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Exploring Pre-Service Primary School Teachers' Informal Reasoning and Argumentation Levels on a Socio-Scientific Issue: The Issue of Transgenic Plants in the Agriculture*

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Abstract

The study aims to investigate pre-service primary school teachers' decision making modes, informal reasoning modes and argumentation levels on a socio scientific issue. The issue of transgenic plants was chosen as s socio-scientific issue. In the content of the study, the case study method which is one of qualitative research methods was used to investigate pre-service primary school teachers' decision-making modes, informal reasoning and argumentation levels. The participants of this study were 38 pre-service primary school teachers attending the faculty of education in a government university. The findings of the study shows 4 different results. The first one is that the participants make decisions on a socio-scientific subject they may come across with in daily life based more on intuition rather than in an evidence-based manner. The second result is that the argumentation levels are low. The third important result is that the participants think in a one-dimensional manner on a subject they need to approach in a multi-dimensional manner. The fourth important result is that the participants experienced applying the knowledge they obtain in their lessons to events they came across with in daily life.

Keywords: Socio-sicentific issue, transgenic plants, pre-service primary teachers, informal reasoning, argumentation

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Introduction

DeBoer (2000) summarized the aims of science education and stated the aim of teaching and learning about science connection with everyday living is particularly important. According to this aim, students should be informed citizens who can deal with socio-scientific issues and understand the influence and importance of these issues on society. Also, Ryder (2001) stated that science education aims to enable individuals to discuss and make decisions about daily issues that require scientific information. These statements about the purposes of science education are related to scientific literacy. Scientific literacy has become one of the most important and internationally well-known science education goals (Millar, 2006; Ryder, 2001). The term of scientific literacy has been used since the late 1950s (DeBoer, 2000). Although there is no definition which has been agreed upon, Ryder (2001) stated that the term has been used as being synonymous with "public understanding of science." According to National Research Council (1996), scientific literacy means that individuals ask questions, search for the answers of these questions about everyday events they meet. A scientific literate person can recognize the scientific issues in daily life and understand national and local decisions about these issues. According to Norris and Philips (2003) and Laugksch (2000), a scientific literate person has the ability to use scientific information while solving problems and being informed about science-based social issues. Environmental issues, energy problems, alternative energy discussions, issues in genetic research can be identified as socio-scientific issues and these issues are important in the society.

Kolsto (2001) and Sadler (2004) stated that dealing with socio-scientific issues has been one of the most important components of scientific literacy. Wu and Tsai (2007) identified socio-scientific issues as social dilemmas which have connections with science. Sadler (2004) and Sadler and Zeidler (2005) stated that socio-scientific issues are open ended, contentious and ill structured problems. Due to the mentioned characteristics of socio-scientific issues, individuals make use of informal reasoning process when they are trying to solve these problems (Dawson, 2009). In informal reasoning process, argumentation skills are very important. Means and Voss (1996) and Shaw (1996) stated that generating and evaluating arguments are the main parts of informal reasoning. In general, logic and formal reasoning which is defined through the rules of mathematics come to the mind when scientific reasoning is mentioned (Wu, 2013). But Zohar and Nemet (2002) stated that informal reasoning is a reasoning outside the formal structure of mathematics and logic. In formal reasoning the problems are well-structured which have explicit premises and only one correct answer. But the process in informal reasoning is not clear. The pre-knowledge and beliefs of individuals affect their approach towards the subject. Therefore, suggestions of solution which are presented as a result of informal reasoning vary from one person to another.According to Sadler (2004) and Wu and Tsai (2007), students practice informal reasoning while trying to solve a socio scientific problem. Also, while discussing about a socio-scientific issue, students share scientific information about the issue (Osborne, Erduran, & Simon, 2004a). Since socio-scientific subjects are complex and multi-dimensional, there is no single solution. Therefore, informal reasoning is used to solve problems related to these areas.

The argumentation process can foster students' scientific thinking and reasoning in the process and help students to use multiple-perspectives while evaluating an issue (Osborne, Erduran, & Simon, 2004). There are some studies in the literature which focus on argumentation approach in science education (Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002; Zohar & Nemet, 2002). The researchers (Von Aufschnaiter, Erduran, Osborne, & Simon, 2008; Duschl & Osborne, 2002; Zohar & Nemet, 2002; Driver, Newton, & Osborne, 2000; Newton, Driver, & Osborne, 1999) state that the argumentation process in science education is a requirement since individuals meet scientific debates in everyday life and they need to make decisions about these debates, the individuals should evaluate the data, search for the information and to create scientific arguments.

Toulmin (1958) identifies argument as an introduction of claims and justifying these claims (Zohar & Nemet, 2002). Toulmin (1958) proposed an argumentation model and the elements of the arguments in the model are claims, data, warrants, backings, qualifiers, and rebuttals (Von Aufschnaiter, Erduran, Osborne, & Simon, 2008). The main components of Toulmin's argumentation model are summarized through the literature(Cross, Taasoobshirazi, Hendricks, & Hickey, 2008; Driver, Newton, & Osborne, 2000) as below:

(a) **The claim** is a conclusion, a hypothesis, or an idea.

(b) **Data** are the facts which the claim.

(c) **The warrant** is a bridge between the data and the claim. It explains how the data supports the claim. The warrant explains the reasons (rules, principles, etc.).

(d) **The backing** is an assumption which is used to help to justify warrants.;

(e) **Rebuttal** provides evidence to disprove the presented other claims, or it displays the conditions when the claim will not be true.

(f) **Qualifier** displays the limitation of the claims; it shows under which conditions the claim can be accepted as true.

In several researches the findings displayed the positive effects of argumentation process on students' informal reasoning, scientific inquiry abilities and science learning (Zohar & Nemet, 2002; Jime´nez-Aleixandre, Bugallo, & Duschl, 2000; Jime´nez-Aleixandre & Pereiro-Munhoz, 2002; Leach, 1999; Mason, 1996; Kelly, Drucker, & Chen, 1998; Osborne, Erduran, & Simon, 2004; Zohar & Nemet, 2002). Also, argumentation process helps students to develop their scientific literacy (Demirbağ & Günel, 2014; Akkus, Gunel, & Hand, 2007).

Individuals' having knowledge about the socio-scientific issue they come across with in daily life and being able to produce solution suggestions about the problems related to these areas are the most important purpose of science education today. Therefore, it is extremely important that teachers who will be educating the students of the future are aware of socio-scientific subjects and produce solutions to these problems. The analysis of the informal reasoning skills of teachers while analyzing a socio-scientific subject and their argumentation levels will contribute to the literature. In this study, the informal reasoning processes and argumentation levels of teacher candidates on transgenic plants were analyzed. The developments which took place in the area of genetic engineering in the recent years have brought the discussions in this area with them. In agriculture, transgenic plantsis one of the current and discussed subjects. Ambiguities, discussions and contending ideas about the subject have turned it into a current socio-scientific subject. Questions such as, "Are transgenic plantsgoing to be a solution to the production pressure put on agriculture due to reasons such as the increasing population of the world, changing world population and decrease in the number of agricultural areas?" "Or do we know what kind of effects transgenic plants are going to have on the ecosystem in the long-term?" are being discussed. Due to the high popularity of the subject in question, it was aimed for teacher candidates to study the subject and increase their knowledge and use their informal reasoning and argumentation skills. In the study, the participants' informal reasoning analyzed by using an integrated framework developed by Wu and Tsai (2007) for analyzing an individual's informal reasoning on an SSI. This framework was used together with a framework developed by Osborn, Erduran and Simon (2004) for analyzing argumentation levels. The details of the mentioned frameworks are described in the method section.

The aim of the study

The study aims to investigate pre-service primary school teachers' decision making modes, informal reasoning modes and argumentation levels on a socio scientific issue. The issue of transgenic plants was chosen as s socio-scientific issue. In line with the purpose of the study, the answers to the following research questions were sought:

Research problems

1.What is the decision-making modes of the participants related to the transgenic plants? Intuitive or evidence-based?

2. Did the participants change their positions following to the application?

3.Following the application, did the intuitive and evidence-based decision-makers change their decisions?

4.What kind of reasoning modes did the participants use?

5.What is the argumentation level of the participants?

6.How do reasoning modes change in accordance with the argumentation levels of the participants?

Method

In the content of the study, the case study method which is one of qualitative research methods was used to investigate pre-service primary school teachers' decision-making modes, informal reasoning, and argumentation levels. This method is used when in-depth explanations of a situation and a behavior required. In the content of the class, the instructor taught Toulmin's argumentation model and the application of the model. For the issue of the argumentation application the subject of transgenic plantswas chosen, since it was a socio-scientific issue and the argumentation model was one of the best methods to teach socio-scientific issues.

The samples

The participants of this study were 38 pre-service primary school teachers attendingthe faculty of education in a government university. The participants were 3rd year students and the application conducted in Science and Technology Teaching Class in 2017-2018 Academic Year, Spring Term. The samples were determined by incidental sampling method.

Data Collection Tools

For the purposes of the study, prior to the application, an open-ended question was asked to determine the decision-making modes of the participants' related to the issue of the usage of the transgenic plants in agriculture. Thequestion was "Do you agree with using transgenic plants in the agricultural applications?" To investigate the participants informal reasoning modes, and argumentation levels, a scenario was written. The scenario narrated an interesting dilemma which was an everyday-related event.

Information about the scenario

Ayşe, one of the main characters in the scenario is a graduate student working on transgenic plants. And the plant she works on is cotton. It is not a coincidence that the cotton plant is selected while the scenario is being prepared. Most of the participants live in the provinces of Adana, Kahramanmaraş, Hatay and Antep, and the cotton plant is an important plant for the regional economy. It is thought that the interest of the subject will be increased by selecting a sample from the lives of the participants. In addition, a master student and her roommate are mentioned in the case. By telling the story through the life and work of a student, a story which is closed to the participants' lives was created.

The scenario starts with a brief information about Ayşe and Ayşe is urgently called by her supervisor and he tells her to come to the laboratory urgently. When she goes to the campus, she sees that the greenhouse and laboratory near the greenhouse was broken into last night by GMO opponents. The scenario continues to describe Ayşe's sadness over this situation and her positive views on the GDO. Ece is the one who advocates anti-GMO views. The event brings together the thoughts of GMO supporters and the thoughts of their opponents, thus the

participants need to think about the situation and make decisions. But of course, it is not easy. And at the end of the scenario, 4 open ended questions are posed to the students to make a choice and defend this choice.

The open-ended questions posed to the participants

Please answer the following questions If you think like Ayşe…./If you think like Ece….

1. Do you agree with the using GMO germs in agriculture? Why? (This question was the same with the one asked prior to the application . The aim of this question was assessing the participants' possible position change on the usage of GMO germs in agriculture.)

2. If you want to convince your friend Ece with your position, what arguments you will propose to convince him/her? (Evaluating students' ability to generate supportive arguments for their positions.)

3. Ece holds an opposite position with you on this issue, what arguments she may have? (Assessing students' ability for counterargument construction.)

4. According to the arguments you have proposed in question 3, can you write down your opposing ideas to justify your position? (Evaluating students' ability for rebuttal construction.)

If you think like Ece...

1. Do you agree with the using GMO germs in agriculture? Why? (This question was the same with the one asked prior to the application . The aim of this question was assessing the participants' possible position change on the usage of GMO germs in agriculture.)

2. If you want to convince your friend Ayşe with your position, what arguments you will propose to convince him/her? (Evaluating students' ability to generate supportive arguments for their positions.)

3. Ayşe holds an opposite position with you on this issue, what arguments she may have? (Assessing students' ability for counterargument construction.)

4. According to the arguments you have proposed in question 3, can you write down your opposing ideas to justify your position? (Evaluating students' ability for rebuttal construction.)

The procedure

Preparations made prior to the application

The researchers wrote a scenario suitable for the subject. The prepared scenario was designed to get the participants involved in the selected topic. So, the participants can conduct discussions in accordance with the argumentation process. Following to the scenario, 4 open ended questions were posed to the participants to develop arguments. Through the questions, it was aimed to investigate the participants' decision making modes, informal reasoning modes, and argumentation levels. A pilot application was designed to make the participants familiar with the application and to gain experience with how the argumentation process worked.

Introducing the process

In the content of the class, the instructor taught Toulmin's argumentation model and the application of this model. The components described in Toulmin's argumentation model were explained to the students with examples of how an argument should be, what components it should contain, how to develop claims, data, warrant, backing and rebuttals. This phase was carried out within 3 hours.

Pilot application

The scenario selected for the pilot application was distributed to the participants and the participants were requested to answer the questions following the scenario. The participants'

arguments were written on the board and the participants discussed the arguments. The written arguments were examined in terms of their components. Thus, the points that the students should pay attention to in the actual application are drawn attention and they become ready for the application. This phase was carried out within 3 hours.

The application process

Step 1. First, the participants were asked to write down whether they agreed with using transgenic plants in agriculture (yes or no) and how they decided (intuitively or evidence-based).

Step 2. Then, the participants were informed about genetically modified organisms and transgenic plants. Advantages and disadvantages were mentioned, only objective information is given.The subtitles about the lecture are given below:

- What is the gene?
- What is gene transfer?
- Techniques used in gene transfer
- Recombinant DNA technology
- What is genetically modified organism?
- What is transgenic plant?
- Application of gene technology in agriculture
- Application of gene technology to animals

Step 3. Following to the lecture, the scenario about transgenic plantswas distributed to the participants and finally, the participants were asked to respond to the following questions and wrote down their answers. They were allowed to use internet to search for the issue and get additional information. The participants were completed the application in 3 hours.

Data Collection and Analysis

To get information about the participants' decision making modes and reasoning modes on a socio-scientific issue (in this study: transgenic plants in agriculture)particular parts of the framework developed by Wu and Tsai (2007) was used.The framework was given below.

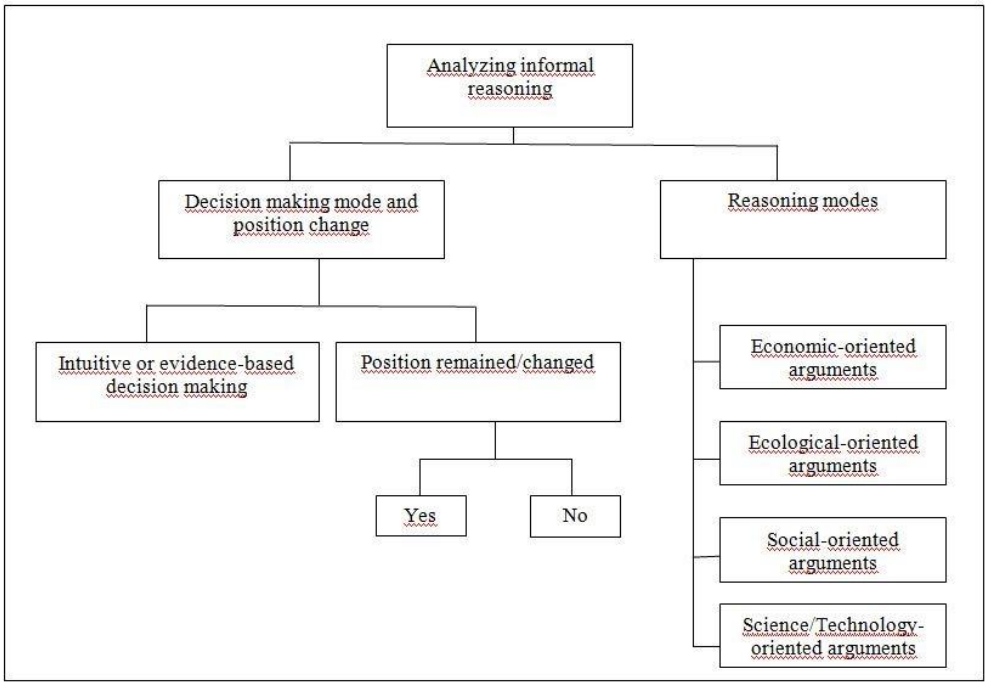

Figure 1. Framework for analyzing informal reasoning (adapted from Wu and Tsai, 2007).

Investigating the participants' decision making modes

In this study, the participants' decision-making modes were divided into two categories, intuitive and evidence-based. Learners may be more oriented to make their decisions intuitively, or, they may make evidence-based decisions on a socio-scientific issue. The number of the intuitive thinkers and evidence-based thinkers were determined. Firstly, the responses of the participants towards the first question which was asked prior to the application examined. The initial position of the participants about transgenic plants and how they decided (intuitively or evidence-based) were determined through analyzing the responses.

Investigating the participants' informal reasoning modes

The participants could construct their arguments by considering different perspectives, such as "social-oriented", "ecological-oriented, "economic-oriented", and "science-oriented or technology-oriented" perspectives. The amount of social-oriented arguments, ecological-oriented arguments, economic-oriented arguments, science-oriented and technology-oriented arguments constructed by the participants were determined. The characteristics of informal reasoning modes were summarized as below (Wu and Tsai, 2007):

- The more social-oriented arguments an individual learner generate, the more he/she was oriented to reason from social-oriented aspects. For example, s/he constructs an argument by considering human welfare.
- The more ecological-oriented arguments an individual learner proposes, the more he/she tends to reason with ecological-oriented care.
- The more economic-oriented arguments an individual learner generates, the more he/she is oriented to think with economic considerations.
- The more science-oriented or technology-oriented arguments an individual learner proposes, the more he/she is prone to reason from science-oriented or technology-oriented perspectives as well as he/she is more able to apply what they have learnt in science classrooms. Their reasoning is based on the applications and strength of the technology and science.

Investigating the participants' argumentation levels

Following to the application, the responses of the participants towards the 4 open –ended questions were analyzed. The responses of the participants were coded with the components of "claim", "data", "warrant", "backing" and "rebuttal" according to Toulmin's argumentation model. The level of argumentation of the participants was determined based on the framework of argumentation level model developed by Osborne, Erduran and Simon (2004).

Table1. Analytical Framework developed by Erduran et al. (2004) used for Assessing the Quality of Argumentation

Level 1 argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim.
Level 2 argumentation has arguments consisting of a claim versus a claim with either data, warrants, or backings but do not contain any rebuttals.
Level 3 argumentation has arguments with a series of claims or counter-claims with either data, warrants, or backings with the occasional weak rebuttal.
Level 4 argumentation shows arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims.
Level 5 argumentation displays an extended argument with more than one rebuttal.

For the reliability of the data analysis, the participants' arguments were coded by two researchers. After the independent coding was completed, the differences were examined and the reasons for the differences were discussed. The difference codings were showed to an expert in the field and the codings were re-organized.

Findings

In this section, the analysis of the participants' answers to the questions asked prior to the application and their argumentation and the questions in the applications are given place to.

Students' decision-making modes and position change.

Prior to the application, the students were asked whether they support use of transgenic plants in agriculture and to explain the reasons for their answers. After the application, the same question was posed to the participants again. The findings obtained from the answers of the participants to the question are given in Tables 2, 3 and 4.

In Table 2, information related to whether there has been a change in the decisions of the students' decision-making modes prior to and after the application is presented.

Table 2. Participants' decision making modes and position change

		N	%
Decision making modes	Evidence-based	8	21,1
	Intuitive	30	78,9
Position change	No	24	63,1
	Yes	14	36,9

As revealed in Table 2, most of the participants (78,9%) were found to make intuitive decisions. Table 1 also displays that about 37 % of the participants changed their decision following to the application.

In this study, the researchers further explored which group of the students (the evidence-based thinkers or intuitive thinkers) were more oriented to change their positions. The change in the students' position according to the decision making modes are shown in Table 3. The evidence-

based and intuitive decision makers' positions before and following to the application were compared and the results were displayed in Table 3.

Table 3. Participants' position change between different decision-making groups

	Decision-making mode			
	Evidence-based		Intuitive	
	N	%	N	%
Position remained	7	87,5	17	56,6
Position change	1	12,5	13	43,4

The results displayed that 87,5 % of the evidence-based thinkers' position remained the same, and only 12 % of them changed their decisions after the application. But compared with the evidence-based thinkers, the participants who made intuitive decisions were more oriented to change their positions, 43,4 of them changed their decisions after the application.

Students' usage of different reasoning modes.

The mean scores of the number of ecological oriented, economic-oriented, social-oriented, and science/technology-oriented arguments proposed by the participantswere displayed in Table 4.

Table 4. Participants' usage of different reasoning modes

	N	Mean	Std. Deviation
Ecological-oriented	38	5,34	3,55
Economic-oriented	38	1,76	1,74
Social-oriented	38	0,31	0,61
Sci./Tec. oriented	38	0,44	0,97

The results presented in Table 4 show that the participants in this study, on average, proposed 5,34 "ecological-oriented" arguments, 1.76 "economic-oriented" arguments, 0.44 "science/technology-oriented" arguments, and 0.31 "social-oriented" arguments.

Examples of ecological-oriented arguments proposed by the participants

"Plant sociology is degraded in the environment where transgenic plants are planted, which leads to the disappearance of some species."

"I think that GMO crops in agriculture will negatively affect natural life and human health."

"Biological diversity will be affected negatively."

"The main enemy of the environment is not transgenic plants; the main enemy is pesticides".

"Biotechnology reduces the use of herbicides and pesticides. Thus, it helps to reduce environmental pollution and health problems".

"The rich flora is replaced by a homogeneous flora."

"During pollination season, the transgenic plants will overtake other species and begin to destroy biodiversity."

"The original plants are replaced by GMO plants in time, so we cannot find a genuine breed soon".

Examples of economic-oriented arguments proposed by the participants

"Agricultural products wait until they are sold, their durability decreases during this waiting period and this is a marketing problem".

"It makes the country dependent on the other countries (who sell the GDO-seeds), because the GMO seed cannot germinate again".

"Only 3-5 international companies produce GMO seeds in the world, this will make the farmer dependent on these companies economically".

Examples of science/technology-oriented arguments proposed by the participants

"It is a technology that can be effective in the treatment of certain diseases that threaten life".

"Allergic aspects can be eliminated by altering the structure of foods which cause allergic reactions such as nuts, wheat, soy bean ".

"The damage of the viruses created in the labs is unknown, and here the current technology may not be able to prevent possible damages".

"Synthetically synthesizing insulin from bacteria with GMO technology is a great scientific achievement".

Examples of social-oriented arguments proposed by the participants

"The problem of hunger and poor nutrition which is one of the most serious problems of public health can be solved by increasing harvest production and enriching nutritional content of the seeds".

"The privatization of DNA which is, a material belongs to all humanity, creates concern."

"How many countries in terms of development can produce transgenic plants?"

"Countries that produce GMO crops can use this blackly."

"The foods with GDO can be used for vaccination, and many children in poor countries can be vaccinated".

"Even if the conditions of life initially improve, it may worsen later".

The argumentation levels of the participants

The argumentation levels of the participants were determined by using the framework developed by Erduran and et al. (2004) and the findings were displayed in Table 5.

Table 5. The argumentation levels of the participants

Argumentation Level	Frequency	%
1	4	10,5
2	18	47,4
3	9	23,7
4	5	13,2
5	2	5,3
TOTAL	38	100

Table 5 showed that only 5,3% of the participants could produce 4th level arguments. Almost

half of the participants (47,4 %) were able to produce level 2 arguments. This finding suggested that participants could provide a data, warrant, or backing in response to a claim, but could not create rebuttals. This finding was supported by the fact that the number of the rebuttals given in Table 5. Only 23.7% of the participants propose level 3 arguments.

It was remarkable that the number of participants in Level 4 and Level 5 was low. Due to the weakness of the participants ' scientific process skills and inquiry skills, it was thought that the number of students at this level was low. The inadequacy of the activities that lead participants to thinking, discussing and researching during the learning process also hamper the development of these skills.

Examples of Level 1 argumentation

Student 52: I'm not for it (claim). Ecological balance can be upside down (claim).

Student 40: No, I'm against (claim). It could be a dangerous experiment on our world and on the living things(claim).

Examples of Level 2 argumentation

Student 6: I'm not for it (claim). Transgenic plants threaten human health (data). The studies show that through these technologies, organisms can emerge that can be used as biological weapons (data).

Student 12: I'm against it (claim). The seed created are infertile, they can be used only once, and following year it is necessary to buy seeds again (data).

Examples of Level 3 argumentation

Student 48: "I'm for it (claim). Because the population of the world is increasing day by day (warrant). One of the most basic needs of people is nutrition(data). For this reason, something must be done to meet the increased nutritional needs (warrant). It is not possible to increase the places to be planted significantly (data). Since water resources are also seriously diminishing, GMOs provides a solution to increase harvest".

Student 22: "I'm not for it (claim). Environmental sociology is degraded in the area where transgenic plants are planted (data). Some species disappear (backing). GDO foods cause the formation of unexpected metabolic products in the living organisms (data); because new and unrecognized genes are perceived as threats to the organism (warrant).

Examples of Level 4 argumentation

Student 29: "I'm for it (claim). The main enemy of the human health is agricultural chemicals (data). Because herbicides and insecticides are given to the plant to kill harmful insects and plants, they pass through the human body without being eliminated (warrant). They claim that it is enough to keep normal agricultural products to be purified from chemicals, but the products are decaying during this wait (rebuttal). In addition, the use of transgenic plants will reduce the use of herbicides and pesticides, as well as environmental problems (backing) ".

Student 61: "I'm not for it (claim). Plants that are resistant to agricultural pests can be seen as an advantage at first glance, but in the future, they will endanger the species with the infertile seeds (rebuttal). Because, the original plants are replaced by GMO crops (warrant). So, in a short time the original species will be run out of (backing). Antibiotic resistance genes are used during gene transfer (data). This is also a problem, because humans develop resistance to antibiotics (warrant). A famous UK food producer forbid the use of GMOs in its production lines(backing).

Examples of Level 5 argumentation

Student (57): "GMO is not a good thing (claim). Plant sociology is degraded in the environment where transgenic plants are planted (data); because these plants cause some species to be

destroyed (warrant). This will affect plant evolution in a negative way (backing). In transgenic plants, genes are transferred to the gene pool and these genes cause severe allergic reactions (data). For GMO plants, the farmers don't use insecticides to kill the insects, for example, the transferred gene to the corn poisons the beetles (data). However, after a while the insect will become resistant to the poison (rebuttal). EU countries forbid transgenic plant production and imports in 1998 (data).People say that the people do not get enough nutrients in poor countries, for this reason, the nutrients enriched with vitamins and minerals, such as gold rice, can solve many health problems in these countries. However, these seeds are produced by large companies, and since the seeds are infertile, the farmers have to buy seeds every year, which makes the farmer dependent on the seed company (rebuttal)".

Student (13): "I'm not for it (claim). GMO is a biodiversity and a human-environmental health problem (claim). It interferes with biodiversity and damages it (data). Because, while transferring a gene from an organism to another, the desirable features are transferred as well as undesirable ones (warrant). Although, they claim that all the features are known, the effects on humans and animals consuming these products are complex and will emerge over time (rebuttal). It is a problem, because there is no resource limitation while getting genes for transfer (backing). Evidently, it is not possible to know certainly the structural changes that will occur in the organism because of the transferred genes from different species (backing). It causes health problems in humans (data), because the pathological, carcinogenic and allergic effects of the transferred genes are not known yet (warrant). Gene transfer is done to make the plant resistant to drought, to protect it against harm, to make it resistant to disease, but what effects it will have on the human organism has not yet been identified yet (rebuttal). It causes environmental problems (data); because it increases the resistance to the chemicals (warrant). Causes socio-economic problems (data); because the seeds produced are patented (warrant). Biotechnology giants such as Monsanto, Dupont et al. are holding back the GMO market (backing).

Although all the characteristics transferred are known, the effects on humans and animals consuming these products are complex and will emerge over time (rebuttal).

Ask, because there is no resource limitation on the transferring genders (backing). Evolutionally, it is not possible to know for certain the structural changes that will occur in the organism from which the genes from the living beings at the different points are transferred (backing). It causes health problems in humans (data), because the pathological, carcinogenic and allergic effects of transferred genes are still unknown. Gene transfer is done to make the plant resistant to drought, to protect against harm, to make it resistant to disease, but what effects it will have on the human organism has not yet been identified (rebuttal).

The reasoning modes used by the participants according to their argumentation levels are presented in Table 6.

Table 6. Students' usage of different reasoning modes between different argumentation levels

Level		ecologic	economic	social	scientific
1,00	Mean	5,00	0,00	0,25	0,00
	N	4	4	4	4
	Sd	2,16	0,00	0,50	0,00
2,00	Mean	4,38	2,38	0,38	0,27
	N	18	18	18	18
	Sd	3,68	2,14	0,69	0,75
3,00	Mean	6,44	1,44	0,22	0,66
	N	9	9	9	9

	Sd	3,77	1,01	0,66	1,00
4,00	Mean	5,40	2,00	0,20	0,40
	N	5	5	5	5
	Sd	2,30	0,70	0,44	0,89
5,00	Mean	9,50	0,50	0,50	2,00
	N	2	2	2	2
	Sd	4,94	0,70	0,70	2,82

While the participants who produced arguments in the first level came up with 5 arguments based on ecology and were not able to produce other argument types. The participants who produced arguments in the second level produced ecological arguments the most (M=4,38). While the average of ecological arguments in the second level is 2,38, the number of social and scientific arguments per person is less than 1. The participants who produced arguments in the third level produced ecological arguments the most (M=6,44). While the average of ecological arguments of the participants in the third level is 1,44, the number of social and scientific arguments produced per person is less than 1.The participants who produced arguments in the fourth level produced ecological arguments the most (M=5,40). While the average of ecological arguments of the participants in the fourth level is 2,00, the number of social and scientific arguments produced per person is less than 1. The participants in the fifth level also produced ecological arguments the most (M=9,5). The average of economic and social arguments of the participants in the fifth level is less than 1, whereas the average of scientific arguments per person is 2,00. When the reasoning modes produced in society are analyzed, the arguments produced per person is 5,34 for ecological arguments, 1,76 for economic arguments, 0,31 for social arguments and 0,44 for scientific arguments.

Results and Discussion

When the answers given to the question "Do you support the use of transgenic plants in agriculture? Why?" asked to the participants prior to the application were analyzed, it was seen that 78,9% made intuitional decisions. This shows that a majority of the participants use their intuition rather than scientific evidence while making decisions. The participants need to use their knowledge and not their intuition when making decisions on transgenic plants. All of the participants expressed a view about the subject. None of the participants stated that they did not have sufficient knowledge on the subject to make a decision. This finding Show that the participants are not able to think scientifically on a subject which may directly affect them in their daily lives. The participants of the study are classroom teacher candidates. It is expected from these teachers to teach their students to interpret scientific information and use it in daily life. It is concerning that a majority of the participants who will be teachers in the near future are intuitive thinkers. The purpose of science education is to make it possible for individuals to be educated as scientifically literate. What is expected here is for the students to be able to transmit their knowledge to their daily lives and use when necessary. The teacher candidates who participated in the study are students who have taken physics, chemistry and biology lessons. They regarded themselves as sufficient in terms of transgenic plants and stated their views prior to the application. However, it is apparent that from a majority of the participant being intuitive thinkers that their scientific knowledge does not have an effect on their decisions about transgenic plants which is a socio-scientific subject. In a similar study, Wu and Tsai (2007) studied high school students' informal reasoning on nuclear energy and determined that approximately one quarter of the participants were intuitive thinkers. They stated that since rational thinking is very important, science educators should pay attention on how students make decisions on a socio-scientific issue.

When it was analyzed whether there has been a change in the decisions of the participants who

made intuitive and evidence-based decisions after the application, it was seen that those who made decisions based on evidence changed their decision in the rate of 12,5%, whereas this rate was 43,4% for those who made intuitive decisions. This finding displayed that, compared with the evidence based thinkers, the participants who made intuitive decisions in this study were more oriented to change their positions after the argumentation application. This shows that the decisions of intuitive decision makers are more variable. However, in Wu and Tsai's (2007) study in which they analyzed the informal reasoning of students on nuclear energy, they found that evidence based thinkers when compared with the intuitive decision makers were more oriented to change their decisions.

Prior to the argumentation application, the participants were given information on genetics and GMO and the participants did their own research during the argumentation application. Since the participants who made decisions based on evidence having some knowledge on the subject and making decisions using this knowledge, it is considered that the rate of changing their decisions for evidence-based thinkers is low. It is possible that they based their decisions on the new knowledge they acquired after they had some knowledge about the subject and that they change their decisions accordingly. Taking this finding as the starting point, the effect of teaching methods used in science education need to be discussed as well. Although the effects of teaching methods in which the students do research, discover information and structure this information are known, still methods based on traditional knowledge transfer are used. Unfortunately, teachers have a tendency to use didactic methods which require them to spend less energy. In this study, the science learning method based on argumentation was used and the subject on transgenic plants and their use in agriculture was taught. The findings of the study show that the students changed their decisions and that their new knowledge was effective in changing their decisions. In the light of this finding, it can be stated that a teaching process in which the students learn by doing research and questioning is effective to enable the students to apply what they have learned to daily life in science education and make healthy decisions about the socio-scientific subjects they came across with.

The participants' reasoning modes were analyzed under the categories of ecological-oriented, economic-oriented, social-oriented and science/technology-oriented arguments. The categories in question show how the participants approached the subject and their view points. When the arguments presented by the participants were analyzed, it was seen that they produced ecologic-oriented arguments the most (M=5,34) and economic-oriented arguments take the second place (M=1,76). The number of social and science/technology-oriented arguments per person is less than 1. The participants proposed relatively less social-oriented and science/technology-oriented arguments. Similarly, the participants in Wu and Tsai's (2007) study proposed relatively less science/technology oriented arguments and the authors stated that the participants may not make connections between what they learnt in science classes and the socio-scientific issues which theyencountered in their lives. The findings of the study concurred with those by Wu and Tsai (2007), Sadler and Zeidler (2005), and Yang and Anderson (2003).The use of transgenic plants in agriculture is not only a subject which has an ecological dimension. It also has economic, social and scientific dimensions. However, it was seen that the participants think in an ecologic-oriented manner about the subject in general. This shows that the participants were unable to form a connection between their knowledge on the subject and daily life, economy and technology. This also shows that the participants focused only on the ecology related part of the subject and were weak in terms of doing research on its relationship with other areas. It can be stated that the participants had a narrow approach while doing research on a multi-dimensional and complex subject in general and continued their research within this narrow scope. For the participants, argumentation based approach for learning science is a new method. Since the participants are familiar in general with the didactic teaching method, it is not possible to guide them towards doing research and develop their questioning skills using a single method.

Within the analytical framework developed by Erduran and et al. (2004), the participants

argumentation levels were determined. The findings show that only 5,3% of the participants were Level 5 and 13,2% of the participants were Level 4. 10,5% of the participants were able to produce arguments in Level 1 and 47,4% produced arguments in Level 2. The findings show that more than half of the participants were able to produce arguments in Leve 1 and Level 2. Similarly, Wu and Tsai (2007) reported the 62 % of the participants in their study were categorized as lower reasoning level. While determining the argumentation levels produced by the participants, it is analyzed whether the participants were able to support their arguments with one or more data, produced counter arguments and presented refutations for these arguments. The participants' low level of argumentation shows that either they do not have knowledge or they cannot form a connection between the knowledge they have, cannot form a connection between their knowledge and daily life and interpret their knowledge. This low level of argumentation may be related to a majority of the participants being intuitive thinkers. Since intuitive thinkers produce arguments without using scientific knowledge, they do not feel the need to prove their arguments using various data.

It was seen in the findings that a majority of the participants produced an argument but did not prove these with data. When the reasoning models used by the participants in terms of their argumentation levels were analyzed, this finding was supported. The participants who produced arguments in Level 1 produced5 ecologic-based arguments but were not able to produce the other argument types. On the other hand, participants in Level 2 produced ecologic arguments the most as well (M=4,38), however they produced economic arguments too (M=2,38). The number of social and scientific arguments produced in Level 2 per person is still less than 1. A similar case is valid for those in Level 3. The participants in Level 5 produced ecologic arguments the most as well (M=9,5). The average of social arguments produced by the participants in Level 5 is less than 1 and the average of scientific arguments produced per person is 2,00. With the exception of the participants in Level 5, scientific/technological arguments were not produced in the other levels. The low number of scientific/technological arguments produced by the participants in concerning. Wu and Tsai (2007) in their study reported that the scientific and technological arguments produced by their participants on nuclear energy is very low. The low number of scientific and technological arguments displays that the participants could not make connections between what they learnt in science classes and a socio scientific issue that they encountered. According to Kolsto (2001), the aim of science education is to develop students' informal reasoning and decision making abilities on a controversial issue.When the participants argumentation levels and the reasoning modes were evaluated together, it was seen that the participants' argumentation levels are low and that they approach events in a one-dimensional manner. It can be stated that as the participants' argumentation levels increase, they use different types and number of reasoning modes.

The findings of the study shows 4 different results. The first one is that the participants make decisions on a socio-scientific subject they may come across with in daily life based more on intuition rather than in an evidence-based manner. Socio-scientific subjects are areas which need to be thought in a multi-dimensional manner in the decision making process due to their nature. In order to be able to decide on these subjects, individuals need to interpret the knowledge they have and use their knowledge to support their arguments. However, the participants did not use their knowledge on a popular socio-scientific subject they can come across with in their daily lives. The second result is that the argumentation levels are low. It is considered that this result is related to a majority of the participants being intuitive thinkers. Individuals who make decisions based on intuition, do not use data while making decisions. This means that there are there are no data and no components needed for a high level of argumentation such as reason, support and refutation. The third important result is that the participants think in a one-dimensional manner on a subject they need to approach in a multi-dimensional manner. The results of the study show that the inquiry and reasoning skills of the participants who will be the classrooms teachers in the future are now very developed. Students start taking science lessons for the first time in the 3rd grade in primary school. Supporting

meaningful learning in the early stages, establishing the relationship between daily life and scientific concepts and developing reasoning skills are very important. In this respect, classroom teachers have important duties. The fourth important result is that the participants experienced applying the knowledge they obtain in their lessons to events they came across with in daily life. The purpose of scienceeducation is to make students scientifically literate individuals who can access and use information. This finding shows that there are difficulties in achieving this goal in science education.

Suggestions

The development of informal reasoning is directly related to the skills of producing arguments. Therefore, science instructors need to develop their students' argumentation levels. In classroom teaching programs, activities which can support the development of students' questioning skills in science lessons should be planned and implemented.

For the development of the scientific process skills of teacher candidates, science learning approaches that are project-based where students will be able to do research and Access information and problem and argumentation based methods should be used instead of the traditional didactic teaching methods. For the teacher candidates who have knowledge on socio-scientific subjects, a connection between the subjects in science lessons and daily life should be established and the related socio-scientific subjects should be put on the agenda. However, forthis connection to be established, teacher candidates need to be educated within the scope of classroom teaching education in a manner as to acquire these skills. In science programs, socio-scientific subjects are increasingly becoming more important. Therefore, activities should be planned and implemented within the scope of classroom teaching programs about what socio-scientific subjects are, how they these socio-scientific subjects which can be a part of their lesson subjects should be taught and how they should approach socio-scientific subjects. The instructors need to identify the pre-knowledge of teacher candidates on various socio-scientific subjects and make it possible in their teaching activities for them to present their views while teaching these subjects and support their views with evidence. Problem-based and argumentation-based sciencelearning are effective methods which can be used in teaching these subjects.

The findings of the study show that the teacher candidates make decisions intuitively, rather than based on evidence while making decisions on a socio-scientific subject. When it is considered that teacher candidates will be playing a significant role in the development of their students' scientific process skills in the future, they need to develop their scientific thinking skills in their decision making process during their university education. Making it possible for classroom teacher candidates who participated in the study to do research within the scope of science and laboratory lessons during their undergraduate education, preparing environments where they can have discussions on scientific subjects and questioning activities on various socio-scientific subjects will help in the development of the scientific thinking skills of the students.

The findingsof the study show that the argumentation levels of the classroom teacher candidates is low. However, the development of their argumentation skills and the ability to produce high-level arguments are not goals which can be achieved within a short period of time. The reason for the argumentation skills of teacher candidates being undeveloped may be related to the education they are receiving. In education which is mostly based on a didactic approach, the development of these skills will not be in question since the teacher candidates will not need skills such as research and questioning. Therefore, learning environments in which the teacher candidates will be at the center, take the responsibility of their own learning, interpret data, access scientific information they need to solve problems and present discussions using scientific information should be provided. In this respect, it will be beneficial to carry out open-ended laboratory application based on questioning, rather than close-ended experiments in

laboratory applications. In addition, methods such as guess-observe-explain which will help the teacher candidates to produce arguments in science lessons can also be used.

The findings show that the teacher candidates approach a socio-scientific subject in a one-dimensional manner. The reason for this may be the insufficient formation of a connection between the science lesson subjects and daily life. Therefore, activities which present multi-disciplinary relationships and the connection with daily life should be designed in the teaching of science lessons. The use of project-based learning and problem-based learning methods in science lessons may help the teacher candidates to see the multi-disciplinary relationships of events and develop their multi-dimensional thinking skills.

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