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# Perspectives Related to Socio-Scientific Issues According to the Scientific Attitude Points of Secondary School Students*

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ABSTRACT

Individuals have different opinions and views on many socio-scientific issues such as stem cells, influenza vaccine, cloning, nuclear power plants, and organ transplantation that affect social life. Scientific attitudes and scientific literacy of individuals can affect their approach to socio-scientific issues. This research aims to reveal how 8th-grade secondary school students' opinions towards socio-scientific issues change according to their scientific attitudes. For this purpose, the "Scientific Attitude Scale" and "Socio-Scientific Issues Evaluation Form" were applied to the students. The study used a mixed research method that included both qualitative and quantitative data collection.The students' levels of scientific attitude were determined based on the quantitative findings of the study. The students were observed to have a moderate scientific attitude in general. According to their scientific attitude scores, students were divided into three groups: lower, moderate, and upper. The opinions of the students in the lower and upper groups on socio-scientific issues were analyzed based on both qualitative and quantitative findings. According to the findings, students who have a high scientific attitude have more awareness and opinions on socio-scientific topics than students who have low scientific attitude.



Keywords:
Socio-scientific Issues, Secondary School Students, Science Curriculum, Scientific Attitude

## 1. Introduction

The topic of what should be the goals of science education has been discussed and investigated for a long time. The content and characteristics of scientific literacy, which is at the forefront today, coincide with the aims of science education. Discussions on the meaning and purpose of scientific literacy are important for the development of all students. Although science education is unified in developing scientific literacy for all students, variables that affect scientific literacy need to be determined. Students' ability to be as creative and productive as the problems they can solve in daily life should be supported (Roberts, 2007). Teachers should use Socio-Scientific Issues (SSI) to make their students scientifically literate (Zeidler, Sadler, Simmons, & Howes, 2005). Because SSI offers teachers a coherent conceptual framework by taking students' moral and emotional development into account (Zeidler, Walker, Ackett, & Simmons, 2002).

Socio-scientific issues generally include the products of scientific processes that cause controversy in social life, and have arisen in recent years cover typically many topics such as nuclear power plants, stem cells, flu vaccine, cloning, blood sugar test for the pregnant, genetically modified foods, cosmetic surgery, global

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warming, cholesterol drugs, and organ transplantation (Sadler and Zeidler 2005: 112). In addition to these topics, reproductive technologies and abortion (Dawson, 2011); use of antibiotics (Friedrichsen, Sadler, Graham, & Brown, 2016); alternative medicine, biodiversity, and human genome project are also considered as socio-scientific issues (Topçu, Mugaloğlu, & Güven, 2014). Sadler (2011) included fluoride addition to water resources in treatment facilities, different diseases such as cystic fibrosis, AIDS or SARS, local and global environmental problems, and water and air quality among socio-scientific issues. SSI has a multidimensional structure. SBK has a multifaceted structure. It is based on science and occurs within the framework of scientific knowledge, has moral and ethical dimensions, relates to science and society, is on the agenda and in the media, includes risk-cost analysis by comparing the interactive relationship between risk and values, has social, economic and political dimensions. It requires decision making in the social environment and personal situations (Ratcliffe & Grace, 2003). In this respect, socio-scientific issues are based on science, technology, and society. While the science-technology-society approach aims to integrate science, technology, and society into science education for meaningful science learning, the environmental dimension has been added to this approach over time.

For this reason, the science, technology, and society approach has turned into a Science-Technology-Society-Environment approach by including the environment (Öztürk & Irmak, 2020). When the scope and characteristics of socio-scientific issues are examined, they can be collected under different titles. These are scientific developments, social dilemmas, informal and socio-scientific reasoning, argumentation, scientific modeling, nature of science, risk analysis, character education and identity, moral and cultural values, and media (Topçu, 2017).

To develop the individual's critical thinking and reasoning skills, the necessity of taking the SSI in the science program emerges (Çakırlar Altuntaş et al., 2017). Also, bringing socio-scientific issues to the agenda in science lessons is an essential tool for both the student's individual development and the development of society (Yavuz Topaloğlu & Balkan Krier, 2018). Topçu (2017) emphasizes that many countries state that socio-scientific issues are important for science education and that socio-scientific subjects are included in their curriculums. In Turkey, it has been said by the Board of Education under the Ministry of Education that socio-scientific issues have been included in the objectives and content of the Primary Science Education Curriculum (Ministry of National Education, [MoNE], 2013; MoNE, 2018).

In science classrooms, it is critical to teach socioscientific issues. The presence of socio-scientific issues contributes significantly to students' scientific literacy (Genç, 2020). To improve scientific literacy, the scientific attitude needs to be developed positively. Individuals with a scientific perspective are eager to recognize problems and seek solutions.

Based on these considerations, in this study, it is crucial to know the level of scientific attitudes of secondary school students during their education and determine their effect on their perspective on socio-scientific issues. When the researches were examined (Çavuş, 2013; Karışan, 2014; Kutluca, 2012; Lee, Chang, Choi, Kim, & Zeidler, 2012; Öztürk, 2011; Turan, 2012), it was seen that students' perspectives on socio-scientific issues were studied, and the relationship between socio-scientific issues and their scientific attitudes is an important issue that needs to be investigated. However, there is no national study examining the effect of secondary school students' scientific attitudes on their perspective on socio-scientific issues. It is aimed to contribute to the literature regarding this study.

This study aims to reveal how the opinions of 8th-grade secondary school students towards socio-scientific issues change according to their scientific attitudes. For this, it aims to determine the students' scientific attitude levels first and reveal their opinions on socio-scientific issues accordingly.

## 2. Methodology

### 2.1.Research Model

The research has the feature of mixed research. This method states that it would be better to include quantitative or qualitative data together in the study than to use each one individually (Creswell, 2012; 535). In this study, the Scientific Attitude Scale was used to gather quantitative data to determine the students'

levels of scientific attitude. The Socio-Scientific Issues Evaluation Form was used to collect both quantitative and qualitative data in order to determine the students' socio-scientific opinions based on their scientific attitude levels. In the qualitative aspect of the study, the phenomenological design was used to determine students' thoughts about a socio-scientific event. This method is widely known but provides more detailed analysis (Mayring, 2000; Yıldırım & Şimşek, 2008).

**2.2. Research Sample**

Secondary school 8th-grade students from four different schools in the Western Black Sea region were chosen as the study group in this study. Two study groups were formed in line with the aims of the study. The first study group was formed to determine the scientific attitude levels of the students. For the first study group, 298 students from a private secondary school, an "imam hatip secondary school", a village secondary school, and a central secondary school in the 2017-2018 academic year were included. Thus, it was aimed to ensure maximum diversity by including school types at different socio-economic levels. However, since 38 students did not fill the scale entirely and meticulously, the study's data analysis was done with data collected from 260 middle school students. There were 120 female students (46.15%) and 140 male students (53.85%) in the study group. On the other hand, the second study group consisted of students at a low and high level according to the scores they obtained from the scientific attitude scale applied in the first study group. In these groups, the study was conducted with 97 students, 49 of whom had a high scientific attitude, and 48 of them had a low scientific attitude, to determine their point of view on socio-scientific issues. While maximum diversity sampling was preferred in the first stage of the study, the study group selected by criterion sampling was chosen for the next stage. Students' participation in the second stage was done voluntarily (Büyüköztürk et al., 2009).

**2.3. Data Collection Tools and Procedure**

The Scientific Attitude Scale was created by Moore and Foy (1997), and Demirbaş and Yağbasan adapted for use in Turkey (2006). The scale's original version is written in English and has six dimensions. The number of items on the scale is 40. Demirbaş and Yağbasan (2006) determined that the scale should have only one factor due to the Turkish adaptation. The scale is a five-point Likert type, with "Strongly Agree," "Agree," "Undecided," "Disagree," and "Strongly Disagree" representing the degree of students' agreement with the statements in the answers. The Cronbach alpha reliability coefficient in the Scientific Attitude Scale's original study is 0.76 ($\alpha$ = 0.76). The alpha value was found to be 0.83 in analysis of this study.

In the study, "Socio-Scientific Issues Evaluation Form" was used to determine how students' opinions on socio-scientific issues changed according to their scientific attitude scores. The form has been developed by Çavuş (2013) and covers socio-scientific topics that students may encounter both in daily life and in lessons. The current original version of the form was examined, and socio-scientific issues that students might encounter in social life were included in the study. By reviewing the curriculum's acquisitions and topics and excluding the elements that were not suitable for the study's issue, the open-ended question form was rearranged. There are three sections to the Socio-Scientific Issues Evaluation Form. In the first part of the form, there are questions about students' gender, parental education level, mother and father occupation types, and the family's monthly income level. In the second part, some questions examine the source of the students' applications about science and the information they obtain about socio-scientific issues. In the third part, there are open-ended questions about different socio-scientific issues. Findings obtained from the first and second parts were analyzed through descriptive analysis.

**2.4. Data Analysis**

The Scientific Attitude Scale results, from which quantitative data were collected, were analyzed using the SPSS 20.0 (PASW 20.0) statistical package program. Students' scores on the scientific attitude scale were calculated and categorized into three groups: low, moderate, and high.While making this classification, the formula developed by Alamolhodaei (1996) was used. According to this formula, students who score more than the score obtained due to adding a quarter of the standard deviation to the mean are classified as "having a high scientific attitude". Those who have a score less than the score obtained by subtracting one-quarter of the standard deviation from the mean are classified as "having a low scientific attitude", and the ones between

these two numbers are classified as "having a moderate scientific attitude" (Black Pine and Fire, 2010; Sarı, Altıparmak and Ateş, 2013). Students with a moderate scientific attitude were excluded from the study.

Analyzing the findings obtained from the Socio-scientific Issues Evaluation Form, frequency and percentage were used for quantitative data, and content analysis was performed for qualitative data. Content analysis is a method that allows for the regular and sequential analysis of written, visual or verbal data objectively (Tavşancıl Aslan, 2001; Cohen, Manion, & Morrison, 2007). Based on students' expressions, categories were created from plain data thanks to open coding. The obtained data were classified according to categories, and meaningful integrity was provided.

The data were analyzed by another expert familiar with qualitative research. An expert's opinion was taken about this coding process, and the codes were revised in line with the suggestions. In this way, coding was carried out by the purpose and problem of the study. Thus, the validity of the research was provided (Cresswell & Plano Clark, 2011). Besides, Miles and Huberman's (1994) durability formula are applied. Two independent people did coding, and the agreement between coders was calculated as 90%. Reliability calculations above 70% are considered reliable for research (Miles & Huberman, 1994).

The frequencies that emerged after the coding was tabulated. Direct quotation expressions about coding were included. In the students' direct quotations from filled forms, the first 49 of the students were numbered between S1-S49 as those with a high scientific attitude, while the students with a low scientific attitude were numbered between S50-S97.

## 3. Findings

### 3.1. Secondary school students' scientific attitude scores

The Scientific Attitude Scale was used to determine the scientific attitude levels of 8th-grade secondary school students, and the descriptive statistics obtained from the scale are shown in Table 1.

**Table 1.** *Descriptive Statistics of the Scores the Students Obtained from the Scientific Attitude Scale*

| | $\bar{X}$ | Sd | Min. | Max. |
|---|---|---|---|---|
| SAS | 100,35 | 11,13 | 73 | 132 |

*$\bar{X}$: average Sd: standard deviation*

The mean score on the scale is = 100.35 (Sd = 11.13) when the descriptive statistics in Table 1 are examined. This data shows the mean value students get on the scale to get between 40-200 points. In this study, the lowest score obtained from the scientific attitude scale is 73, and the highest score is 132. The scores obtained by the students from the scientific attitude scale were calculated and divided into three categories as low, moderate, and high. Within this classification scope, the classification distributions made according to the students' scores from the scientific attitude scale are presented in Table 2.

**Table 2.** *Distribution of the Study Group by Total Scores They Got from Scientific Attitude Scale*

| Classification | Score Interval | f | % |
|---|---|---|---|
| Low | 73-97.57 | 107 | 41,15 |
| Moderate | 97,58-103,12 | 50 | 19,23 |
| High | 103,13-132 | 103 | 39.62 |
| Total | | 260 | 100 |

*f: frequency %: Percent*

103 students with high scientific attitude scores and 107 students with low scientific attitude scores were identified in the classification. The research group consisted of 49 volunteers with a high scientific attitude and 48 volunteers with a low scientific attitude

### 3.2. Perspectives of students with different scientific attitudes scores on socio-scientific issues

Those who have different scientific attitude scores from the participants were researched about their activities related to science, the source of their information about socio-scientific issues, and their views about socio-

scientific issues. Participants were given a series of science-related activities and asked how often they did them. According to different scientific attitude levels, the frequency levels of the participants' activities towards science are presented in Table 3.

**Table 3.** *Findings on Activities Carried Out by Participants in Science Subjects*

| | Students with High Scientific Attitudes (f) | | | | Students with Low Scientific Attitudes (f) | | | |
|---|---|---|---|---|---|---|---|---|
| **Activities** | I never do | Sometimes I do | I often do | I do regularly | I never do | Sometimes I do | I often do | I do regularly |
| Watching documentaries, etc., on science. | 5 | 35 | 6 | 2 | 9 | 35 | 3 | 2 |
| Borrowing or buying science books | 10 | 28 | 10 | 0 | 24 | 21 | 3 | 1 |
| Visiting websites related to science subjects | 7 | 26 | 14 | 1 | 12 | 25 | 12 | 0 |
| Reading science-related news in newspapers | 22 | 22 | 4 | 0 | 27 | 19 | 3 | 0 |
| Following science-related magazines (Science Kids, National Kids, etc.) | 18 | 23 | 5 | 2 | 22 | 22 | 3 | 2 |
| Participating in science-related activities (Travel, Science Club activities, etc.) | 16 | 23 | 6 | 3 | 19 | 25 | 5 | 0 |
| Reading books on science topics | 8 | 28 | 11 | 1 | 16 | 30 | 2 | 1 |
| Total | 86 | 185 | 56 | 9 | 129 | 177 | 31 | 6 |

In Table 3, it has been determined that the frequency of choosing the expressions "I do often" and "I do regularly" among the activities that the participants have done in science subjects are higher in students with high scientific attitudes than students with low scientific attitudes. This difference is observed more particularly in borrowing or buying and reading books on science subjects. The number of students who say “I never do” activities related to science is more common in low scientific attitude levels. According to these findings, it has been determined that students with a high scientific attitude level have a higher frequency of performing science-related activities. Also, a series of activities were given to the participants, and they were asked what activities they thought they could easily do on their own (Table 4).

**Table 4.** *Activities That Participants Think They Can Do Easily on Their Own*

| | Students with High Scientific Attitudes (f) | | | | Students with Low Scientific Attitudes (f) | | | |
|---|---|---|---|---|---|---|---|---|
| **Activities** | I cannot do this | It's hard for me to do | I can do if I try this | I can do this easily | I cannot do this | It's hard for me to do | I can do if I try this | I can do this easily |
| Recognizing the underlying problems when reading a newspaper article dealing with a health problem | 5 | 4 | 30 | 9 | 6 | 11 | 28 | 4 |
| Explaining the problems caused by unconscious drug use | 5 | 3 | 19 | 21 | 7 | 7 | 19 | 16 |
| Explaining the reasons for the proper collection and treatment of wastes | 2 | 3 | 19 | 24 | 4 | 7 | 19 | 19 |
| Predicting how environmental problems may affect the survival of living things | 1 | 2 | 16 | 29 | 4 | 5 | 18 | 22 |
| Understanding the product information given on foodstuff labels | 5 | 4 | 17 | 22 | 7 | 8 | 14 | 20 |
| Distinguishing renewable and non-renewable energy sources | 2 | 0 | 13 | 33 | 1 | 6 | 14 | 28 |
| Explaining the factors that cause acid rain to occur | 1 | 3 | 17 | 27 | 6 | 7 | 19 | 17 |
| Total | 21 | 19 | 131 | 165 | 35 | 51 | 131 | 126 |

According to Table 4, the frequency rate of students with a high scientific attitude level generally says "I can do easily" is seen more than students with a low scientific attitude level. Also, the frequency of thought of the participants who say “I can not do” or “It's hard for me to do” the activities stated in the table is observed more in students with a low scientific attitude. As a result, students with a high scientific attitude think that they can understand, explain, distinguish, and predict the reasons for various subjects related to science more easily than students with a low scientific attitude.

Participants were asked where they get their information on socio-scientific issues in science from (Table 5).

**Table 5.** *Sources of Information on Socio-Scientific Issues Related to Science They Reach*

| | **Students with High Scientific Attitudes (f)** | | | | | | | **Students with Low Scientific Attitudes (f)** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Socio-Scientific Issues** | From no source | From the teacher | From Media (TV, radio, newspaper, etc.) | From my friends | From my family | From the books | From the Internet | From no source | From the teacher | From Media (TV, radio, newspaper, etc.) | From my friends | From my family | From the books | From the Internet |
| Organic agriculture | 6 | 19 | 7 | 0 | 13 | 1 | 3 | 3 | 19 | 11 | 0 | 6 | 0 | 9 |
| Blood donation | 3 | 11 | 21 | 0 | 9 | 2 | 3 | 2 | 7 | 22 | 0 | 9 | 0 | 8 |
| Organ donation | 4 | 10 | 25 | 0 | 3 | 0 | 7 | 0 | 7 | 25 | 0 | 6 | 0 | 10 |
| Unconscious drug use | 4 | 3 | 21 | 0 | 13 | 1 | 7 | 2 | 8 | 24 | 0 | 9 | 0 | 5 |
| Substances that cause addiction | 5 | 11 | 15 | 1 | 10 | 0 | 7 | 1 | 3 | 19 | 1 | 11 | 0 | 13 |
| Visual and hearing impairment | 11 | 11 | 14 | 4 | 5 | 2 | 2 | 4 | 9 | 15 | 2 | 5 | 2 | 11 |
| Endangered animals and plants | 3 | 18 | 11 | 0 | 4 | 3 | 10 | 0 | 23 | 4 | 0 | 0 | 4 | 17 |
| Environmental problems | 3 | 17 | 16 | 2 | 1 | 3 | 7 | 0 | 25 | 9 | 1 | 1 | 4 | 8 |
| Determination of gender | 11 | 15 | 2 | 1 | 18 | 1 | 1 | 9 | 18 | 1 | 0 | 11 | 3 | 6 |
| Consanguineous marriages | 8 | 6 | 7 | 2 | 25 | 0 | 1 | 11 | 1 | 7 | 0 | 26 | 1 | 2 |
| Genetic diseases | 2 | 14 | 14 | 1 | 10 | 5 | 3 | 1 | 18 | 7 | 0 | 9 | 3 | 10 |
| Biotechnology, genetic engineering applications | 6 | 24 | 10 | 1 | 0 | 3 | 5 | 2 | 26 | 7 | 0 | 0 | 2 | 11 |
| Nuclear energy | 5 | 28 | 10 | 2 | 0 | 2 | 2 | 2 | 24 | 5 | 0 | 0 | 1 | 16 |
| Recycling | 4 | 31 | 10 | 2 | 1 | 0 | 1 | 1 | 26 | 5 | 0 | 5 | 2 | 9 |
| Total | 75 | 218 | 183 | 16 | 112 | 23 | 59 | 38 | 214 | 161 | 4 | 98 | 22 | 135 |

The majority of students with high and low scientific attitudes choose "teacher" as their knowledge source, as seen in Table 5. Students mostly saw the teacher as a source of information on organic agriculture, endangered animals and plants, environmental problems, genetic diseases, biotechnology, genetic engineering, nuclear energy, and recycling in both groups. Similarly, the media, the family, and the Internet took place as a source of information, respectively.

**Findings on "Organic Products"**

At this stage, students were asked to complete a conversation about "consuming organic products" related to the "organic products" subject. The codes determined from the answers of the students in two different groups are shown in Table 6.

**Table 6.** *Findings on the Answers Given by the Study Group about the Importance of Organic Agriculture*

| Codes | Students with High Scientific Attitudes (f) | Students with Low Scientific Attitudes (f) |
|---|---|---|
| Being eaten by animals | 3 | 1 |
| Being organic | 16 | 14 |
| Being natural | 12 | 12 |
| Not being genetically modified | 3 | 3 |
| Free of drugs and chemicals | 6 | 11 |
| Having vitamins | 3 | 0 |
| Being fresh | 1 | 0 |
| Being healthy | 4 | 1 |
| Being harmful | 0 | 3 |
| Should not be consumed | 3 | 1 |
| Being useful | 1 | 0 |
| I do not know | 1 | 1 |
| No idea | 0 | 3 |
| Unanswered | 2 | 1 |
| Total | 53 | 51 |

Considering the participants' answers to the question regarding the consumption of organic products, both students with a high scientific attitude and students with a low scientific attitude mostly expressed their opinions about the "being organic" and "being natural" characteristics of the products. Also, the students emphasized the feature of being free of drugs and chemicals. Particular individuals with a low scientific attitude emphasized this more.

Students with a high scientific attitude emphasized such features of organic products as "having vitamins", "being healthy", and "being eaten by animals", as well as "should not be consumed" more often than the other student group. According to this result, it can be said that students with a high scientific attitude put forward a more comprehensive perspective on organic products.

The opinions of the participant S3, from the group with a high scientific attitude, about the consumption of organic products, are given below:

"*Apple worms enter and eat natural, fresh, and healthful apples (foods). Therefore, this apple can be eaten. We shouldn't waste them just because they have worms inside.*"

The student coded as S87, who is in the group of students with a low scientific attitude, expressed his/her view as "*It is eaten as it is natural*".

**Findings on "Substances That Cause Addiction"**

To reveal their thoughts on substances that cause addiction, participants were asked to write down what kind of information they are planning to provide, considering that they will give a seminar to their friends about "substances that cause addiction" in their schools. Table 7 shows the codes and frequency of the codes determined after content analysis of the participants' answers to this query.

According to the analysis results in Table 7, both students with high scientific attitudes and low scientific attitudes emphasized the "substances that cause addiction" code. The students with a low scientific level preferred to "give advice" more about substances that cause addiction.

Unlike the other student group, students with a high scientific attitude also emphasized the Content/nature of substances, being a harmful substance, religiously forbidden, and the need for education. As a result, students with a high scientific attitude suggested more diverse topics about substances that cause addiction.

S25 from a student group with a high scientific attitude expressed his/her opinion as: "*I would talk about drug use, cigarette and alcohol addiction in Turkey. Because the current generation is very fond of these substances. Finally, I would share that terrorist organizations earn most of the money from drugs*." S91, from students with a low scientific attitude, listed the substances that cause addiction by saying, "*Substances that cause addiction are like alcohol, cigarettes, and drugs, but these are caused by friends also*".

**Table 7.** *Findings on the Answers Given by the Participants About Substances That Cause Addiction*

| Codes | Students with High Scientific Attitudes (f) | Students with Low Scientific Attitudes (f) |
|---|---|---|
| Health effects | 8 | 6 |
| Substances that cause addiction | 15 | 19 |
| Social damages | 0 | 1 |
| Content/nature of substances | 2 | 0 |
| Being a harmful substance | 5 | 0 |
| Psychological effects | 1 | 2 |
| Religiously forbidden | 1 | 0 |
| Giving advice | 6 | 14 |
| Fatal effects | 4 | 2 |
| Emphasis on education | 2 | 0 |
| Addictive | 3 | 2 |
| The influence of the friend environment | 5 | 6 |
| Indifferent answer | 0 | 1 |
| Unanswered | 1 | 0 |
| Total | 53 | 53 |

**Findings on the Subject of "Genetically Modified Organisms"**

The students' opinions about foods containing genetically modified organisms (GMOs) and the areas where GMOs are used were tried to be determined by asking various questions. Participants' thoughts on GMO-containing foods were obtained through this question: "Do you know what genetically modified food is? Please explain briefly." The codes determined from the participant responses and the frequencies of these codes are shown in Table 8.

**Table 8.** *Findings on the Study Group's Answers About GMO-Containing Foods*

| Codes | Students with High Scientific Attitudes (f) | Students with Low Scientific Attitudes (f) |
|---|---|---|
| Knowledgeable | 20 | 21 |
| Partially knowledgeable | 9 | 7 |
| Not knowledgeable | 14 | 7 |
| Incorrect information | 4 | 7 |
| Indifferent answer | 0 | 6 |
| Unanswered | 2 | 0 |
| Total | 49 | 48 |

According to Table 8, among the participants with a high and low scientific attitude, the frequencies of those who have information about GMO foods are close to each other. It has been determined that 14 of the participants who have a high scientific attitude about GMO foods stated that they lacked information on this subject. The participants with a low scientific attitude gave seven wrong and six irrelevant answers. As a result, students with a high scientific attitude claim to have no more knowledge, while students with a low scientific attitude gave more incorrect and irrelevant answers. Students with a high scientific attitude were more cautious about the subjects they did not know, rather than giving wrong answers.

S43, one of the students with a high scientific attitude, defined genetically modified foods as "*They ensure that the foods are genetically changed with some drugs, and thus they do not spoil for a longer time*." S72, one of the students with a low scientific attitude, said "*I don't know, for example, normal chicken is 10kg, GMO chicken (20kg). The weight numbers are not real*." and this shows that he/she has misinformation.

Options were presented to determine the participants' opinions about the purpose for which GMO products are produced and their common areas of use. They were asked to mark one or more of these options according to their own opinions and rank them in terms of importance. Thus, the production purposes and the areas where these products are used have been tried to be determined. The frequency distributions and categories of the participants' responses to this question are shown in Table 9.

**Table 9**. *Opinions on Production Reasons and Common Uses of GMO Products*

| Codes | | Students with High Scientific Attitudes (f) | | | | | | Students with Low Scientific Attitudes (f) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Premise | 2nd Premise | 3rd Premise | 4th Premise | 5th Premise | Total | 1st Premise | 2nd Premise | 3rd Premise | 4th Premise | 5th Premise | Total |
| Production purposes | Resistance to pests and drugs | 15 | 3 | 1 | 2 | 0 | 21 | 10 | 3 | 4 | 4 | 2 | 23 |
| | Increasing nutritional value and quality | 2 | 19 | 2 | 2 | 0 | 25 | 3 | 17 | 5 | 3 | 1 | 29 |
| | Extending the shelf life of the product | 6 | 4 | 24 | 0 | 0 | 34 | 18 | 9 | 15 | 0 | 0 | 42 |
| | Increasing the amount of product | 3 | 3 | 2 | 18 | 1 | 27 | 3 | 11 | 9 | 13 | 3 | 39 |
| | For diagnosis and treatment purposes | 1 | 0 | 2 | 0 | 8 | 11 | 2 | 1 | 2 | 4 | 5 | 14 |
| Common usage areas | Agriculture | 33 | 1 | 0 | 0 | 0 | 34 | 37 | 3 | 1 | 1 | 0 | 42 |
| | Animal husbandry | 0 | 26 | 1 | 0 | 0 | 27 | 1 | 23 | 7 | 2 | 0 | 33 |
| | Medical applications | 1 | 2 | 10 | 1 | 0 | 14 | 3 | 7 | 7 | 0 | 0 | 17 |
| | Other | 0 | 0 | 4 | 8 | 1 | 13 | 3 | 2 | 1 | 6 | 0 | 12 |
| | No idea | | | | | | | | | | | | |

According to the data obtained from the participants regarding the production purposes of GMO products, the students with a high scientific attitude mainly focused on the option of "resistance to pests and drugs" (15) as the first premise and the choice of "increasing nutritional value and quality" (19) as the second premise. It is seen that students with a low scientific attitude primarily refer to the option of "extending the shelf life of the product" (18) as the first premise and the option of "increasing the nutritional value and quality" (17) as the second premise. Considering the total values, “extending the shelf life of the product” and “increasing the amount of product” are among the most marked options for both groups. Also, although the premise rankings for both groups are different, there is a consensus that GMO is to extend the shelf life of the product and increase the amount of product.

When the common usage areas of GMO products are examined, it is seen that those who have a high scientific attitude focus on the option of "agriculture" (33) as the first premise and the option of "animal husbandry" (26) as the second premise. On the other hand, those with a low scientific attitude concentrated on the "agriculture" (37) option as the first premise and the option "animal husbandry" (23) as the second premise. Also, there were some participants from both groups who did not answer this question.

**Findings on "Organ Donation"**

To determine the importance of organ donation, the participants were asked to imagine themselves as a relative of a patient waiting for organ donation and prepare a text that will take place in the print media to help their relatives regain their health. The situations expressed by the participants in the texts they prepared were divided into codes, and the frequencies of these codes are presented in Table 10.

When Table 10 is examined, the frequency of “making requests for relatives” is seen as the highest code for both groups. However, this code's emphasis was approximately twice as high in students with low scientific attitude than the other group. Also, groups made requests for organ donation through social messages, creating slogans, giving a religious notice, awarding and announcing advertisements. Students with a high scientific attitude also requested organ donation with messages containing an emotional approach.

One of the students with a high scientific attitude, S47, gave an emotional message by saying “*I will talk about how good organ donation is and how good it is to help people*”. On the other hand, another student with a low scientific attitude, S62, gave an example of the category of providing a religious message by saying, "*Emergency kidney is expected. Those who want to do good deeds, take this news into consideration*".

**Table 10.** *Findings on the Answers of the Study Group about the Importance of Organ Donation*

| Codes | Students with High Scientific Attitudes (f) | Students with Low Scientific Attitudes (f) |
|---|---|---|
| Social message | 8 | 6 |
| Emotional approach | 5 | 0 |
| Creating a slogan | 6 | 3 |
| Religious message (for God's sake, for reward, etc.) | 8 | 5 |
| Awarding (Money etc.) | 5 | 4 |
| Making announcements, advertisement | 1 | 6 |
| Making requests for relatives | 11 | 20 |
| Indifferent answer | 2 | 3 |
| Unanswered | 3 | 1 |
| Total | 49 | 48 |

**Findings on "Human and Environment" Subject**

Students' opinions on "Human and Environment" were determined by asking questions about "environmental problems encountered" and "nuclear energy".

*Environmental Problems:* Participants were asked to draw a cartoon or a picture or write a poem, story, or an article on the subject by stating that they would participate in a contest about environmental problems, and thus their views on the subject were tried to be determined. Next, they were asked to briefly explain what they did and suggest solutions for the problem they chose, and the codes of their answers were determined. The frequency distributions of these codes are given in Table 11.

**Table 11.** *Findings on the Answers Given by the Study Group about the Activities They Did Relate to Environmental Problems*

| | Type of the Study | Students with High Scientific Attitudes (f) | Students with Low Scientific Attitudes (f) |
|---|---|---|---|
| Activity Type | Art | 36 | 32 |
| | Poetry | 3 | 1 |
| | Prose | 2 | 2 |
| | Empty | 8 | 13 |
| Problems they addressed at the events | Environmental pollution | 17 | 14 |
| | Nature problems | 10 | 6 |
| | Air pollution | 9 | 7 |
| | Water pollution | 4 | 3 |
| | Recycling | 6 | 3 |
| | Harming living things | 4 | 2 |
| | For warning or suggestion | 9 | 11 |
| | Unanswered | 3 | 4 |
| | Total | 62 | 50 |
| Solution suggestions for the problems | Raising awareness of people | 11 | 9 |
| | Using environmentally friendly methods | 6 | 0 |
| | Installing filters in factory chimneys | 13 | 9 |
| | Afforestation | 0 | 2 |
| | Recycling | 3 | 9 |
| | Not littering | 13 | 5 |
| | Classification of garbage | 2 | 4 |
| | Having a penalty/reward system | 4 | 12 |
| | Unanswered | 4 | 4 |
| | Total | 56 | 54 |

When the participants' activities on the subject of environmental problems are examined in Table 11, it is discovered that both students with a high scientific attitude and students with a low scientific attitude attempted to explain their opinions primarily through painting. Also, considering the subjects emphasized in their studies, it has been determined that students with a high scientific attitude worked on the codes of "nature problems" and "environmental pollution" and participants with a low scientific attitude worked on the code of "environmental pollution". When the total values are examined, it is seen that students with a high scientific attitude (62) deal with more types of problems than students with a low scientific attitude (50).

S12, one of the students with a high scientific attitude, drew a picture showing the factory's environmental impact. In his/her statement about the painting, he/she stated that the factory fumes caused acid rain and posed a risk to living beings' lives in the picture where the factory showed its effect.

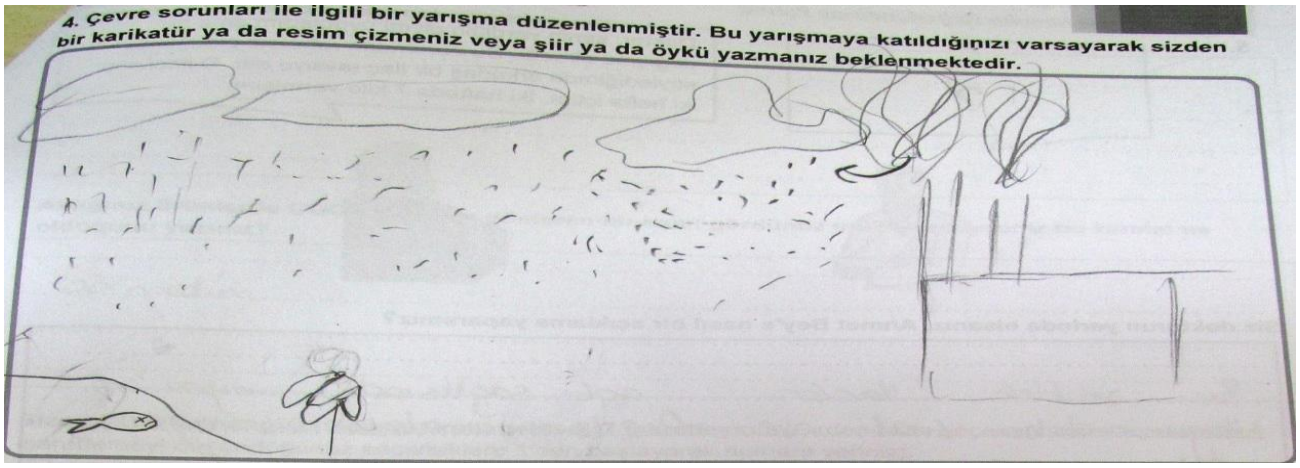


**Figure 1.** *The Picture Drawn by the Student with High Scientific Attitude (S12)*

S83, one of the students with a low scientific attitude, drew the negative behaviors of an individual in his/her picture. In his/her statement, he/she stated that people throw garbage on the ground, not in the garbage can.

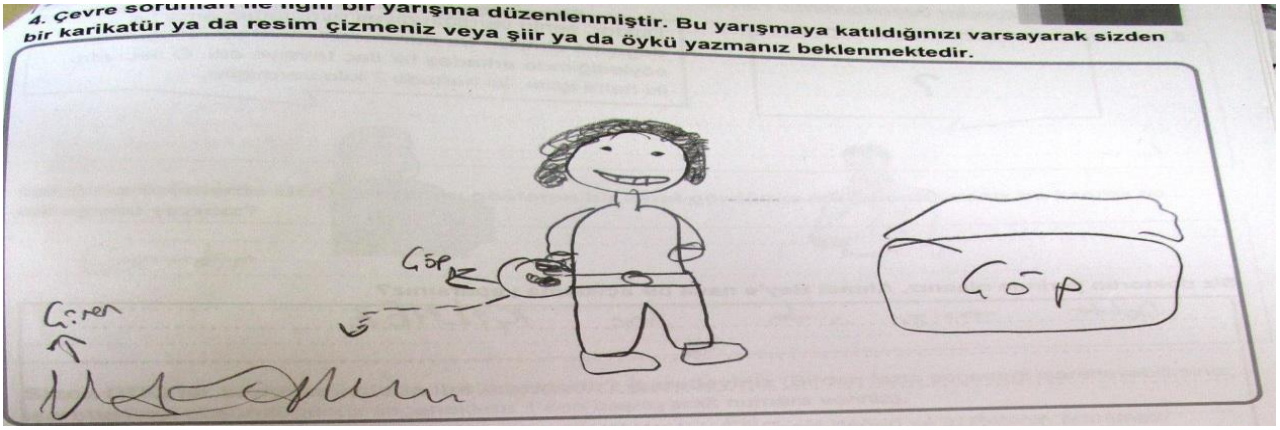


**Figure 2.** *The Picture Drawn by the Student with Low Scientific Attitude (S83)*

When the participants' opinions on how to solve environmental problems were analyzed, it was discovered that students with a high scientific attitude expressed the codes of "installing filters in factory chimneys" (13) and "not throwing waste and garbage" (13) the most frequently. On the other hand, students with a low scientific attitude stated the code of “having a penalty/reward system” (12) most often.

While students with a high scientific attitude mostly made statements about taking precautions before environmental pollution and environmental problems occur (raising awareness of people, installing filters in factory chimneys, using environmentally friendly methods, not littering), students with low scientific attitudes made more suggestions for the solution after the formation of the problem (penalty/reward system, garbage classification, and recycling).

*Nuclear Energy:* To determine the participants' opinions about nuclear energy, which is the most striking socio-scientific subject of today, a newspaper article covering this subject was used. It was stated in the article that a nuclear power plant will be installed in the town of Akkuyu in Mersin, and 4,800 megawatts will be produced in this power plant, which can meet approximately 6% of Turkey's electricity production. The students were asked to write about their thoughts on establishing this power plant in their town, considering they live in this region. Codes were determined depending on the participants' opinions about the nuclear power plant, and the frequency distributions of these codes are presented in Table 12.

**Table 12.** *Findings on the Answers of the Study Group about Nuclear Power Plants*

| Themes | Codes | Students with High Scientific Attitudes (f) | Students with Low Scientific Attitudes (f) |
|---|---|---|---|
| Positive Opinion | Contribution to the national economy | 1 | 2 |
| | Meeting the energy needs | 7 | 4 |
| | Contribution to country development | 2 | 1 |
| | Supporting | 6 | 2 |
| Negative Opinion | Harming nature | 7 | 4 |
| | Harming living things | 3 | 2 |
| | Harmful to human health | 3 | 8 |
| | Dangerous | 0 | 6 |
| | Opposing | 11 | 7 |
| | Protest | 0 | 6 |
| Making suggestions | | 4 | 4 |
| Supporting both sides | | 5 | 7 |
| Unanswered | | 2 | 2 |
| Total | | 51 | 55 |

When the participants' responses about "nuclear energy", which is an essential socio-scientific issue, are examined in Table 12, it is seen that students with a high scientific attitude expressed positive opinions with 16 frequencies and negative opinions with 24 frequencies in total. Participants with a low scientific attitude emphasized positive opinions with nine frequencies and negative opinions with 33 frequencies. Among the positive opinions, “meeting the energy needs” was prioritized in both groups. In negative opinions, both of the groups used expressions stating that they are opposed to nuclear energy. As a result, students of both groups expressed their negative views on nuclear power plants more. Moreover, the students made some suggestions besides having opinions supporting both sides.

One of the students with a high scientific attitude, S4, stated his/her positive and negative opinions by saying "*It is a good thing to provide electricity production. It should not be forgotten that this causes air pollution and harms people, animals or plants, and precautions should be taken in return*." On the other hand, one of the students with a low scientific attitude, S68, approached the issue in two directions and made a different suggestion by saying, “*I think it is good for electricity but bad for the environment. Geothermal can be used instead*".

## 4. Conclusion, Discussion, and Recommendations

This research sought to expose students' socio-scientific viewpoints based on their scientific attitude ratings. The arithmetic mean of the scientific attitude scores of the students participating in the study was found to be 100.35. The participants were found to have a moderate scientific attitude, according to this finding. The scientific attitude levels of the students were moderate in other studies (Kılıç, 2011; Mıhladız and Duran, 2010; Böyük, Koç and Erol, 2013) that calculated the scientific attitude score.

In the study, the students with a low scientific attitude and a high scientific attitude were examined in terms of the activities they do related to science, their source of information about socio-scientific issues, their opinions on socio-scientific matters, organic products, substances that cause addiction, genetically modified organisms, organ donation, environmental problems, and nuclear energy.

The research discovered that students with a high scientific attitude level have more frequency of performing science-related activities. Furthermore, it is expected that students in this category will be better able to understand, explain, discern, and forecast various science-related subjects' explanations than students with low scientific attitudes (Başaran, 1992; Okan, 1993). Moreover, students in both groups see the most teachers as a source of information.

When students' opinions on organic products, which is a socio-scientific subject, are investigated, it is discovered that students with a high scientific attitude have more detailed views on organic agriculture, whereas students with a low scientific attitude have more limited knowledge on this topic. In the study of Toraman (2013), students with a high scientific attitude stated that this type of agriculture is healthy and beneficial and sorted more organic agriculture features. It is important that students understand the value of this form of agriculture. The environmental and agricultural awareness of young people can make positive contributions to the lives of current generations, especially in the following years (Akgül & Macaroğlu Akgül, 2011), therefore, it is of particular importance to include organic agriculture in curriculums (Çeken, 2010).

Although it is seen that students with a high scientific attitude about substances that cause addiction have a wide variety of information on many subjects such as substances that cause addiction, their contents, harm, educational needs, and religious aspects, the explanations about the substances that cause addiction are the most discussed topic in both groups. Similarly, when the related literature is reviewedd, it is found that primary school, middle school, and high school students have sufficient information about the harms of substances that cause addiction, especially tobacco (Atan, Durmaz, Erkuş, Sevil and Taşçı, 2005; Bahar and Çuhadar, 2007; İnal and Yıldız, 2006;). In their study, Öztürk and Bıkmaz (2007) stated that including subjects related to addictive substances in the secondary school science curriculum will contribute to creating health awareness at young ages.

When the students' opinions about GMO foods are examined, it is seen that the frequency of those who have information in both groups is close to each other. Students with a low scientific attitude, on the other hand, were found to have more incorrect and insignificant responses. In another study, it was stated that 8th-grade students were informed that the concept of GMO is related to changing organisms' genetics (Demir & Düzleyen, 2012). While students with a high scientific attitude in GMOs' production purposes emphasized resistance to pests and drugs, students with a low scientific attitude stated that extending the products' shelf life is their first priority. In the participants' opinions regarding GMO products' common usage areas, both groups emphasized agriculture and animal husbandry in the first two places. In line with this study, Bilen and Özel (2012) indicated in their research that the participants stated that Genetically Modified Organisms were mostly used in agriculture and animal husbandry.

It has been determined that the participants especially emphasized the expressions containing messages and slogans about the importance of organ donation, which is one of the current problems. It has been found out that students with low scientific attitudes prepared more texts for organ requests for their relatives than students with high scientific attitudes. According to Toraman (2013), students have varying levels of awareness about organ donation. Özkan and Yılmaz (2009) stated in their study that patients' relatives have incomplete information about organ donation. At the same time, it was determined that their attitudes and behaviors towards organ donation differ, and very few of those, who stated that they want to donate organs verbally, donated organs. Sakmen, Genç, and Arslan (2020) stated in their study that middle school students had negative attitudes and positive attitudes towards organ donation. They stated that some students were indecisive because they did not have enough information.

Participants answered different questions about environmental problems at different frequencies. Participants mostly prefer to draw pictures while clarifying their views about environmental problems. It has been observed that students mostly chose to draw pictures to express social problems (Ersoy & Türkkan, 2010). It has been seen that students with high scientific attitudes deal with more types of problems than students with low scientific attitudes. In solving the problems, students made more precautionary suggestions without polluting the environment, while students with low scientific attitude suggested interventionist methods. From the first step of education, it is thought that activities and practices should be prepared about environmental problems in science lessons (Ayvacı & Şenel Çoruhlu, 2009). When the views of the participants

on nuclear energy are examined, it has been found out that students in both groups stated that nuclear power plants mostly harm the environment and are harmful to health. However, they had positive aspects of them.

As a result, students' way of dealing with socio-scientific issues, their interpretations, judgments, and solution suggestions can change according to their scientific attitude scores. Students with a high scientific attitude generally provided a more detailed, varied, and comprehensive view on socio-scientific issues. Students with a low scientific attitude reported more limited and sometimes incorrect opinions. It is important to develop socio-scientific perspectives for individuals to think reasonably, make decisions, and produce creative solutions to all kinds of issues and problems they encounter. Therefore, socio-scientific issues can be addressed in curriculums from an interdisciplinary perspective. Activities that improve the socio-scientific aspects of students can be organized in learning environments. Since students mostly consider teachers as a source of information, professional development activities that will enhance teachers' socio-scientific teaching skills can be organized. Also, for research, similar studies can be made by adding current and different socio-scientific topics. It can research socio-scientific perspectives according to different variables other than scientific attitude.

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