscientific issue that is rarely covered. In addition, these research data were collected before the Covid-19 outbreak. For this reason, pandemic and pandemic vaccines did not appear in the media as much as today when the data were collected. Similarly, since euthanasia is prohibited in our country, it is possible that it does not take place in the media much. Participants' weak arguments on this issue can be attributed to the fact that these issues are less on the agenda. Therefore, it can be thought that there may be less knowledge about a topic which is less discussed on the agenda. There are no quantitative results that show the level of knowledge in a comparative way for each socioscientific issue in this study. As a result of the observations, it is, however, possible to observe that the participants have different level of field knowledge in different socioscientific issue. At this point, it seems reasonable to associate field knowledge with socioscientific issues with the level of argumentation. In other words, the level of argumentation can be shaped according to the field knowledge, and the field knowledge can be shaped according to the coverage of the subject in the media. In this direction, when the literature is examined, there are studies that support the above argument and conclude that argumentation levels vary according to socioscientific issues (Isbilir, 2010; Kutluca, 2012; Lee & Grace, 2012; Topcu, 2008; Walker & Zeidler, 2007). For example, in the study conducted by Evren Yapicioglu (2016), the opinions of the teacher candidates on socioscientific issues were evaluated. In the results, it was determined that teacher candidates benefited from the field knowledge in order to make decision in the face of a socioscientific problem. In the related study, it was stated that they should have knowledge in order to deal with such issues in the classroom discussion process. In another study, it was determined by Jime´nez-Aleixandre and Preiro-Munoz (2002) that more in-depth knowledge content rather than superficial knowledge is needed when making decisions within the scope of the argumentation process in the face of a socioscientific issue. Similarly, in the studies conducted by Maloney and Simon (2006), Roychoudhury and Rice (2009), Clark and Sampson (2008), Sampson and Clark (2011) and Acar (2008), it was stated that field knowledge was an important factor in the argument formation process. Osborne, Erduran and Simon (2004) and Demiral and Turkmenoğlu (2018) emphasized that having a good level of field knowledge supports the argument quality. Similarly, the study conducted by Cirit Gul and Apaydin (2021) concluded that the quality of the arguments and the skills of defining, explaining, analyzing and evaluating the arguments increase when the pre-service teachers have knowledge about the relevant argumentation process.

In general, no significant change was observed in pre-service teachers' argument levels over time. However, a qualitative difference was observed in the level of argument based on the context of the subject. Lack of a training process in this study in regards to argumentation may be the reason why pre-service teachers' argument levels had no significant change over time. According to the results of the data obtained from the research, suggestions for socioscientific issue practitioners and researchers are presented below.

- It can be said that education faculties have important responsibilities in order to train prospective teachers on socioscientific issues. In this context, it may be suggested to open specific field courses with socioscientific issues in relevant undergraduate departments of universities.
- Organizations such as panels, congresses, workshops can be organized to increase the field knowledge of teacher candidates.
- Data were collected from qualitative research approaches through observation in this study. Conducting studies with mixed methods in order to achieve stronger results may contribute to the literature.

- This study was carried out with 8 teacher candidates. Studies can be designed by changing the number of participants and collecting data from different samples.
- Only the observation technique was used as data collection tool in this study. Studies can be done using different data collection tools.

STATEMENTS OF PUBLICATION ETHICS

This research was reviewed by the Mersin University Social and Humanities Ethics Committee and it was decided that the research was ethically appropriate. Meeting date and ethical decision number: 26/08/2020-36.

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RESEARCHERS' CONTRIBUTION RATE

Authors	Literature review	Method	Data Collection	Data Analysis	Results	Conclusion
Aybike Gökçehan CENK	☒	☒	☒	☒	☒	☒
Feride ERCAN YALMAN	☒	☒	☒	☒	☐	☒

CONFLICT OF INTEREST

There is no conflict of interest in the study.

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ANNEX 1.

Argumentation Quality Rubric (Sadler *ve Fowler, 2006)*

Score	Explanation
0	Invalid claim
1	Groundless reasoning
2	Simple reasoning
3	Detailed reasoning
4	Detailed reasoning and counter argument