REPUBLIC OF TURKEY
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

INVESTIGATING MIDDLE SCHOOL STUDENTS' SUPPORTING REASONS THROUGHOUT WRITTEN ARGUMENTATION IN THE CONTEXT OF SOCIOSCIENTIFIC ISSUE-BASED INSTRUCTION

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MSc. THESIS
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Büşra AKKAŞ

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LIST OF SYMBOLS

ScK The combination of science subject area and knowledge aspect
ScV The combination of science subject area and value aspect
ScP The combination of science subject area and personal experience aspect
EtK The combination of ethics/morality subject area and knowledge aspect
EtV The combination of ethics/morality subject area and value aspect
EtP The combination of ethics/morality subject area and personal experience aspect
SoK The combination of sociology/culture subject area and knowledge aspect
SoV The combination of sociology/culture subject area and value aspect
SoP The combination of sociology/culture subject area and personal experience aspect
EcK The combination of economy subject area and knowledge aspect
EcV The combination of economy subject area and value aspect
EcP The combination of economy subject area and personal experience aspect
EnK The combination of environment subject area and knowledge aspect
EnV The combination of environment subject area and value aspect
EnP. The combination of environment subject area and personal experience aspect
PoK The combination of policy subject area and knowledge aspect
PoV The combination of policy subject area and value aspect
PoP The combination of policy subject area and personal experience aspect

LIST OF ABBREVIATIONS

CCC Crosscutting Concepts
DCI Disciplinary Core Ideas
MEB Ministry of National Education (Milli Eğitim Bakanlığı)
NGSS Next Generation Science Standards
NOS Nature of Science
OECD Organization for Economic Co-operation and Development
PISA Programme for International Student Assessment
SP Scientific Practices
SSI Socio-Scientific Issues
STS Science–Technology–Society
TAP Toulmin's Argument Pattern

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ABSTRACT

INVESTIGATING MIDDLE SCHOOL STUDENTS' SUPPORTING REASONS THROUGHOUT WRITTEN ARGUMENTATION IN THE CONTEXT OF SOCIOSCIENTIFIC ISSUE-BASED INSTRUCTION

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The skills of argumentation have been gaining importance in science education recently. In order to achieve scientific literacy, students need the skills of thinking critically, making informed decision, developing arguments, etc. and socio-scientific issue-based instruction (SSI-based instruction) helps enhance these skills. Behind these skills, it is also important to understand what supporting reasons affect the process of making decision, developing arguments during argumentation. Therefore, the aim of this research is to examine the supporting reasons that the middle school students' use when they are writing arguments about a socio-scientific issue related to a gene editing method (CRISPR).

In this research, an SSI unit (including argumentation), about CRISPR method was developed according to the SSI-based instruction model by Sadler, Foulk, Friedrichsen (2017). CRISPR method is used as the focal socio-scientific issue because of the dilemma among the researchers, countries, engineers, etc. about whether CRISPR method should be used or not. The main question of the unit was "How might using CRISPR method affect the future?" The unit was taught to 7^{th} grade students who are studying in a middle school for 4 weeks. At the end of the unit, written arguments were collected. Qualitative approach was adopted to the research and SEE-SEP model was used as an analytical framework because of the multi-perspective feature of SSI. The model includes six subject areas (sociology/culture, economy, environment/ecology, science,

ethics/morality, and policy) and three aspects (knowledge, value and personal experience). The supporting reasons that the students used in the written arguments were investigated from these aspects and the subject areas. It is revealed that students benefited from their science knowledge and value aspect when they need to decide about the use of CRISPR method in the future. Also, ethics/morality subject area is on the foreground in their written argumentation.

Keywords: Socio-scientific issue (SSI), SSI-based instruction, CRISPR method, argumentation, SEE-SEP model

ÖZET

SOSYOBİLİMSEL KONU TEMELLİ ÖĞRENME BAĞLAMINDA ORTAOKUL ÖĞRENCİLERİNİN ARGÜMANTASYON GEREKÇELERİNİN İNCELENMESİ

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Son dönemlerde argümantasyon becerileri, fen bilimleri eğitiminde önem kazanmaktadır. Fen okur-yazarlığının gelişimi için öğrenciler eleştirel düşünme, bilgiye dayalı karar verme, argüman geliştirme gibi becerilere ihtiyaç duymaktadır ve sosyo-bilimsel konu temelli öğretim bu becerilerin gelişimine katkı sağlamaktadır (SBK-temelli öğretim). Bu becerilerin yanında, argüman geliştirme ve karar verme süreçlerini etkileyen destekleyici nedenleri anlamak da önem kazanmaktadır. Bu tezin amacı ortaokul öğrencilerinin sosyo-bilimsel konu olarak uyarlanan bir gen düzenleme yöntemi (CRISPR/Cas9) ile ilgili argüman yazarken kullandıkları destekleyici nedenleri incelemektir. Bu araştırmada Sadler, Foulk ve Friedrichsen (2017) tarafından SBK temelli öğretim modeli olarak geliştirilen model baz alınarak, argümantasyon yöntemini de içeren bir SBK ünitesi geliştirilmiştir. CRISPR/Cas9 yönteminin kullanımının bilim insanlarını, mühendisleri ve ülkeleri ikilemde bırakması, farklı düşünceleri barındırması nedeniyle, temel sosyo-bilimsel konu olarak CRISPR/Cas9 yöntemi üniteye uyarlanmıştır. Ünitenin temel sorusu "CRISPR yönteminin kullanımı geleceği nasıl etkiler?" olarak belirlenmiştir. Geliştirilen SBK ünitesi, 4 hafta boyunca bir devlet ortaokulunda okuyan yirmi sekiz 7. sınıf öğrencisine uygulanmıştır. Ünite sonunda ise, öğrencilerden konu hakkında görüşlerini belirten yazılı argümanlar toplanmıştır. Nitel araştırma yönteminin benimsendiği bu çalışmada, SBK'nın çok yönlü özelliğine vurgu yapan SEE-SEP modeli analitik çerçeve olarak kullanılmıştır. Bu model 6 konu (sosyoloji/kültür, ekonomi, çevre/ekoloji, bilim, etik/ahlak ve politika) ve 3 boyut (bilgi, değer ve kişisel deneyimler) içermektedir. Öğrencilerden toplanan yazılı argümanlar ise bu konular ve boyutlar baz alınarak incelenmiştir. İncelemeler sonucunda ise öğrencilerin argümanlarını yazarken sıklıkla

bilimsel bilgi ve etik konularından, değer boyutundan yararlandıkları ve destekleyici nedenlerini bu konu ve boyutlara dayanarak oluşturdukları tespit edilmiştir.

Anahtar Kelimeler: Sosyo-Bilimsel Konu (SBK), SBK Temelli Öğretim, CRISPR/Cas 9 Yöntemi, Argümantasyon, SEE-SEP Modeli

CHAPTER 1

INTRODUCTION

Recently, socio-scientific issue (SSI) based instruction is gaining importance in order to achieve scientific literacy in science education. Turkish Science Curriculum [1], which is generated by Ministry of National Education, also defined the importance of including socio-scientific issues in science education and its effect on scientific thinking, reasoning, and decision-making, as one of the special aim of the science curriculum. That is, socio-scientific issue based instructions help students improve reasoning, critical thinking, decision-making skills and argumentation is one of the ways included in SSI-based instructions to improve these skills.

Students make decisions by reasoning, thinking critically, thinking all the aspects of the issue during argumentation. In this context, students are expected to corroborate and/or give reasons about their ideas. Chang & Chiu (2008) [2] emphasized that in SSI-based instructions including argumentation, the supporting reasons used to corroborate the ideas forms the core of the instruction. It means, in SSI-based instructions including argumentation, the supporting reasons students use to support their decisions, ideas and beliefs are gaining importance.

Therefore, in this thesis, the aim is to investigate the supporting reasons that middle school students use when they are writing arguments about the effects of using CRISPR method in the future on humanity. For this aim, an SSI unit was developed about the focal issue “CRISPR/Cas9 Method” and it was instructed to 7^{th} grade students for 4 weeks. At the end of the 4-week SSI-based instruction, the participant students were asked to write their arguments and supporting reasons for their arguments.

1.1 Literature Review

1.1.1 Scientific Literacy

The term scientific literacy started to be used in late 1950's, in order to stress the "public understanding of science" [3]. That is, the idea of spreading the skills of scientific understanding to the public had gained importance and several definitions and approaches arose for scientific literacy since 1950's. Miller (1983) [4] defined scientific literacy in two parts; one is "to be learned" and the other part is "to be able to read and write". The first part emphasizes the meaning of the scientific content knowledge for scientifically literate. It means, it is important to have scientific knowledge to communicate science. The second part explains the skills as understanding the scientific issues, reading, expressing beliefs / ideas about the scientific issues. That is, in order to be scientifically literate, besides the scientific content knowledge, the abilities to read, write, discuss, express ideas about scientific matters should be improved.

Similar to Miller, Roberts (2007) stated that

> As I suggested earlier, the current status of the concept of scientific literacy can best be grasped if we cut through the many details about definitions and concentrate on two 'visions.' On one hand is the Vision II concept suggested by Fitzpatrick's original use of the slogan: citizen's understanding of the enterprise of science and how it permeates human affairs other than – but also including – scientific investigation itself. On the other hand, Vision I concentrates on having students understand human affairs as a scientist would [3].

Roberts [3] defines scientific literacy in two visions, as Miller [4]. The Vision 1 emphasizes that students should have a scientific understanding as scientist does and the Vision 2 emphasizes "science as a citizenship" aspect of scientific literacy.

Not only definitions and approaches, but also some events to assess the scientific literacy of students are developed. One of the most famous event is "Programme for International Student Assessment (PISA)". PISA which is a world-wide event developed by Organization for Economic Co-operation and Development (OECD) aims to evaluate the literacy of 15 year-old students in science, mathematics, etc [5]. One of the most important parts of this event is to assess the scientific literacy levels of the students. In PISA 2006, scientific literacy is gathered in 4 components, which are scientific contexts,

scientific competencies, the domains of scientific knowledge, and the student attitudes toward science. [6]

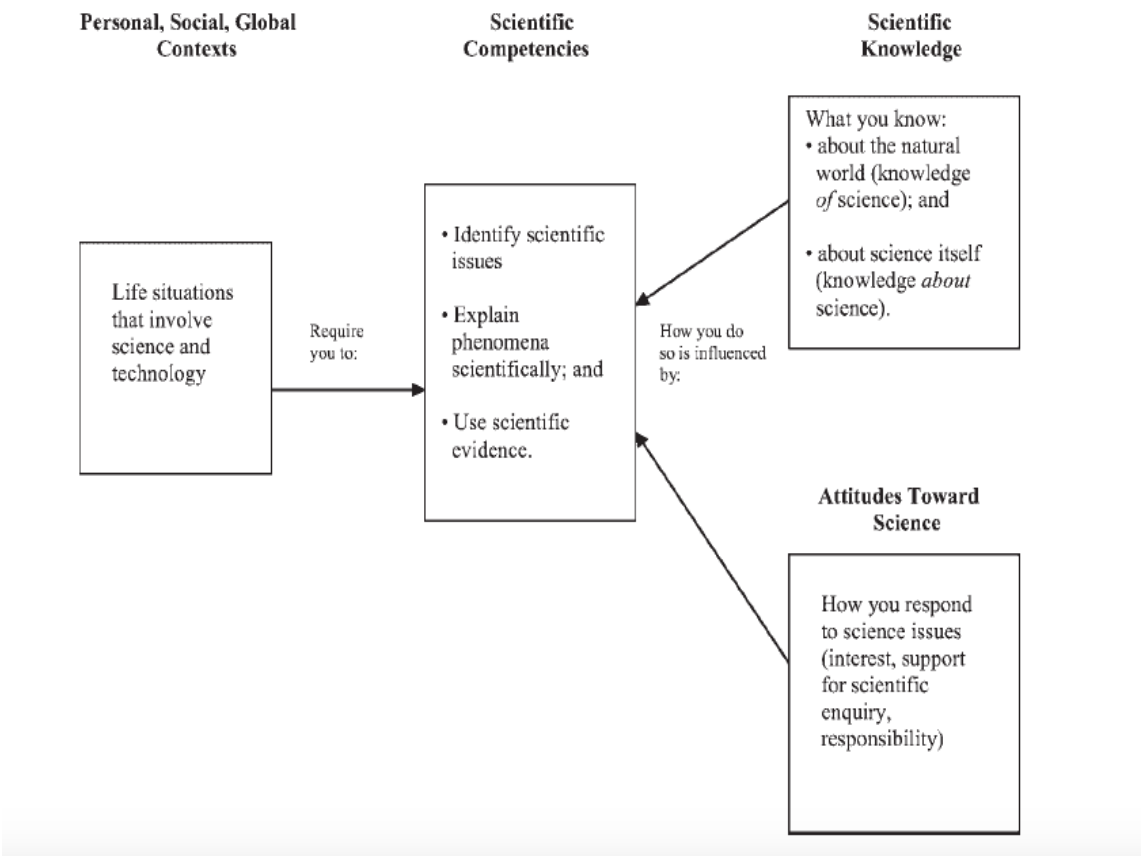

Figure 1.1 The components of scientific literacy in PISA 2006 [6]

Figure 1.1 shows the 4 components of scientific literacy defined in PISA 2006. The first component is scientific context which is about the issues that citizens expose to in daily life. Health issues, environmental issues, issues related to nature are some examples of science context that students confront as citizens in daily life. The second component is scientific competencies. It emphasizes the skills that students need to have in order to be scientific literate as reasoning skills, interpretation skills, informed-decision making skills, argumentation skills, etc. The component of scientific knowledge has two parts. One of them is *knowledge of science*, which is understanding scientific content knowledge and the other is *knowledge about science*, which is understanding how science works, nature of science. The last component is attitudes towards science. It stresses that the students attitudes is important for scientific literacy. That is, students' interests, beliefs, motivations about science affect the scientific literacy levels.

As discussed in the earlier paragraphs, scientific literacy is an ultimate aim of science education. For this aim, scientific literacy started to be included in science curriculums [3]. As in many other countries, achieving scientific literacy is determined as one of the main objective of science education curriculum in Turkey. The detailed information about the science curriculum in Turkey is explained in the following part.

1.1.2 Turkish Curriculum

According to the science curriculum published by The Ministry of National Education (MEB) in 2018 [1], the main goal of the science curriculum is to raise scientific literate students. For this aim, several objectives are defined in the curriculum. These objectives are;

a) Helping them gain the basic knowledge about astronomy, biology, physics, chemistry, earth and environmental sciences, and science and engineering practices,
b) During the process of discovering of the nature and understanding the relationship between individual-society, produce solution for the problems about these areas by adopting the scientific process skills and scientific research approaches,
c) Making them realize the interrelation among individual, environment and society; building consciousness about sustainable development for society, economy and natural sources,
d) Helping them take responsibility for the daily life problems and use scientific information, process skills and other life skills to solve these problems,
e) Helping them improve career consciousness and entrepreneurship skills for science,
f) Helping them understand how scientific knowledge is formed by the scientists, the process of forming scientific knowledge and how these knowledge is used in new research,
g) Arousing curiosity and interest, develop attitude towards the events occur in nature and immediate environment,
h) Creating awareness for working safe by making them realize the importance of security in scientific works,
i) Making them improve the skills of decision making, scientific thinking, and reasoning by using socio-scientific issues,

j) Making them adopt the principles of scientific ethics and national, cultural values, and universal moral values [1] (p. 9).

As seen in the objectives developed by MEB (2018) [1], the first objective is about the basic understanding of the scientific content knowledge about the disciplines. The other objectives generally mention about the skills that students need to have in order to achieve scientific literacy as argumentation skills, scientific process skills, etc. That is, according to the science curriculum in Turkey, nature of science is one of the components of scientific literacy. Also, the interrelationship among science, society, individual and environment is stressed in some objectives. Moreover, objective "i" emphasizes the use of socio-scientific issues to improve the skills needed to achieve scientific literacy so in order to achieve the goal of raising scientific literate students, socio-scientific issues are important issues that helps improve skills as informal reasoning, decision making, etc. Therefore, in general, the three components, which are the scientific content knowledge about the disciplines, the skills (argumentation - decision making), and understanding nature of science as how science works, and also socio-scientific issues to show the social aspect of science and the relationship between science and society, are needed to achieve scientific literacy.

These three components of scientific literacy are also emphasized in the SEE-SEP model, which is adopted as the framework of the study. It means, in parallel with the MEB objectives, the SEE-SEP model also emphasizes the three aspects of scientific literacy as MEB, which are nature of science (NOS), socio-scientific issues (SSI), and scientific concepts to achieve scientific literacy. The detailed information about the framework and the will be discussed in the framework chapter.

1.1.3 Socio-Scientific Issues (SSI)

The origin of socio-scientific issues is grounded on "Science-Technology-Society" (STS) approach. The idea behind STS approach was integration of science, technology, and society in science education to achieve meaningful learning [7]. In 1970's, "All people need some science education so that they can think, speak, and act on those matters, related to science, which may affect their quality of living" [8] expression emerged to stress the need to integrate science and society (p. 16). Aikenhead (1994) [9] defined the STS education as;

> Good science-technology-society science education is relevant, challenging, realistic, and rigorous. STS science teaching aims to prepare future scientists/engineers and citizens alike to participate in a society increasingly shaped by research and development involving science and technology. (p. 59)

Therefore, STS was seen as a new approach in science education that integrates science, technology and society. Solomon (1993) [8] defined the features of STS approach as;

- An understanding of the environmental threats, including global ones, to the quality of life.

- The economic and industrial aspects of technology.
- Some understanding of the fallible nature of science.
- Discussion of personal opinion and values, as well as democratic action.
- A multi-cultural dimension (p. 19).

However, STS approach had some drawback as it has lack of ethical and moral constructions [9]. Zeidler, Sadler, Simmons, & Howes (2005) [10] rationalize replacing STS with SSI as;

> "In order to advance the claim that science educators should attend to SSI related to cultivating the morality of our students to achieve a "functional" view of scientific literacy, a coherent conceptual framework must be developed that is flexible enough to allow for multiple perspectives while enabling educators and curriculum specialists to better understand the moral growth of the child" (p. 360).

That is, they emphasized that in order to achieve scientific literacy, a more coherent conceptual framework should be involved in science education, which is SSI. Then they developed a model to show the elements of socio-scientific approach to achieve scientific literacy.

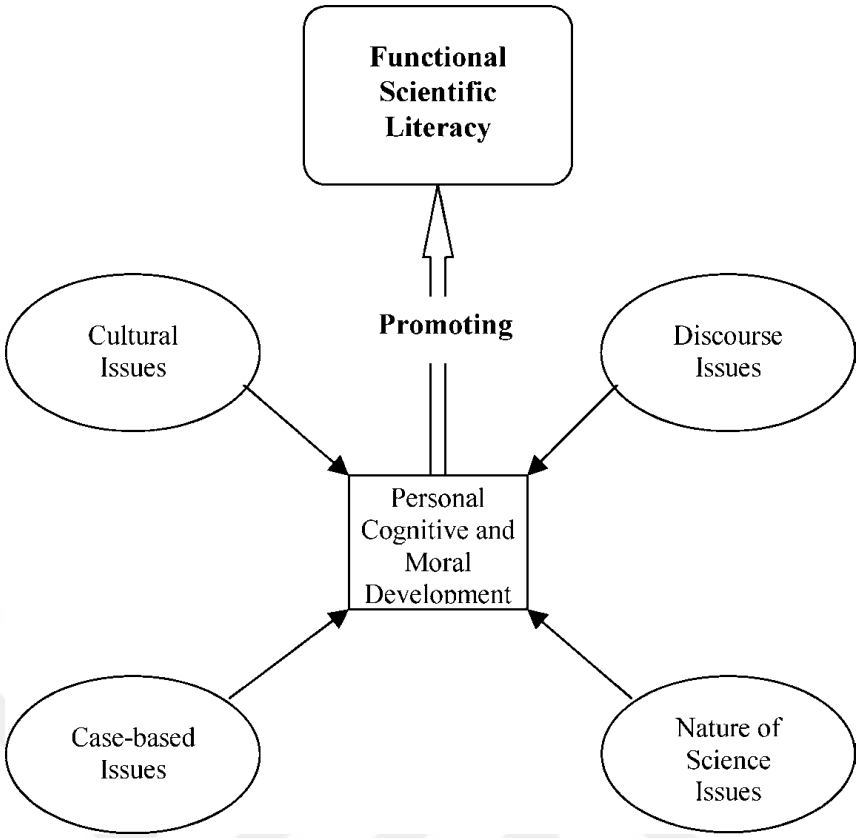

Figure 1.2 The elements of SSI for scientific literacy [10]

Figure 1.2 shows the elements of SSI to achieve scientific literacy. It has some similarities with the features described for STS. For example, “discussion of personal opinion and values” component means discourse issues, “economic, industrial aspects” means case-based issues, “multi-cultural dimension” emphasizes cultural issues, “some understanding of the fallible nature of science” mentions about nature of science issues. However, in the middle of the Figure 1.2, “personal, cognitive and moral development” component of SSI is put and all the other components are related to this component. That is, STS does not involve the personal, cognitive and moral development aspects but SSI does. Also, by promoting personal, cognitive and moral development, with the help of other components, functional scientific literacy can be achieved.

Sadler and Zeidler (2005) [11] has defined the features of SSI as;

- Causes conflicts in society by its nature,Open to discussions,

- Problematic,

- Can be assessed from different perspectives,

- Cannot be concluded easily,

- Includes moral and ethical issues in general. (p. 7)

As seen in the features of SSI defined by Sadler and Zeidler (2005) [11], socio-scientific issues are complex, requires discussion, and the process of decision making is not easy because it requires to think from different perspectives as ethics, morality, scientific, social, economic, environmental etc. Therefore, one of the most important features of SSI is that it needs to be multi-perspective. That is, socio-scientific issues should be evaluated in multi-perspective approach. Chiappetta, Koballa, and Collette (1998) [12] defined SSI as "socio-scientific problems are ill-defined, multidisciplinary, heuristic, value-laden (invoking aesthetic, ecological, economic, moral, educational, cultural, religious, and recreational values), and constrained by missing knowledge" (p. 3). Also, Zeidler and Nichols (2009) [13] explain that socio-scientific issues contribute interdisciplinary connections. Therefore, it is clear that one of the curial aspects of SSI is multi-perspective and multi-disciplinary feature, as stressed in the framework of this thesis, called SEE-SEP model. The multi-disciplinary and multi-perspective features of SSI lead students to think about different views and aspects of the issue so it makes decision-making process complicated.

According to Zeidler (2003) [14], the decision making process for socio-scientific issues should be depended on discussions, argumentation by considering the value aspects of the issues. Also, Driver, Newton and Osborne (2000) define argumentation as the central component for decision making process [15]. Therefore, argumentation should be an important part of SSI, when considering the decision-making process and multi-perspective and multi-disciplinary feature of SSI.

1.1.4 Argumentation

Argumentation plays an important role in science and science education [16]. Also, argumentation should be involved in SSI because it helps students "practice education for citizenship" [13] (p. 54). In the literature, there are some argumentation models. One of the most famous model is Toulmin's Argument Pattern (TAP) developed in 1958 [17]. TAP includes five components, which are data, claim, warrant, backing, and rebuttal (Figure 1.3).

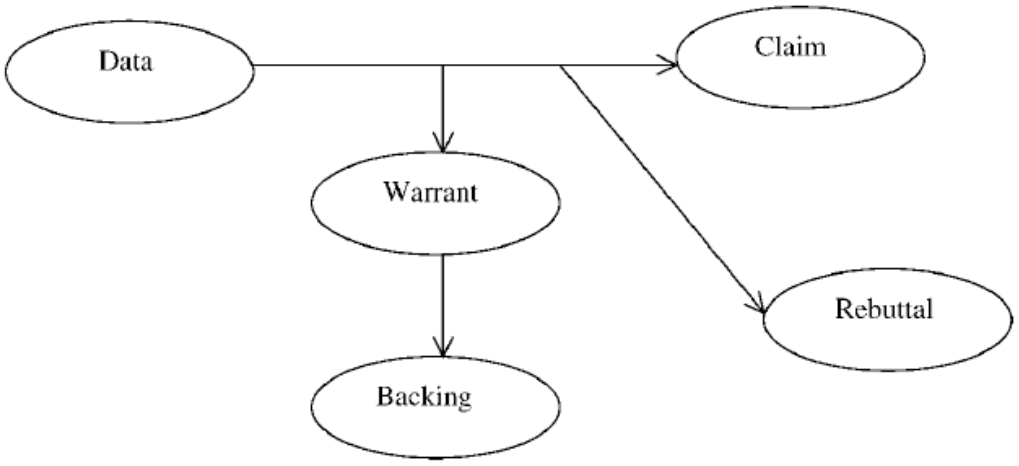

Figure 1.3 Toulmin's argument pattern [17]

As seen in Figure 1.3, the components are interrelated. Claim, which is the argument presented for the issue, is supported by data. Warrant means the link between the claim and data. Backing supports warrant and rebuttal, which disproves claim, shows the aspects that the claim is not true. However, Erduran, Simon, and Osborne (2004) [17] argued that this pattern has some methodological problems as ambiguity. It means, Toulmin's argument pattern defines what the claim, data, warrant, rebuttal and backing are separately but sometimes it becomes complex to differentiate claim, data, warrant and rebuttal, and backing.

Then, Erduran and Jimenez-Aleixandre (2007) [18] defined the dimensions of introduction of argumentation clearly in science classes as;

- Supporting the access to the cognitive and metacognitive processes characterizing expert performance and enabling modelling for students,

- Supporting the development of communicative competences and particularly critical thinking,

- Supporting the achievement of scientific literacy and empowering of students to talk and to write the languages of science,

- Supporting the enculturation into the practices of the scientific culture and the development of epistemic criteria for knowledge evaluation,

- Supporting the development of reasoning, particularly the choice of theories or positions based on rational criteria (p. 5).

The first dimension is about including cognitive processes into argumentation. The second one emphasizes the critical thinking and communication skills during argumentation. The third dimension shows the effect of argumentation in scientific literacy. The fourth one stress the epistemology of science and the last one emphasizes the role of reasoning in argumentation. It can be concluded that argumentation helps development of cognitive, critical thinking, reasoning skills, as well as improving scientific literacy and nature of science, which are in parallel with the SSI and scientific literacy, discussed in the previous sections. Therefore, argumentation is one of the useful ways to achieve scientific literacy and for SSI and different sources can be used when arguing about a socio-scientific issue and there are many factors that affect argumentation patterns.

One of the factor that affect argumentation patterns is the content knowledge. In the literature, there are some models that show the effect of content knowledge on socio-scientific argumentation. Sadler and Fowler (2006) [19] designed a model called "Threshold Model of Content Knowledge Transfer for Socioscientific Argumentation" (Figure 1.4). The emphasis of this model is the effect of content knowledge on socio-scientific argumentation quality.

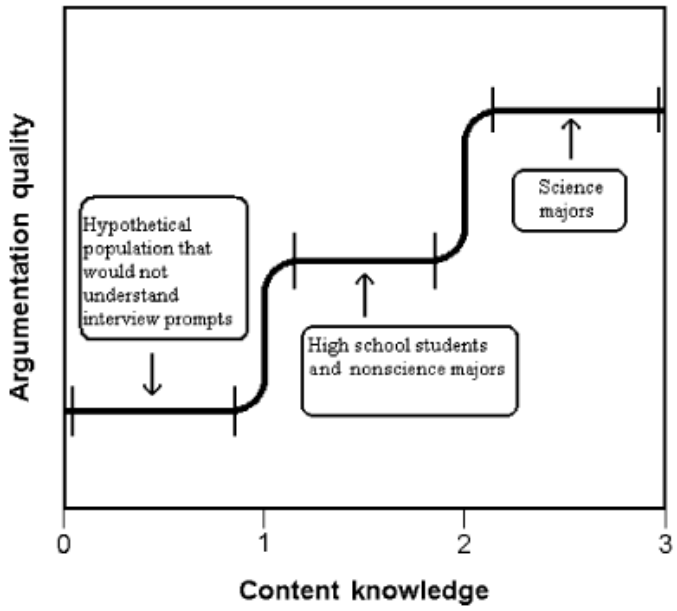

Figure 1.4 Threshold model of content knowledge transfer for socioscientific argumentation [18]

They stressed that the argumentation quality of science majors is higher than the non-science majors. As shown in Figure 1.4, the scientific content knowledge of science majors are better than the other groups and also their argumentation quality is higher than the others. That is, scientific content knowledge about the given socio-scientific issue is one of the factors that affect the quality of arguments. Therefore it is an important aspect of socio-scientific argumentation.

However, Chang and Chiu (2008) claims that different aspects and sources affect the argumentation about SSI and these different sources forms the core [2]. That is, not only the scientific content knowledge but also different aspects affect the argumentation about SSI because SSI has multi-perspective and multi-dimensional feature. For example, society, culture that students live, education system that students possess may affect the argumentation so, argumentation about SSI should be viewed in several dimensions. Therefore, it should not be evaluated in one perspective or in one dimension because it requires to think about different views, aspects, dimensions, disciplines by its nature.

1.1.5 Informal Reasoning and Argumentation regarding SSI

As mentioned in the last dimension of introduction of argumentation, argumentation should support the developments of reasoning skills. Sadler (2006) [16] explained that "argumentation is the expression of reasoning in the context of ill-structured, controversial, and debatable problems that may possess multiple, plausible solutions and be viewed from a variety of perspectives" (p. 325). Also, Means and Voss (1996) [20] argued that ''Informal reasoning assumes importance when information is less accessible, or when the problems are more open-ended, debatable, complex, or ill-structured, and especially when the issue requires that the individual build an argument to support a claim'' (p. 514). Therefore, by considering the ill-structured, complex, open to discussion, and multi-perspective features of SSI, argumentation including informal reasoning about SSI may be an effective way.

Voss and Means (1991) [21] argued about the reasoning as;

> Reasoning is typically defined as an inferential process by which a person, beginning with some given information or premise(s), makes an inference that enables that individual to reach a conclusion or provide some new (inferred) information that was not given (e.g., Halpern,1984). However, the inference does

> not stand by itself. It requires justification, the justification consisting of what permits the individual to go from premise to the conclusion. The justification may of course be in the form of a premise, as one typically finds in deductive reasoning. But reasoning also involves generating support for a claim, or providing reasons for a conclusion, and in this case also, the support requires justification. (p. 13)

As Voss and Means [21] argued, reasoning requires supporting reasons provided for arguments. That is, justification of the claims is one of the important aspect of reasoning during argumentation. Whether the justification is based on scientific evidence or not, it is important to investigate the underlying reasons in argumentation. In this way, informed decision making and the conclusion for the issue that is argued can be achieved. Especially, it is important to understand the underlying reasons for the arguments when making informed decisions.

Bekker et. al. (1999) defined informed decision making as;

> "An informed decision is one where a reasoned choice is made by a reasonable individual, using relevant information about the advantages and disadvantages of all the possible courses of action, in accord with the individual's beliefs" (p.1). [22]

In this definition, a reasoned choice is emphasized. That is, the choice which is the decision, should be supported with a reason to achieve informed decision-making. People need to be aware of the factors that affects their decisions and be informed about the reasons of their decisions to make informed decisions. Therefore, in this thesis, the students are asked to write not only their arguments but also their supporting reasons for their decisions, with advantages and disadvantages of the issue.

1.1.6 Ethical Concerns for Socio-Scientific Issues Related to Genetic Engineering

During the process of making decision, people utilize morality and ethics [23]. Sadler (2004) [23]stressed that "decision-makers cannot compartmentalize science and ethics and still deliver an informed decision; ethics and morality are inseparable from science in the context of socioscientific issues" (p. 42). That is, two of the important components of SSI reasoning and argumentation is ethics and morality. Therefore, socio-scientific argumentation and reasoning cannot be considered without ethical and moral concerns.

However, the importance of ethical and moral concerns may depend on the nature of the issue. Sadler and Zeidler (2004) [24] concluded that ethical and moral considerations are the two important considerations that students use when they try to solve socio-scientific issues, related to genetic engineering. It means, for socio-scientific issues related to genetic engineering, ethical and moral concerns are in the foreground for students. The socio-scientific issue of this thesis is CRISPR method, which is related to genetic engineering. Therefore, moral and ethical concerns should be considered as the main considerations during argumentation.

1.2 Objective of the Thesis

The aim of this thesis is to investigate the supporting reasons that 7th grade students use when they are writing arguments about the effects of using CRISPR method in the future on humanity. For this aim, an SSI unit about CRISPR method is designed and instructed to twenty eight 7th grade middle school students for 4 weeks in a middle school in İstanbul. The research question is;

"What supporting reasons do the middle school students use when arguing in a socio-scientific issue related to gene editing method (CRISPR)?"

The detailed information about the framework of the SSI unit design, the analytical framework of the thesis are discussed in the following chapter.

1.3 Hypothesis

Qualitative research approach is adopted to this thesis. Therefore, the researchers do not have a need to state any hypothesis about the research question. However, the importance of the study is discussed in detail in the next steps.

1.3.1 Importance of the Thesis

The importance of scientific content knowledge in SSI-based instruction has been argued in the **"**Threshold Model of Content Knowledge Transfer for Socioscientific Argumentation" developed by Sadler and Fowler (2006) [18]. In this thesis, an SSI-based unit is developed, which aims to make the students understand the scientific content knowledge about the focal issue with the help of reasoning practices, disciplinary core

ideas, scientific practices, cross-cutting concepts, and culminating activities. Therefore, the students could benefit from the scientific content knowledge they obtain throughout the SSI-based unit during argumentation.

The focal issue of the unit is "CRISPR/Cas9 Method", which is a newly developed gene editing method in genetic engineering. Since it is a new method, there has not been any study about the use of CRISPR method as the focal issue in SSI-based unit, including argumentation about CRISPR method. It means, CRISPR method is a new socio-scientific issue that has not been discussed by students before, which makes this thesis unique.

The written arguments of the students about the use of CRISPR method in the future is analyzed according to the SEE-SEP model. In the literature, one of the features of the socio-scientific issues is that it is multi-dimensional. For example, as mentioned before, Chiappetta, Koballa, and Collette (1998) defined SSI as "socio-scientific problems are ill-defined, multidisciplinary, heuristic, value-laden (invoking aesthetic, ecological, economic, moral, educational, cultural, religious, and recreational values), and constrained by missing knowledge" [12] (p. 3). Also, SEE-SEP model emphasize the multi-dimensional and multi-perspective feature of SSI.

Moreover, in the literature, it is emphasized that for issues related to genetic engineering, it is important to think about the ethics and morality perspectives. The socio-scientific issue in this research is CRISPR method, which is a gene editing method in genetic engineering. Therefore, for this thesis, it is important to involve the ethics and morality perspective throughout the process of data analysis and SEE-SEP model includes ethics/morality subject area as one of the criteria when analyzing the arguments of the students.

In short, students need to view the socio-scientific issues in multi-dimensional perspective to form their own beliefs and when discussing about an SSI ethical and moral concerns are on the core. As mentioned before, SEE-SEP model also emphasizes the multi-dimensional and multi-perspective features of SSI and it has ethics/morality subject area. By considering all these features of SSI and SSI discussion, SEE-SEP model accepted as a comprehensive model to analyze the students' arguments. Therefore, it is adopted as the analytical framework of this thesis. (Detailed information about the SEE-SEP model will be discussed in the further chapters.)

CHAPTER 2

FRAMEWORK

2.1 Framework for Socio-Scientific Issue (SSI)-Based Instruction

Socio-scientific issue (SSI)-based science instruction has been used as an effective way to demonstrate the social aspects, impacts of science in daily life and to achieve scientific literacy. For years, research that presents SSI based instruction as an effective way to achieve desired goals in education as development of epistemological understandings, has done but few studies introduce ways and resources to advance the implementation of SSI in classes [25]. Therefore, limited resources for the use of SSI make it difficult for educators and resources to implicate SSI in curriculum and research [26]. For this reason, Sadler, Foulk and Friedrichsen [25] have designed a model as a guide to develop an SSI unit and in the thesis, this model is used as a framework during the development process of the SSI unit about CRISPR method.

2.1.1 Development of the Socio-Scientific Issue Teaching and Learning Models

The current SSI teaching and learning model by Sadler, Foulk, and Friedrichsen (2017) [25] has evolved from series of models presented by several researchers. In this section, some models that helped the formation of the current model will be presented. It is important to explain that the general idea behind and the features of the presented models are almost the same but the difference is that the current model fills some gaps as mentioned in the following section.

2.1.1.1 SSI Teaching and Learning Model by Presley et al. (2013)

Presley et al. (2013) [27] developed a framework for SSI teaching by reviewing theoretical and practical studies about SSI in 2013. They introduced a flexible model including the core elements of SSI based instruction and SSI teaching for classroom & curriculum use and research designs [27]. The core elements of this model are *Design Elements, Learning Experiences*, and *Teacher Attributes*. Also, the model includes two other elements as *Classroom Environment*, and *Peripheral Influences*. (Figure 2.1)

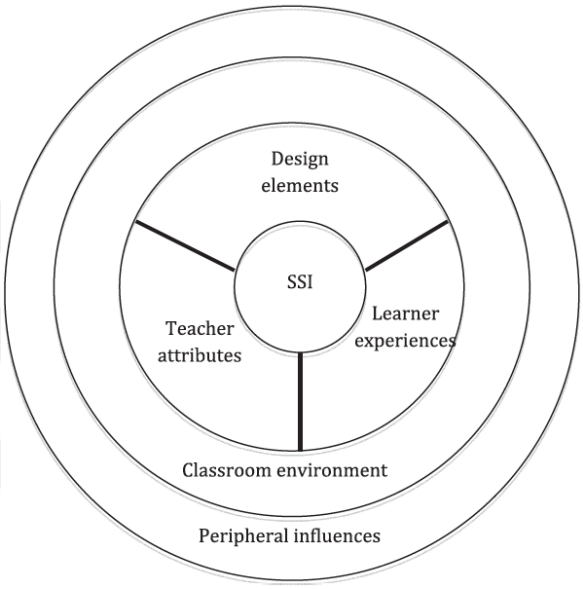

Figure 2.1 Representation of SSI based instruction model developed by Presley et al. in 2013 [27]

- ✓ *Design Elements*

In this element, four important features are explained as;

- Building instruction around a compelling issue.

- Presenting the issue first.

- Providing scaffolding for higher order practices (e.g. argumentation, reasoning, and decision making).

- Providing a culminating experience. [27] (p.27)

The first feature emphasizes that in an SSI-based instruction the unit should be designed around a compelling issue related to science. That is, the compelling issue should be at the focus. For this aim, the second feature explains that the compelling issue should be given at the beginning of the unit so that the learners can realize the social aspect of science. The third feature mentions about making student to challenge more and use higher order skills as argumentation. These higher order skills are also important for the fourth feature because a successful culminating activity, in which the learners reflect what they have learned and relate the scientific knowledge with the compelling issue, should include higher order skills and experience. Apart from these feature, media and technology use are also emphasized to reach more resources and enhance learning.

- ✓ *Learning Experience*

The second core element of the model is learning experiences. As in the design elements, four fundamental experiences that learners should experiences are explained. They are;

- Engaging in higher-order practices (e.g., reasoning, argumentation, decision making and/or position taking).

- Confronting scientific ideas and theories related to the issue being considered.

- Collecting and/or analyzing scientific data related to the issue being considered.

- Negotiating social (e.g., political and economic) dimensions of the issue being considered. [27] (p.28)

Engaging in higher-order practices is also emphasized in design elements as a part of the SSI unit design. Here, it is explained as an experience that learners should be engaged in. The second fundamental experience explains that learners should comprehend the scientific content knowledge. Then, with the help of individual works, the learners should analyze scientific data to develop arguments about the related issue, which is the third fundamental learning experience. The final experience emphasizes the social aspect of learning science. In this part, learners need to have a negotiation on the issue by considering the social and scientific experiences they had. Also, it is recommended to involve ethical considerations and nature of science (NOS) if the issue is appropriate.

- ✓ *Teacher Attributes*

The last core element of SSI teaching and learning model is teacher attributes. In order to conduct SSI-based instruction successfully in classrooms, teachers need to have some necessary attributions as;

- Familiarity with the issue being considered.

    a. Knowledgeable about the science content related to the issue.

    b. Aware of the social considerations associated with the issue.

- Teachers as learners.

    a. Honest about knowledge limitations.

    b. Willing to position self as a knowledge contributor rather than sole authority.

- Willingness to deal with uncertainties in the classroom. [27] (p.29)

The first attribution is about the familiarity of the teacher with the issue in terms of both scientific content knowledge and the social aspect of the issue. Socio-scientific issue has 2 dimensions; scientific and social. Therefore, when a teacher instructs a socio-scientific issue, s/he should be aware of the both dimensions of the issue. The second attribution is about the position of the teacher in class. It is important for teacher to position herself/himself as the contributor of the issue and scientific knowledge. Also, the teacher should not be afraid of talking about the limitations about the issue. Finally, because socio-scientific issues are complex, there may be some uncertainties among the learners. When the uncertainties occur in classrooms, the teacher should comfort the learners and take it into an advantage.

- ✓ *Classroom Environment and Peripheral Influences*

The second and third layer of the model is classroom environment and peripheral influences and these layers affect the core aspects of SSI-based instruction. For a successful SSI teaching and learning, the classrooms should be interactive, respectful, safe and highly participated environments. Also, as shown in the Figure 2.1, the peripheral influences are the outer most layers, which also affect the classroom environment. These

peripheral influences (policies, school, community, etc.) should be supportive to the implementation of SSI teaching and learning, provide materials, curriculum flexibility for SSI based instruction, etc.

2.1.1.2 The Socio-Scientific Issue Unit Design Model developed by Friedrichsen, Sadler, Graham & Brown (2016)

This design model developed by Friedrichsen, Sadler, Graham, and Brown (2016) [26] has also the same idea with the model developed by the Presley et al. (2013) [27]. The theoretical background is similar but there are some added points and detailed information about the unit and lesson plans. (Figure 2.2)

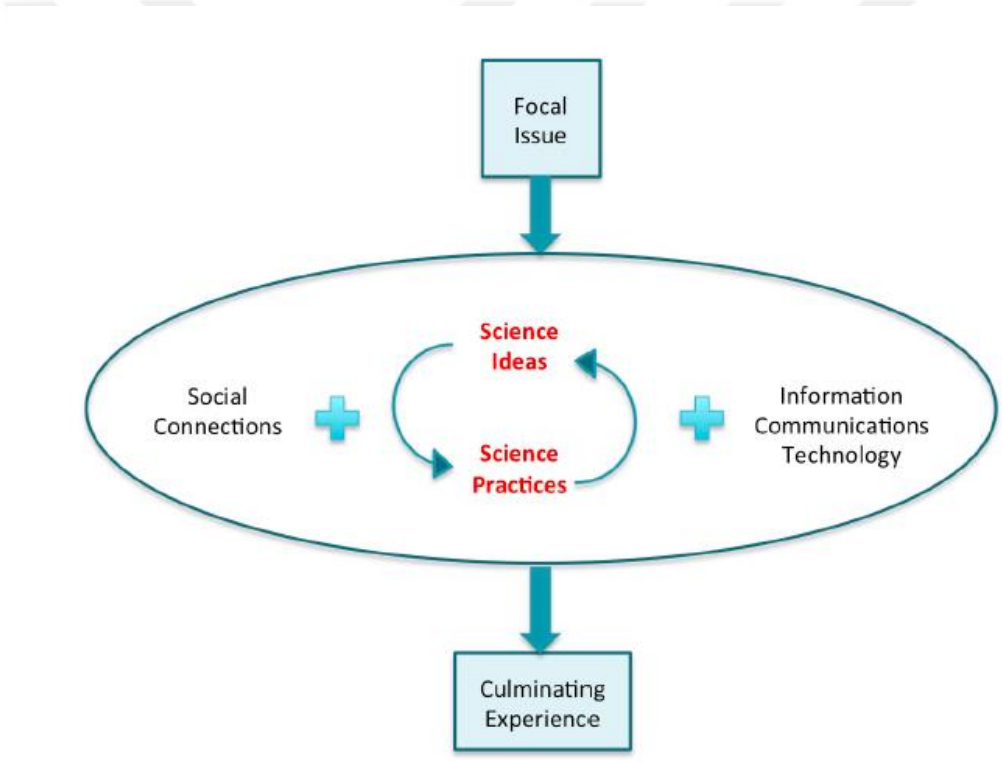

Figure 2.2 Representation of the SSI unit design by Friedrichsen, Sadler, Graham & Brown in 2016 [26]

In this model, the unit starts with the focal compelling issue. Similar to the previous model developed by Presley et al. (2013) [27], the focal compelling issue is presented at first and the unit is developed around this issue. During the learners' learning experience, three elements are shown as social connections, scientific ideas and scientific practices and information communications technology. Also, all the elements are interacted with each

other. That is, learners need to consider the social aspect of the issue and relate it with the scientific knowledge with the help of practices. In order to reach and analyze information, and share ideas, Information communications technology (ICT) should be integrated. At the end of the unit, learners synthesize what they have experience during the SSI-based instruction. It means, they relate the scientific content knowledge with the social aspects of the issue with an activity.

2.1.1.3 The Current SSI Teaching and Learning Model developed by Sadler, Foulk, and Friedrichsen (2017)

The current socio-scientific issue teaching and learning by Sadler, Foulk, and Friedrichsen (2017) [25] is the model that is used as a framework for the unit developed in this thesis. This model has also similar theoretical background with the previous models. However, it emphasizes the gaps and presents an updated/current model for SSI teaching and learning. Besides the other models, in this model, the objectives that the learners need to acquire at the end of the unit are determined (Figure 2.3). Also, it is developed according to the Next Generation Science Standards (NGSS) [25].

The model is developed at the end of the 4 four design-based research projects. Figure 2.3 shows the graphical representation of the model. It has 2 dimensions. The first dimension (left side of the Figure 2.3) explains the learning experiences during the SSI teaching and learning process. As in the previous models mentioned before, in the first phase, the unit starts with the focal issue and the issue is connected to scientific knowledge and social aspects. The second phase is arranged similar to NGSS. NGSS explains science learning in 3 parts; scientific and engineering practices disciplinary core ideas, and crosscutting concepts [28]. Disciplinary core ideas involve four discipline areas and it emphasizes the content of the intended discipline (ex. earth science). Crosscutting concepts are explained as linkage among the disciplines and it helps learners make sense of the knowledge by making connection among disciplines (ex. cause and effect). Finally, scientific and engineering practices help learners to get familiar to the practices that scientists and engineers follow (ex. asking questions) [29].

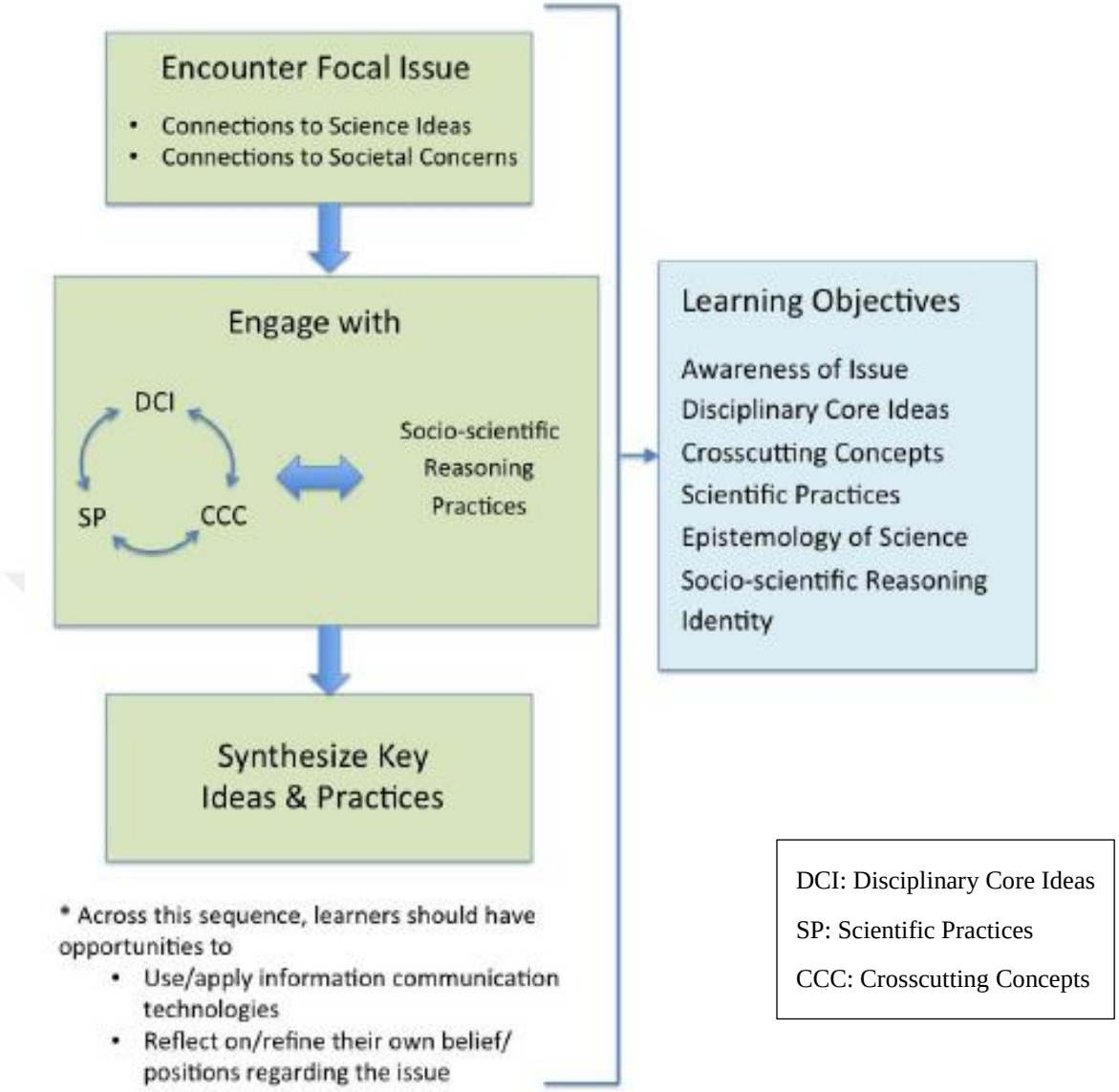

Figure 2.3 Representation of the current SSI teaching and learning model by Sadler, Foulk, and Friedrichsen in 2017 [25]

In this method, disciplinary core ideas, crosscutting concepts and scientific practices are interacted with each other and with socio-scientific reasoning practices. In this way, learners need to consider the scientific and social aspect of the issue. The last phase is synthesize key ideas and practices is very similar to the culminating experience in the model developed by Friedrichsen, Sadler, Graham, and Brown (2016) [26]. In this phase, learners are expected to synthesize what they have learned and experience.

Other than these parts, there are 2 recommended features; using information communications technology and reflecting or refining own perspectives. Using information communications technology is also emphasized in the previous method but in this method it is recommended because socio-scientific issue are current issues and there may be new information or news about these issue. In order to reach these new advancements or information, learners may need technology use. The other recommended feature is reflecting and refining own perspectives about the issue. That is, the learners should reflect what they think about the issue individually.

The second dimension of the model (right side of the Figure 2.3) explains the learning objectives, that are not included in the other models. It has 7 categories as awareness of the issue, disciplinary core ideas, crosscutting concepts, science practices, epistemology of science, socio-scientific reasoning and identity. Awareness of the issue, disciplinary core ideas, crosscutting concepts, science practices and socio-scientific reasoning are explained in the previous dimension. Epistemology of science is mostly related to nature of science (NOS) and identity emphasizes to take a position and developing identity for the learners.

In this thesis, an SSI-based unit according to the SSI teaching and learning model by Sadler, Foulk and Friedrichsen (2017) [25] is developed. The learning experiences and learning objectives of the model presented in the previous paragraphs are included in the unit. The focal compelling issue is determined as “CRISPR/CAS9” which is a new technique in gene editing. The focal issue “CRISPR Method” is discussed in the following.

2.2 CRISPR Method

The focal compelling socio-scientific issue in this thesis is a gene editing method called CRISPR/Cas 9. CRISPR/Cas 9 is a new approach in genetic engineering. It is a new approach used in genetic engineering but it is actually a mechanism of some bacteria used to protect themselves from viruses. In 2000’s, Philippe Hovarth and Rodolphe Barrangou has discovered that some bacteria, that are facilitated in making cheese and yogurt, use a mechanism to cut the genome of the viruses invading them [30]. In this mechanism, the bacteria could identify the DNA structure of the invading virus and in order to protect themselves, bacteria cut the DNA of the virus. The bacteria could identify the viruses by

using an RNA that matches up with the DNA structure of the invading viruses. That is, make a copy of some parts of the invader viruses' DNAs and keep them in its DNA as the "Wanted RNAs" [30] (p.484). Therefore, the bacteria could identify when a wanted virus invades thanks to the wanted RNA. After it identifies, the enzyme called "Cas9" starts to work. The copied RNA leads the cas9 enzyme to go to the intended DNA part and this part is cut by the cas9 enzyme. In this way, bacteria could protect themselves from the viruses.

Recently, scientists try to use this method in human. However, the difference between the mechanism of bacteria and human is that bacteria copy the leading RNA but for human it is not possible. Therefore, scientists use an RNA of the target DNA part and then the cutting process starts. The target DNA part may be responsible for some diseases as cancer, Huntington, AIDS that many people suffer from and in some cases, there is not a certain type of treatment for some serious diseases. Therefore, people suffer from these serious diseases may use this method as a treatment method.

Although, the method seems as a powerful cure for some serious diseases, the risks of this method cannot be underestimated. For example, there is a lack of knowledge about the reaction of the human immune system to this method [31]. Also, this method can be used in the embryonic level. That is, it can be used to design babies as determining the eye color, hair color, length of a baby, etc. Not only the physical design but also the mental and health design is possible for babies. For example, parents who have a genetic disease don't want their babies to have the same genetic disease and may prefer to design their baby without this disease by using this method. Moreover, parents who want their babies to have high intelligence level may prefer to use this method. Therefore, ethical considerations about "designing babies" show up because it is way to play with the natural flow of life.

As seen in the examples, CRISPR/Cas9 method can be used for different purposes. There may be several perspectives and ideas about using or not using this method on human so it is a complex issue which is worth to discuss as a socio-scientific issue. Therefore, in this thesis, CRISPR/Cas9 method is used as the focal compelling issue in the SSI unit.

2.2.1 Design of CRISPR/Cas9 Unit

The unit was designed by the researcher according to the SSI-based instruction model developed by Sadler, Foulk and Friedrichsen (2017). As shown in Figure 2.3, the model requires to begin the unit with a focal compelling issue; which is CRISPR/Cas 9 method in the unit used in this thesis. Since CRISPR/Cas9 method is related to genetics and the concepts as DNA, gene, chromosome, etc., the disciplinary core ideas is determined as "Life Science" mentioned in NGSS [29] and "DNA and Genetic Code" in MEB [1]. The unit expectations are;

- Construct explanations about the function and structure of DNA. (All cells contain genetic information in the form of DNA molecules.) (modified from NGSS, HS-LS-3-1),

- Develop and use a model to describe the phenomena. (NGSS, MS-LS3-1), (NGSS, MS-LS3-2),

- Science and engineering are influenced by society and society is influenced by science a-and engineering. (NGSS, HS-LS3-3),

- Write arguments focused on discipline content. (NGSS, MS-LS1-4),

- Construct relationship among DNA, gene and chromosome by giving explanations. (MEB, F.8.2.1.1),

- Show DNA on a model. (MEB, F.8.2.1.2),

- Explain how DNA replication occurs (without using the word "replication"). (MEB, F.8.2.1.3).

The main question of the unit is "How might using CRISPR method affect the future of humanity?" which is asked at the beginning and at the end of the unit. That is, the unit is developed around this question. Therefore, "Cause and Effect" dimension of crosscutting concepts is emphasized in this unit.

The scientific practices facilitated in this unit are;

- Developing and Using Models,

- Analyzing and Interpreting Data,

- Engaging in Argument from Evidence,

- Obtaining & Evaluating & Communicating Data.

The disciplinary core idea, crosscutting concept and the scientific practices are all interacted with each other throughout the unit. These are also related to the socio-scientific reasoning practice, which is argumentation. Written arguments are used to make reasoning about the main question "How might using CRISPR method affect the future of humanity?". Finally, students have a chance to synthesize what they experienced throughout the unit with a culminating activity which is poster presentation or role-playing (depends on the preference of the students).

In the model, learning objectives are explained as awareness of the issue, disciplinary core ideas, crosscutting concepts, scientific practices, socio-scientific reasoning practices, epistemology in science and identity. Awareness of the issue is presented at the beginning of the unit by videos and discussions. Disciplinary core ideas (life science), crosscutting concept (cause and effect), scientific practices (ex. asking questions), and socio-scientific reasoning practices (written arguments) are all interacted with each other throughout the unit. Epistemology in science is stressed as relating the inspiration of scientists from bacteria when develop CRISPR/Cas 9 method in human. Also, CRISPR/Cas9 method is connected with genetic engineering. Finally, the objective of identity is achieved by asking the students to write their own beliefs about the effects of CRISPR/Cas9 method on human in the future. The written arguments collected from the participant students are analyzed according to the analytical framework adopted to the thesis.

2.3 Analytical Framework: SEE-SEP Model

Ratcliffe and Grace (2003) explain that socio-scientific issues cover different subjects so it has a cross-disciplinary feature [32]. It is also emphasized that different dimensions as scientific knowledge and different perspectives as values, ethics, etc are covered during the reasoning process about a socio-scientific issue [33]. Therefore, SSI involves cross-disciplinary, multi-dimensional and multi-perspective features. It means, separate views are included by its nature. Shu-Nu Chang-Rundgren and Carl-Johan Rundgren (2010) [33] developed a holistic view which is called "SEE-SEP Model" (sociology/culture (So), environment (En), economy (Ec), science (Sc), ethics/morality (Et), and policy (Po)) for socio-scientific issues to gather the views on roof. They defined six SSI role in science education.

✓ *Beyond STS to the achievement of scientific literacy*

In 1980's, in order to achieve meaningful learning, the idea of including the relationship among science, technology and society (STS) in science education emerged and Science-Technology-Society approach became widespread [7]. However, according to Sadler (2004) [23], STS has lack of some features that SSI has like moral and ethical component. Therefore, Chang-Rundgren and Rungren (2010) argue that SSI help students to scientific literacy by serving a context [33].

Figure 2.4 shows the relationships among school science, SSI, and scientific literacy [33]. In this Figure, it is stressed that scientific literacy is achieved when the learners are aware of nature of science (NOS), the relationship between science, technology, society, and the scientific content knowledge which are involved in SSI.

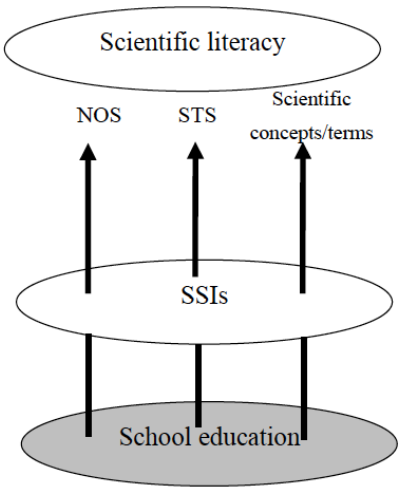

Figure 2.4 Representation of the relationships among school education, SSI, and scientific literacy [33]

✓ *Transferring content knowledge and skills to real context*

In this role, relating the scientific content knowledge with the social aspects of the issue is emphasized. It is argued that SSI helps transfer of scientific content knowledge to social context. For example, when students making a decision on the use of pesticide in agriculture, they need to know the scientific effect of it on agricultural products, on human and also, they need to consider the social aspects of using pesticide. That is, when they decide, they transfer their scientific content knowledge to the real-life context about the use of pesticide in agriculture.

- ✓ *Enhancing decision making and critical thinking*

As mentioned in the role 2 (Transferring content knowledge and skills to real context), in SSI instruction, in terms of pesticide use in agriculture, students need to make a decision in some SSI contexts. That is, they are encouraged to make informed decision making via critical thinking. For example, the students in pesticide example, should think about different aspects of the issue. They need to consider the scientific content knowledge and relate it with the social effects of the issue. By doing that, critical thinking and informed decision making skills are enhanced. However, not only the content knowledge and social aspects are involved in decision making and critical thinking process but also students' personal lives, beliefs, experiences are important.

- ✓ *Promoting science communication*

SSI is generally connected with informal argumentation. There are different ways to conducting argumentation as written argumentation, group argumentation, etc. In all cases, students have a chance to express their ideas, beliefs and arguments and use argumentation skills to communicate. Therefore, scientific communication is achieved when SSI involves argumentation.

- ✓ *Inducing interest in learning science*

There are many studies show that SSI instruction could improve the science interests of students. Therefore, engaging students in SSI methods may make them more interested in science. Sadler (2009) have discussed that students engaged in SSI instruction more is more likely to get involved in science at college level [34].

- ✓ *Providing cross-disciplinary concepts*

In the literature, there are studies that show different aspects that affect the SSI. Sadler and Zeidler (2004) [24], emphasized that when thinking about the issues related to genetic engineering, moral and ethical issue are in the foreground. Other examples may be the personal experiences, scientific content knowledge, environment, policy, etc.

Besides these roles of SSI, it also has a multi-dimensional feature. Socio-scientific issues are multi-dimensional and multi-disciplinary issues. That is, socio-scientific issues cover social, scientific dimensions and relates these dimensions with different disciplines. The multi-perspective feature of SSI may cause these issues to be seen as complex to analyze. Considering all the roles and multi-dimensional feature of SSI, Chang-Rundgren &

Rundgren (2010) [33] developed a holistic model to show the multi-dimensional characteristic of socio-scientific issue, called as “SEE-SEP Model”.

SEE-SEP model includes three aspects; knowledge, value, and personal experience. These three aspects of SSI are connected to six subjects areas; sociology/culture, ethics/morality, policy, environment, economy, and science (Figure 2.5).

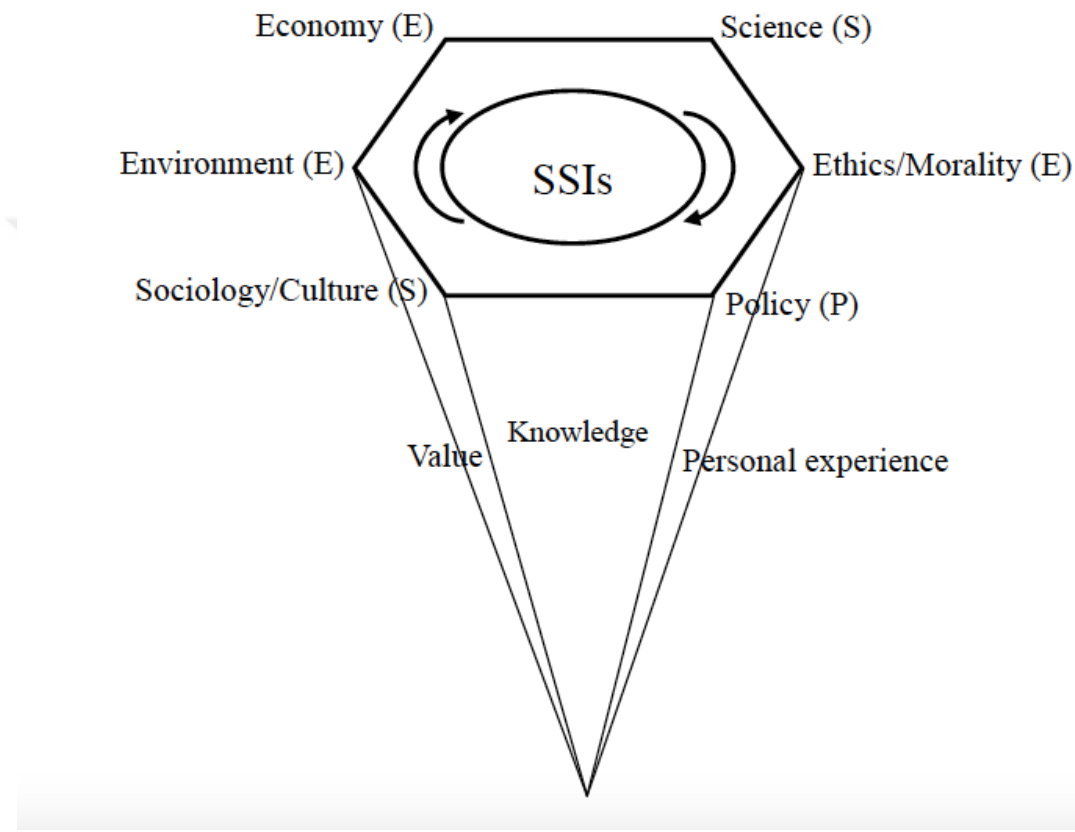

Figure 2.5 Representation of the relationships between the three aspects and six subjects areas of SEE-SEP model [33]

As shown in the Figure 2.5, the SEE-SEP model is represented on an image like a diamond. On the top of the image, the six subject areas are put in the corner of a benzene-like structure. The six subjects areas represents the carbon atoms in benzene structure, which symbolize the multi-perspective and complexity feature of SSI. In the middle of the benzene-like structure, there is a circle that represents the bonds in benzene structure. This circle symbolizes that diverse subject areas are connected and these areas should be viewed in a more comprehensive perspective. Also, there are two arrows around the circle to show the necessity for inquiry and skepticism in SSI. At the root part of the SEE-SEP

model represented, the three aspects of SSI, which are personal experience, value, and knowledge, are shown. As seen in the Figure, the root is joint with the benzene-like structure. That is, the six subject areas (the benzene-like structure) is interlocked with the three aspects of SSI (the root) and they cannot be separated. The six subject areas and three aspects of SSI is examined in the next part.

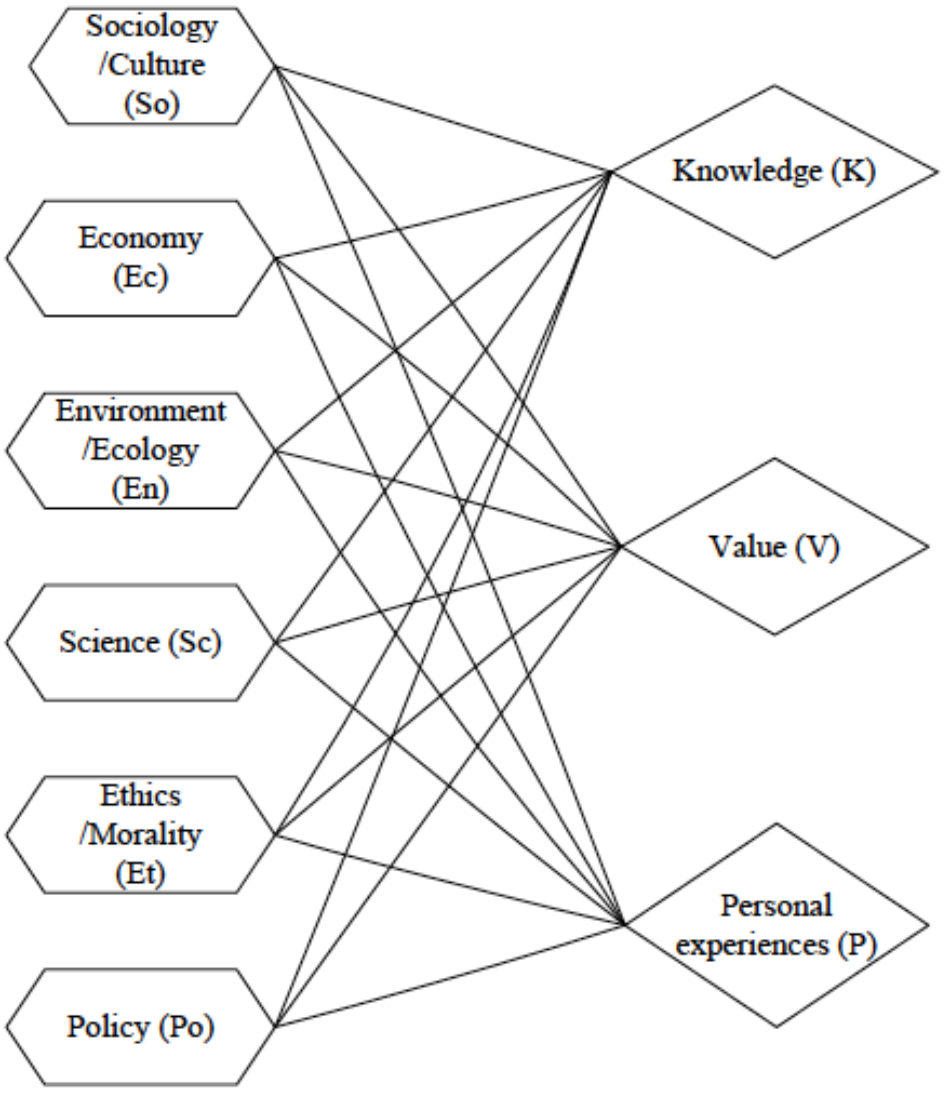

Figure 2.6 Combination of the subject areas and aspects of SEE-SEP model [33]

2.3.1 Subject Areas

The six subject areas defined in SEE-SEP model developed by Shu-Nu Chang Rundgren and Carl-Johan Rundgren (2010) [33] are explained in this section. Some examples that relate the mentioned subject area and the aspects defined in SEE-SEP model are given. However, as mentioned before, it is important to say that all subject areas can be combined with all aspects of SSI (Figure 2.6) and the combination and the involvement of the subject areas and aspects depends on the issue.

- ✓ *Science (Sc)*

Scientific literacy is one of the aims of science education. For this aim, students are expected to translate scientific content knowledge to daily life experiences. Therefore, people may benefit from their scientific knowledge when they produce arguments, make decisions in the experiences about SSI. This subject is about the scientific knowledge that the people use when discussing about SSI. For example, it may be connected to personal experiences when people use their experiences while doing an experiment or it may be connected to value aspect when they express their attitudes and scientific knowledge together about SSI.

- ✓ *Economy (Ec)*

People may use economic concern when discussing about SSI. When discussing about the use of genetically modified foods, people may have some economic concerns as purchasing cheap food. This subject area may be related to personal experience aspect of SSI. For example, a student who has economic trouble in family life may give an example from her personal experience in buying food and give this as a reason for using genetically modified food.

- ✓ *Policy (Po)*

The subject area, policy, is more related to the laws and governmental issues. It is supposed that people who use policy subject area when deciding about SSI are tended to trust laws and governments. For example, for abortion issue, people may give argument according to the laws and the decision of governments.

- ✓ *Ethics/Morality (Et)*

Ethical concerns are crucial when deciding on a socio-scientific issue. For example, for gene editing issue, ethical, moral, and sometimes religious perspectives affect the

decision making process. This subject area may be related to the value aspect when discussing whether gene editing is appropriate to use in human or not.

- ✓ *Sociology/Culture (So)*

The subject area of sociology/culture is related to the people's sociologic and cultural backgrounds. That is, people use their cultural and sociological backgrounds when they discuss. It is supposed that sociology area is mostly connected to value aspect because when people make decisions about an SSI, they use their attitudes. However it may be also related to the other aspects as personal experiences, and knowledge. For example, a student whose family is engaged with agriculture may explain his/her family life experiences in agriculture and how s/he grew up when discussion about pesticide use, which is related to personal experiences.

- ✓ *Environment (En)*

Environmental concerns may have been included under science subject area because environmental science is one of the disciplines of science. However, the environment area is examined separate from the science subject area in order to stress the environmental concerns in SSI discussions. There are many SSI that environmental concerns are on the foreground as climate change, smoking, genetically modified organisms, etc. For example, a person may be concerned about the environmental effects of genetically modified foods (given as an example in economy subject area and related to the economy).

2.3.2 Aspects

- ✓ *Knowledge (K)*

In knowledge aspect, the information, evidences, data are important in decision making process. That is, people use their knowledge about SSI when they discuss and make decisions. For example, people may be use the knowledge of law about the rights of animals when discussing about an SSI related to animal welfare (Combination of policy subject area and knowledge aspect).

- ✓ *Value (V)*

Chiu and Chang (2008) argue that people trust their values when there is no scientific evidence for the crucial SSI [2]. That is, when people have to make decisions about the

harmless of an issue, they use their values if there is no evidence. Therefore, the value aspect is more related to affective domain. For example, when a student discusses about climate change, s/he may defend it as a dangerous issue because of the environmental effects of it (Combination of environment subject area and value).

- ✓ *Personal Experience (P)*

It is argued that people also use their personal experiences when there is no evidence. For example, people who smoke may think that is should be legitimized to smoke in enclosed spaces for people who have allergy against cigarette smoke, smoking in enclosed spaces should be banned because of their bad experiences with cigarette smoke (Combination of policy subject area and personal experience aspect). Therefore, personal experience may be crucial aspect when discussing about SSI.

2.4 The Reason of Adopting SEE-SEP Model as the Analytical Framework

In this thesis, the aim is to investigate the supporting reasons that students use when they write arguments on a socio-scientific issue called CRISPR method. That is, students come from different cultural, economic, political, etc. backgrounds may also use different supporting reasons when they argue and the aim is to examine the effects of the diversity of the students' reasons that students use. SEE-SEP model also stresses the multi-dimensional perspective of SSI. It defines separate subject areas and aspects and forms an holistic view about SSI. Therefore, one of the reasons for adopting SEE-SEP model is to investigate the diversity of the reasons among students who has different backgrounds in a multi-dimensional perspective.

The other reason for adopting SEE-SEP model as an analytical framework of the thesis is that it includes "Ethics/Morality" subject area. The focal issue of the unit used in this thesis is CRISPR/Cas method. That is, the students are expected to write their supporting reasons on the effects of using CRISPR method in the future. Sadler and Zeidler (2004) [24] claimed that for the issues related to genetic engineering as cloning, gene therapy, etc., it is important to think about the ethical and moral concerns. CRSIPR method is a gene editing method, which is an issue included in genetic engineering. Therefore, it is necessary to examine the written arguments in ethical and moral perspectives which are one of the subject areas of SEE-SEP model also.

CHAPTER 3

METHODOLOGY

3.1 Method

The aim of this thesis is to investigate the supporting reasons that middle school students use when they write arguments about CRISPR method. Qualitative approach is adopted for the thesis in order to address the research question. The research question is

> "What supporting reasons do the middle school students use when arguing in a socio-scientific issue related to gene editing method (CRISPR)?"

For this purpose, a unit plan which includes CRISPR method as the focal socio-scientific issue was developed according to the SSI based instruction model by Sadler, Foulk and Friedrichsen (2017). The unit developed in this thesis is instructed to the 7^{th} grade students who study at a public middle school. At the end of the unit, written arguments (including beliefs and supporting reasons – arguments about the issue) about the main question of the unit are collected. SEE-SEP model is used as an analytical framework to analyze the written arguments of the participants. The participants, instruction sequence and data collection process will be described in detail in the following section.

3.2 Research Approach

The aim of this study is to explore the supporting reasons used by the middle students in written argumentation about a case, which is the effects of using CRISPR method in the future. Exploratory case study approach is adopted to address the research question. Exploratory case study is explained as "sets to explore any phenomenon in the data which serves as a point of interest to the researcher" (p. 3) [35]. In this study, the supporting reasons students use when they argue about the effect of using CRISPR method in the

future, which is the point of interest of the researcher, represented as the phenomenon, is explored by analyzing the written arguments of the participant students. The participant students are exposed to 4-week SSI-based instruction, which is designed in the context of this thesis. Therefore, the participants are bounded to the middle school students who exposed to the 4-week SSI-based instruction about the case, which is CRISPR Method.

3.3 Participants

The unit developed for this thesis is applied to twenty eight 7th grade students of a public middle school, Üsküdar, İstanbul. In Turkey, there is a standardized test called High School Entrance Exam (LGS). It is applied at the end of the 8th grade and generally schools prefer to focus on this exam. It means, school administration and the teachers usually give importance on content knowledge and doing tests to prepare their students to the entrance exam. Therefore, studying with the 8th graders is generally difficult in terms of getting permission from the schools and teachers. For this reason, the advice of the experienced teachers is received. They recommend to study the 7th graders who are not instructed DNA and genetic code before and are not getting prepared to the standardized exam overly. After that, the teacher at the middle school chose a class that she think they are prepared for the unit design.

Then, a 7th grade is chosen with the science teacher's recommendation of the school. The unit is applied to twenty eight students. In Turkey, some types of religious vocational middle schools have different classes for female and male students and there is no mix class in terms of gender. The school where the unit design is implemented is also a religious vocational school and the chosen class for the CRISPR/Cas 9 unit is a female class, filled with female students. Therefore, the participants of the study are 28 female students study in a middle school in İstanbul.

3.4 Instruction Sequence of the Unit

The unit involves 4 lesson plans, each of them is 80 minutes. In Turkey, one lesson takes 40 minutes, so one lesson plan is equal to two lesson hours. Therefore, each lesson plan was instructed in a week, for 2 lesson hour. In total, it took four weeks to complete the unit at school. (The outline of the unit and detailed information about the lesson plans are presented in Appendix 1 and 2)

The unit started with the focal issue which is CRISPR/Cas9 method by watching videos about the effect of using CRISPR method on a one year-old baby and a mouse to make the students engage in the method and discussion. The main question of the unit "How might using CRISPR method affect the future of humanity?" was asked at the beginning of the first lesson. Then in the first and second lesson hour, the content knowledge (DNA, gene, chromosome, replication, etc.) about the issue was presented via images, presentation on prezi, a DNA model, and a simulation. After the content knowledge instruction, in order to be sure that the students have the required content knowledge for the issue, a test (Appendix C) is applied. The students solve the problems on the test on their own and then all the questions are solved together, with the help of the teacher. In this part, students also asked some questions so that they have a clear understanding about the issue. Therefore, the teacher got sure that all the students have the required content knowledge about the issue.

The students were asked to model a DNA and show the gene, chromosome, and replication process on the models they prepared in the third and fourth lesson hours. In the next lesson, epistemology of science and the detailed information about CRISPR method was presented via videos and discussion. Also, the models that the students prepared in the previous lessons were used to show how CRISPR method is applied on DNA.

In the final week, the students were asked to write their beliefs and supporting reasons about the main question of the unit "How might using CRISPR method affect the future of humanity?" by explaining the reasons of their beliefs individually. Then, as culminating activity, the students had two choices; one was to prepare a poster in groups and the other was role-playing that shows their experiences throughout the unit in groups. Some example images are shown to give an idea about the poster preparation. Three groups preferred to study on poster presentation and two groups preferred**.** At the end of the lesson, the groups presented their work.

3.5 Classroom Environment and Teacher Attribution

As mentioned in the framework chapter, classroom environment is one of the important factors for SSI-based instructions. Throughout the 4-week instruction, the participant students are allowed to participate actively by asking questions, expressing their ideas

about the questions/issue, giving comments on the ideas that are expressed by their friends, etc. Students did not judge the other students who are not agree with them. That is, all the students are respectful and the students felt safe about expressing their ideas. Therefore, there was no need to encourage the students to be interactive, since they participate actively.

Also, another factor which is important for a successful SSI-based instruction is the attributions of the teacher. The teacher (also the researcher of this thesis) has a grasp of the focal issue. She was aware of the social dimension of the issue and deal with the uncertainties of the students by emphasizing the normality of these uncertainties for this issue. Moreover, she did not express her idea about the issue until the end of the data collection process. Therefore, the necessary conditions described in the framework for a successful SSI-based instruction was provided throughout the instruction.

Moreover, the school administrators were very helpful and gave support throughout the 4-week instruction. Especially the science teacher of the participant students helped us to get to know the participant students. Before the unit instruction process, she chose a class according to the requirements for a successful SSI-based instruction. For example, she chose a class which is more active, talkative, ready for the intended content knowledge. Therefore, peripheral influences were helpful and gave support for 4 weeks.

3.6 Data Sources

The aim of the thesis is to investigate the supporting reasons that middle school students use when they write arguments about CRISPR method. In order to investigate the use of supporting reasons, at the end of the CRISPR/Cas9 unit prepared for this thesis, the students are asked to write their beliefs and arguments and supporting reasons about how might CRISPR method affect the future. The participants of the study, twenty eight 7^{th} grade female students study in a public middle school in a district of İstanbul, wrote their beliefs and supporting reasons- arguments about their beliefs. These written arguments are collected from the participants and analyzed.

3.7 Analysis of Arguments

The analytical framework of this thesis is SEE-SEP Model. Therefore, the data obtained from the written arguments of the participant students are analyzed according to the SEE-SEP model. As mentioned in the "Analytical Framework" part, SEE-SEP model includes six subject areas; sociology/culture, environment, economy, ethics/morality, science, and policy, and three aspects; personal experience, knowledge, and value. All the subject areas can be combined with all the aspects and there are 6 subject areas and 3 aspects. Therefore, eighteen codes are generated from the combination of subject areas and aspects (Figure 3.1) and these codes are used to analyze the supporting reasons that the students use in written arguments about CRISPR method.

Aspects / Subject areas	Knowledge (K)	Value (V)	Personal experiences (P)
Sociology/culture (So)	SoK	SoV	SoP
Environment (En)	EnK	EnV	EnP
Economy (Ec)	EcK	EcV	EcP
Science (Sc)	ScK	ScV	ScP
Ethics/morality (Et)	EtK	EtV	EtP
Policy (Po)	PoK	PoV	PoP

Figure 3.1: Analytical codes that are generated from the combination of subject areas and aspects of SEE-SEP model

The written arguments of twenty eight students are collected and analyzed according to the codes explained in SEE-SEP model by the researcher. The researcher read some articles about how coding process should be performed. Firstly, according to the knowledge she has after reading the articles, she read the written arguments one by one and detected the codes generated by the students. The same process is repeated for five times. After the codes are detected, they are put in a table on excel and the graphs and tables that show the ratios of each code and students are formed. The example sentences from the arguments and supporting reasons of students are given below.

3.7.1 Coding Process

The written arguments of the students are analyzed according to the codes generated in SEE-SEP model. Examples from analyzing process are given below to have a general idea about coding adopted in this thesis.

1) The argument and the supporting reason about EtV of student 18 are;

- *From the religious perspective, I think it is wrong to change the features that God gaves us. (EtV).*

Here, the attitude of the student for the issue is stressed as "I think it is wrong", which means the students views the issue according to the value aspect. Also, she emphasized the religious perspective and says "from the religious perspective, …, God gave us", which shows that she gives supporting reason based on her religious beliefs and the subject area of ethics/morality. Therefore, we can see the combination of ethics/morality subject area and the value aspect.

2) Student 5 generated 4 arguments, two of them belongs to ScV code. The arguments and the supporting reasons about ScV of student 5 are;

- *I think this method will be beneficial in the future because it inhibits the diseases that would emerged before birth or just after the birth. (ScV – 1)*

- *…a mother may want to change the eye color or any other feature of the baby in mother's womb but certainly, for me, it (the method) should be used for diseases, not for physical change. (ScV – 2)*

In the first example (ScV – 1), the students mentioned about the scientific knowledge, which is the method *inhibits diseases*. Also, she mentioned about the attitudes towards the issue as *I think this method will be beneficial.* It means the student supports her argument "*I think this method will be beneficial" by explaining the reason with the help of scientific knowledge about the issue, as "it inhibits the diseases that would emerged before birth or just after the birth".*

In the second example, the student also make an argument based on the value aspect as "*for me, it (the method) should be used for diseases, not for physical change".* Also, she explains the supporting reason for her argument based on the scientific knowledge she learnt throughout SSI based instructions about CRISPR method as "*a mother may want to change the eye color or any other feature of the baby".* That is, in both of the examples,

she combines scientific knowledge and attitudes towards the issue when give arguments and supporting reasons. Therefore, the combination of science subject area and value aspect helps her to express their beliefs about the issue. However, in the first example, she stresses the aspect of "inhibiting diseases" of the issue but in the second example, she explains the feature of "physical change" of the issue. It means, the both arguments are belong to ScV code but in different aspects.

More examples from the written arguments and supporting reasons of the students;

- Argument and supporting reason of student 2

…*if we think about religiously*, we are changing the features that God gave us so *I think it would be unfavorable*. (EtV)

- Argument and supporting reason of student 4;

I think this method should be used in the future because this method may *have importance for genetically inherited diseases*. (ScV)

- Argument and supporting reason of student 11;

…*it may cause a damage on a baby* when applying this method. (EtK)

- Argument and supporting reason of student 15;

…*applying this method for the diseases causes positive results*. (ScK)

- Argument and supporting reason of student 20;

I think *it is better to live with the negative effects* (of CRISPR method like risk as application of the wrong gene) *than dying*. (SoV)

- Argument and supporting reason of student 26;

I watched that CRISPR method has been used on a one-year old baby who has cancer. *I think, the method that genetic engineers presented is beneficial* to prohibit the cancer. (ScP)

3.8 Personal Stance

As a science teacher, I have always been curious about the genetic issues and the issues related to genetics always take my attention. One day, I was reading a science magazine and an article about CRISPR/Cas9 method took my attention. When I read it, I was

impressed by the history and improvement of the method. In these months (when I read the article), I was thinking about a new and creative socio-scientific issue, which is my interest area. Therefore, I thought that it would be wonderful to combine the CRISPR/Cas9 method with socio-scientific issue teaching and learning method. I asked my adviser about my idea and he supported me to design an SSI-based unit and teach it. Finally, with the help of my adviser, I have designed the SSI-unit plan about the CRISPR method and instructed it to the participants of the study.

3.9 Truth Value & Consistency

In this thesis, I have designed an SSI-based unit and instructed it to the student. Since I was curious about the method, I read a lot of articles and watched a lot of videos about it. Therefore, before the instruction of the unit, I had my own values and beliefs about the effects of CRISPR/Cas9 method in the future. As the researcher of this thesis, I researched the use of CRISPR method and when developing the unit and this leads having a belief about the effect of using of CRISPR method in the future. Also, I instructed the unit for 4 weeks to the participant students. Throughout the 4-week instruction, I tried to not reflect my belief about the use of CRISPR method. Although, the students ask me my opinion about the issue, I did not give any feedback and try just to give the content knowledge and other stuff included in the unit. By considering these, I tried not to reflect my belief about the issue during the 4-week instruction and during the data analysis. I analyzed the arguments of the students for 5 different times. Also, my adviser analyzed the 15% of the written arguments in order to achieve the trustworthiness and there was 90% of consistency among the analysis of the researcher and the adviser. 10% of the nonconcurrence about the codes was resolved by discussion. Since we reached the consistency for the 15% of the arguments and resolved the nonconcurrence by discussion, the rest of the written arguments are analyzed by the researcher. That is, to overcome the prejudice, we benefited from investigator triangulation method to eliminate our own beliefs and values about the issue, to reach the consistency among the codes and to ensure the trustworthiness of the analysis.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

The written arguments collected from the participants are analyzed according to the SEE-SEP model, which is the analytical framework of this thesis. In SEE-SEP model, there are 6 subject areas; sociology/culture (symbolized as So), environment (symbolized as E), economy (symbolized as E), science (symbolized as Sc), ethics/morality (symbolized as Et), and Policy (symbolized as Po), and three aspects; knowledge (symbolized as K), personal experience (symbolized as P), and value (symbolized as V). Therefore, in total, by combining all aspects and subject areas, 18 codes are generated (as shown in Figure 3.1).

Table 4.1 shows the codes and also the number of supporting reasons for each code used by the participants in their written arguments. The result from the collected written arguments show that, the participants, who study in 7th grade in a public middle school, used only six codes, although there are eighteen defined codes in SEE-SEP model.

Table 4.1 Representation of codes and the number of supporting reasons for each code used in written arguments about the effects of using CRISPR method in the future

Codes	Number of Arguments
SCK	16
SCV	26
SOV	6
ETV	20
ETK	6
SCP	1
Toplam	**75**

The codes used by the participants in their written arguments are the combination of science and value (ScV), combination of ethics/morality and value (EtV), combination of science and knowledge (ScK), combination of ethics/morality and knowledge (EtK), combination of sociology/culture and value (SoV), and combination of science and personal experience (ScP). The subject areas; policy, environment, and economy is not mentioned in the written arguments.

As shown in Table 4.1, the number of students participated in the study is twenty eight but the total number of supporting reasons analyzed from the written arguments of the participants are seventy five. The participant students generally generate more than 2 supporting reasons in their writings (Table 4.2). Some of the students generate 4 supporting reasons in different perspectives and some of them generate just one supporting reason.

Table 4.2 Examples from the number and name of codes that some students generated in their written arguments

Number of Students	Number of Codes	Name of the Codes
Student 1	4	ScK, ScV, SoV, ScK
Student 3	5	ScK, ScK, ScV, EtV, EtV
Student 5	4	ScV, EtV, ScK, ScV
Student 9	2	ScV, EtV
Student 14	1	ScV
Student 19	2	ScV, EtV
Student 24	4	ScV, EtV, ScK, SoV
Student 28	2	EtV, ScV

As shown in the Table 4.2, there is no written argument that does not have supporting reason for the effects of using CRISPR method in the future. Also, some students generated one code two times. That is, these students give supporting reasons about one code by looking at the issue in different perspective.

The distribution of the codes used in the written arguments are given in Figure 4.1. It is shown that, the combination of science subject area and value aspect (ScV) which is used

by 35%, is mostly generated by the students. Then, the combination of ethics/morality subject (EtV) area and value aspect, which is used by 27%, is mentioned slightly less than the combination of science and value (ScV).

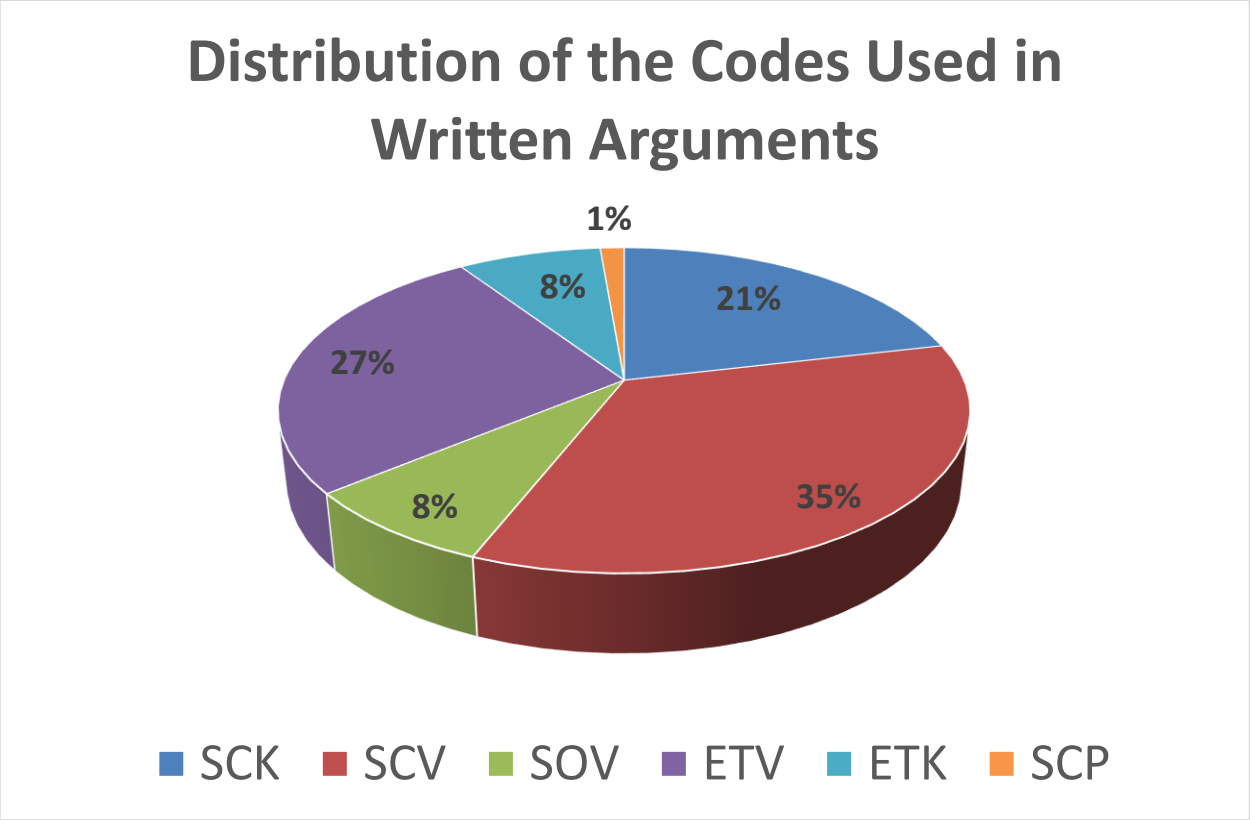

Figure 4.1 The distribution of the codes used in written arguments

The combination of science and knowledge (ScK) is used by 21%. The combination of ethics/morality and knowledge (EtK), and sociology/culture and value (SoV), that is used by 8%, follow them. Finally, the least generated code which is the combination of science and personal value (ScP) is just used by 1%. We can see that, the mostly used subject area is science. The subject area ethics/morality is also on the foreground. Moreover, the mostly used aspect is value and then knowledge aspect follows it.

The subject area science is usually mentioned from the perspectives of the application of CRISPR method for preventing the serious diseases as cancer, physical change and the risk after the application of the method from the aspects of value and knowledge. Examples related to science subject area from the aspects of value and knowledge, written in the arguments of the students are;

Student 6;

It would be useful to apply this method for diseases.. (ScK)

Student 8,

Playing with the genes of a child is very dangerous because after applying this method to the child, another disease may occur and or another gene (that is not targeted in the application) may get damaged. (ScV)

Student 9;

I think this method will be beneficial because……. and it provides us a chance to change the eye color, hair color etc. (ScV)

Only one student mentioned about what would happen if a child who is applied CRISPR method is lost. She/he thinks that applying CRSIPR method to a child may complicate to find the family of the child because the genes of the child is changed and this may be a handicap for DNA test when the child is lost.

As shown in Figure 4.1, subject area ethics/morality is the second most generated area. The students, who generated codes from the subject area of ethics/morality, generally used reasons supported by the religious aspect of the issue. Also, they relate the use of the issue in the future with the positive effects of humanity. Examples related to ethics/morality subject area from the aspects of value and knowledge, written in the arguments of the students are;

Student 2;

If we think about the issue from the religious perspective, we would change things that God gave us and I think this is unfavorable. (EtV)

Students 18;

If we look at the positive effects of the method, it helps us to step in the diseases in childhood and this is good for humanity. (EtK)

Among all the supporting reasons used by the students, 8% of it belongs to the combination of sociology/culture subject area and value aspect. Example related to sociology/culture subject area from the aspects of value, written in the arguments of the students is;

Student 27;

I prefer to use this method in the future because it will make contribution to our country. (SoV)

As shown in table 4.1 and Figure 4.1, only one students combined the science subject area and personal experiences. She mentioned about a video that was watched in lesson one. The argument and supporting reason of the student is;

Student 26;

I watched that CRISPR method has been used on a one-year old baby who has cancer. I think, the method that genetic engineers presented is beneficial to prohibit the cancer. (ScP)

Finally, Table 4.3 shows the total number of subject areas/aspects and codes individually. As seen in the table, just three of the subject areas out of 6 are generated in the written arguments of the students and the mostly used subject area is science. Also, all the aspect are used in the written arguments but the value aspect is most widely used aspect. Moreover, the subject area of ethics/morality is used 26 times and the knowledge aspect is used by 22 times, which have also high percentages in total.

Table 4.3 The total number of subject areas and aspects used in the written arguments of the students

Subject Area	**Number of subject areas in written arguments**
Science	43
Ethics/Morality	26
Sociology/Culture	6
Aspect	**Number of aspects used in written arguments**
Value	52
Knowledge	22
Personal experience	1

4.2 Discussion

4.2.1 Variation of the Codes

The data which is obtained from the written argumentation of the students who participated in a 4-week SSI-based instruction about CRISPR method, is analyzed according to the SEE-SEP model. In SEE-SEP model, there are six subject areas and three aspects so with the combination of all the subject areas and aspects, in total, eighteen codes are generated. However, according to the analysis of the written arguments, students used just six combination codes when giving supporting reasons in their arguments. The six combination students used are: the combination of science and value, science and knowledge, ethics/morality and value, ethics/morality and knowledge, sociology/culture and value, and science and personal experience. As seen in Table 4.1, the subject areas of policy, environment, and economy but all three aspects are used.

The reason for this not including the policy subject area may be that the student are not aware of the laws about the gene editing methods. That is, gene editing is a critical issue and gene editing methods restricted in some contexts. The students are not so aware of the restriction of the using gene editing method and they could not generate supporting reasons related to policy subject area. Also, environment and economy subject areas are not included in the codes generated by the students about the CRISPR method. This may result from that the effect of CRISPR method on environment and economy is not mentioned throughout the unit. That is, the students cannot imagine the environmental and economic effects of CRISPR method. However, they share their ideas in terms of science, ethics/morality, and sociology/culture subject areas about the use of CRISPR method throughout the unit.

According to the written arguments of the students, the mostly used subject areas are science and ethics and the mostly used aspects are value and knowledge. The students exposed to 4-week SSI-based instruction about CRISPR method. Throughout the instructions, it is aimed to give the content knowledge, by having the students experience activities as modeling, simulation, etc., around an SSI. Therefore, the ultimate aim of SSI-based instruction is giving content knowledge with the help of activities and SSI. Since the content knowledge is emphasized throughout the 4-week instruction, and the students are exposed to this 4-week instruction, they may be affected from the content knowledge they gained during instruction. This may lead them to support their reasons by using their

content knowledge that they exposed for 4 weeks, in their written arguments. According to SEE-SEP model, including the content knowledge when supporting the reasons of arguments means using science subject area and/or knowledge aspect. Therefore, the student who use their content knowledge to support their reasons may consciously or unconsciously affected from the 4-week instruction and generated reasons supported by science subject area and knowledge aspects.

Moreover, Sadler [23] emphasized that ethical implications are on the center of socio-scientific issues. Also, Sadler, Amirshokoohi, Kazempour, and Allspaw (2006) argued that ethics is an important concern for socio-scientific issues and ethical concerns and values interacts with each other [36]. In this study also, value aspect is the mostly used aspect and the ethics/morality subject area is the second frequently used subject area. That is, in parallel with the literature, ethical concerns and values aspect are also in the foreground in the written argumentation of the participant students of this thesis.

4.2.2 The Number of Codes

The number of participant students who get a 4-week SSI based instruction is twenty eight, but the total number of codes generated from the written argumentation of the students are seventy five (Table 4.1). Therefore, the number of students participated in the study is almost 3 times more than the number of codes generated by them in their written argumentation. As shown in Table 4.2, students generally tend to generate more than 2 reasons when they argue about the issue and this causes to have much more codes.

At the beginning of the lesson 4, in which the written arguments are collected from the students, it is emphasized that the students should just write their beliefs, ideas and support them with reasons so there is no need to give content knowledge about the issue. Also, it is stressed that they should not hesitate to express their beliefs and reasons when they are writing about the issue. For this reason, they may feel free to state their ideas after the warning given at the beginning of the lesson and they express all the aspects in their minds about the issue.

The supporting reasons of the students in their written argumentation vary for each student. That is, the students want to write arguments about the effects of CRISPR method in future, whether it is positive or negative but they also wanted to write the opposite argument and reason that support the opposite view. They ask if they are allowed to write

the opposite views that comes to their minds about the issue. Therefore, they may get confused, troubled to make a decision, and tend to give supporting reasons from diverse perspectives, which are the three of the features of SSI defined by Sadler and Zeidler (2005) [11]. For example, if a student gives an argument about that it would be useful to apply CRISPR method in the future and gives supporting reasons for this argument, she is also free to write the unhealthy views about the issue and give supporting reasons for this opposite argument. This is favorable for the nature of the thesis because the aim of this thesis is to investigate the students' supporting reasons used in written argumentation, not to detect their side about the use of CRISPR method as positive and negative.

4.2.3 **Multiple Use of the Codes**

Table 4.2 shows the number and name of the codes some students generated in their written arguments about the effects of using CRISPR method in the future. As seen in the table, some students generated the same code more than once. For example, student 5 generated five codes but 2 of them is the combination of science and value (ScV). That means, the student gives arguments about the issue and supporting reasons based on scientific knowledge and attitude by using different views about the issue. As mentioned in coding process, the arguments and supporting reasons of student 5 is;

- I think this method will be beneficial in the future because it inhibits the diseases that would emerged before birth or just after the birth. (ScV – 1)

- …a mother may want to change the eye color or any other feature of the baby in mother's womb but certainly, for me, it (the method) should be used for diseases, not for physical change. (ScV – 2)

Here, we can see that the name of the codes are the same for both arguments and supporting reasons but the context is different. In example 1, the student looks at the issue from the "inhibiting diseases" view but in the second example, she sees the issue as a way to "change the physical features of baby". Therefore, students can look at the issue from different perspectives and dimensions, which meets the multi-perspective and multi-dimensional feature of SSI [33], explained in the framework of this thesis. They try to support their arguments by giving more than one reason and explain their beliefs about the issue by writing all the reason that they can think of. As mentioned previously, they also want to write the opposite arguments and the reasons that supports the opposite

views. That is, they think broadly and try to think the effects of the issue over in different perspectives and dimensions.

4.2.4 Meaning of the Codes Used by the Students in their Written Argumentation

The analytical framework of this thesis is SEE-SEP model. That is, the written arguments collected from the students are analyzed according to this model. As mentioned in the "Framework" chapter (Chapter2), SEE-SEP model generates codes according to 2 criteria, which are subject area and aspects. Therefore, in this part, the meaning of the codes that are generated by the participant students are discussed according to these 2 criteria, adopted from the SEE-SEP model.

Subject Areas

As mentioned before, "Threshold Model of Content Knowledge Transfer", which is developed by Sadler and Fowler (2006) [18], emphasizes the effect of content knowledge on socio-scientific argumentation. That is, when arguing about a socio-scientific issue, content knowledge is an important aspect. Also, in this thesis, the science subject area is most widely used area about the CRISPR method (as shown in Table 4.3). That is, the students generated supported reasons based on their scientific content knowledge about the issue. Before the 4-week SSI based instruction, none of the students had an idea about the CRISPR method (At the beginning of the lessons, it is asked to the students if they have an idea about the issue and they answered "No"). The scientific content knowledge about the CRISPR method is given to the students during the 4-week SSI based instruction, and after these instructions, they constructed knowledge about it. Since, the content knowledge is given during 4 week of instruction and the data is obtained just at the end of the lessons, the students may consciously or unconsciously relate their opinion about the issue with the scientific content knowledge and are affected by the instruction.

The subject area of ethics/morality is used 26 times, which cannot be underestimated. The ethical concerns about the issues used in the written arguments of the students are mostly related to the religious concerns and the benefit of humanity. The focal issue of the thesis, which is CRISPR method, is a type of gene editing method. Sadler and Zeidler (2004) [24] emphasized that when thinking and making decision about the issues related to genetic engineering, as gene therapy, gene editing, etc., the ethical and moral concerns

are on the foreground. In parallel with Sadler and Zeidler [24], it is logical to relate use of CRISPR method in the future with ethical concerns in this thesis.

Finally, the subject area of sociology/culture, which is combined with the value aspect by the participant students, is generated 6 times. The students are generally tend to explain their ideas and relating these ideas with the effects of the culture they live in, whether the culture of the family, school, nation, etc. Therefore, they combined the sociology/culture subject area and value aspect to reflect their beliefs and support their ideas.

Aspects

Tal and Kedmi (2006) emphasizes that value judgement and forming value position should be included in SSI teaching widely [37]. That is, value judgements and position is an important aspect of socio-scientific issue based instructions. Consistent with Tal and Kedmi [37] , according to the written arguments collected from the students for this thesis, the most widely used aspect is value, in which students reflect their attitudes towards the issue. Therefore, value positioning is also on the foreground in socio-scientific argumentation in this thesis.

At the beginning of the lesson 4, when the written arguments are collected, the students are stressed that they are free to express their ideas, beliefs about the issue. They don't need to explain the scientific process about how CRISPR method is applied or any other explanation about the issue because the aim of this thesis is to investigate the arguments and supporting reasons of students, not their content knowledge. Since, this is emphasized at the beginning of the written argumentation, the students may think that they have to express their opinions and generated supporting reasons including value aspect, not the aspect of knowledge. However, there are also 22 codes including knowledge aspect (Table 4.3) and there are some students that write the application process of CRISPR method on human, which is explained in the 4-week SSI based instruction. Therefore, the students may be affected from the 4-week instruction and reflect this effect on their written arguments.

The aspect of personal experience is just generated once and combined with the science subject area. The sentences of the student 26 who generated this code are;

- *I watched* that CRISPR method has been used on a one-year old baby who has cancer. *I think, the method that genetic engineers presented is beneficial* to prohibit the cancer. (ScP)

The video she watched is one of the videos included in the first lesson of the SSI unit used in this thesis. Therefore, not only the student 26, who used these sentences about the video to support her argument, but also all the participant students watched the video. However, none of the students but her mentioned about the video. The video is about a one-year old baby who suffers from cancer. The classic treatment methods do not work for the baby and they decide to apply the CRISPR method to the baby. The video is about the story of pulling through the illness of the baby. The student 26 generated the code by using her personal experience about this video. This may be because she is more sensitive to the issues related to babies. Maybe, she has a close and real-life experience related to the sickness of a baby. This can be investigated in detail by using interview method.

The combination of science subject area, which is the widely used subject area, and the value aspect, which is the widely used aspect, is the mostly generated code in written arguments of the students. That is, the students give arguments about the effects of CRISPR method in the future based on the scientific knowledge they gained throughout the 4-week SSI-based instruction and relate it with their values. This may be because of the effect of SSI based instruction on science subject area and the warnings, made at the beginning of the written argumentation, about expressing ideas and beliefs, not the pure content knowledge about the issue. Therefore, the students prefer to include their values more than their knowledge.

4.3 Inferences

The aim of this thesis is to investigate the supporting reasons of the middle school students when they are arguing about a socio-scientific issue called "CRISPR Method". Since the students don't have scientific content knowledge about CRISPR method, the SSI unit is designed and it is instructed to twenty eight 7^{th} grade students of a public middle school. The written arguments about the issue are collected at the end of the lessons, just after the instructions. Therefore, collecting the written arguments just after the SSI-based instruction may affect the students' decision making process and as seen in Table 4.3, the mostly generated subject area is science. That is, the students may be benefited from the

scientific content knowledge they learn throughout the SSI-based instruction and this may direct them to use science subject area most in their written arguments.

During the SSI-based instructions, the students express their ideas with the help of guided questions about the effects of CRISPR method on humanity verbally. Therefore, students may be affected by their friends' ideas because the same ideas are shared by some of the students in their written arguments. For example, almost all the students mention about the pulling through the illness feature of CRISPR method. This feature is usually discussed in the lessons. Therefore, the discussions in lessons may affect the decision making process of the students in their written arguments.

Also, before the collection of written arguments, I wanted to make them feel free about expressing their ideas and beliefs about the effects of the issue in the future.. The aim of this thesis is not to evaluate their content knowledge about the issue, but investigate their arguments and supporting reasons. For this aim, I explained that they should not hesitate to write their ideas because I am not here to judge their beliefs, I want to read their beliefs, reasons about the issue, not the content knowledge they gained throughout the 4-week instruction. In this way, students may feel free and express their arguments and reasons freely because the number of participant students is 28 but the number of codes generated by these students are 75. That is, each student generates almost 3 codes.

Finally, the participants students have not been experience with the SSI-based instruction before. All the steps take their attention and throughout the unit, they are curious about the next step. That is, the students are not familiar with how an SSI-based instruction should be. For example, at the beginning of the lesson two, when they need to model a DNA, there are some materials as pasta, post-it, pipette etc. The students generally focus on the materials more than the explanation I gave for the modelling process. Also, they try to use different materials than they generally use at school as pasta. Therefore, the students are not familiar to the design and implication of SSI-based instruction and this may cause them to focus on the design more than the context.

4.4 Limitations

When analyzing the data collected from the written arguments of the students, I read all the papers one by one and in 5 different times and consulted to my adviser to make the thesis methodologically more bounded and appropriate, to reach the consistency and to

cope with the prejudice in the coding process. We tried to be so careful and try not to reflect our view and prejudice to the data analysis process as much as we can but, as the researcher of this thesis, I give the 4-week SSI based instruction and I witness all the discussions in lessons. Therefore, the ideas of the students during the class discussions may affect my perception about their views for the issue and this perception may also affect the data analysis process unconsciously. Also, when we prepare the unit design, we read a lot of articles about the CRISPR method, get advices from the professionals when necessary and this may cause to form a view about the use of CRISPR method in the future. That is, our view about the use of CRISPR method in the future may affect the data analysis process unconsciously.

Moreover, the data is analyzed from the written arguments of the students. However, in order to have a detailed understanding of the supporting reasons of some students, interview may have been done. For example, although all the students have watched the video about a baby, one of the students explained the reasons for her argument as the effect of a video she watched in a lesson and none of the students, but her, give the video as a supporting reason for the effect using this method in the future. The reason for using the video as a supporting reason for her argument may have been asked by doing an interview. However, because of the time restriction, interviewing could not be included in this thesis.

4.5 Further Research

The SSI unit developed in this thesis is instructed to one class, 28 middle school students studying in a public middle school in İstanbul. For the further research, it may be applied to more students and in a different type of school because the results from the religious vocational school and a different type of school may be different in terms of ethics/morality subject area. Also, the SSI unit may be improved and instructed to high school students when the objectives and the activities are rearranged. Then the data from the high school students can be analyzed according to the SEE-SEP model.

The SEE-SEP model is adopted as analytical framework of this thesis because it emphasized the multi-perspective and multi-dimensional feature of SSI, which also reflects the multi-dimensional use supporting reasons for the arguments that the students generated, and it includes ethics/morality subject area, which is one of the crucial area for

the issues related to genetic engineering. However, by considering the features of SSI, another analytical framework may be adopted to analyze the written arguments of the students.

Also, in this thesis, the written arguments are collected just after the SSI-based instruction and this may affect the supporting reasons students use in written arguments. Therefore, the written arguments may be collected after 2 or 3 weeks from the SSI-based instruction about the issue. Moreover, in order to have a deep understanding of the reasons students use, the written arguments may be supported by interview method.

4.6 Conclusion

The aim of this thesis is to investigate the supporting reasons of the students when they are arguing about a socio-scientific issue, which is CRISPR method. For this aim, an SSI-based unit, include CRISPR method as the focal issue is developed and instructed to twenty eight 7^{th} grade students, studying in a religion vocational middle school, for 4 weeks. At the end of the instruction, written arguments about the effects of using CRISPR method in the future are collected from the participant students. These arguments are analyzed according to the SEE SEP model, which is the analytical framework of the thesis. At the end of the analysis, it is investigated that students mostly used their scientific knowledge to support their arguments. Also, the second frequently used subject area was ethics and morality so they have some ethical and moral concerns about the issue. In the literature, ethical and moral concerns are generally on the foreground when discussing about socio-scientific issues related to genetic engineering. The focal issue of the unit developed for this thesis is a gene editing method, used in genetic engineering. Therefore, in parallel with the literature, students benefited from ethical and moral concerns mostly in their written arguments about CRISPR method.

Moreover, the students use the value aspect when writing arguments about the issue mostly. That is, when they are deciding about the use of CRISPR method in the future, they put forward their values. In this way, we can observe that the values student have is an important aspect in school environment. That is, students come from different ethnic, social, cultural areas and these differences affect their views about socio-scientific issues, when they need to decide. Therefore, investigating the reasons that students use when

they argue about a socio-scientific issues is important in order to understand how they decide and which factors affect their decision-making process.

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APPENDIX-A

CRISPR METHOD – UNIT PLAN

Introduction

Scientific Themes: DNA structure, gene chromosome, nucleotide, mutation, and replication

Scientific Practices: Developing and Using Models, Analyzing and Interpreting Data, Engaging in Argument from Evidence, Obtaining & Evaluating & Communicating Data.

SSI: CRISPR-Cas 9 Method

Driving Question: "How might using CRISPR method affect the future of humanity?"

Scientific Concepts

- DNA
- Nucleotide
- Gene
- Chromosomes
- Replication

Social Ideas

- Ethics
- Politics
- Health
- Treatments for Serious Diseases

Unit Expectations

- Construct explanations about the function and structure of DNA. (All cells contain genetic information in the form of DNA molecules.) (modified from NGSS, HS-LS-3-1)
- Develop and use a model to describe the phenomena. (NGSS, MS-LS3-1), (NGSS, MS-LS3-2)
- Science and engineering are influenced by society and society is influenced by science and engineering. (NGSS, HS-LS3-3)
- Write arguments focused on discipline content. (NGSS, MS-LS1-4)

Unit Assessment

- DNA Model
- Written Arguments
- Responses to the Guiding Questions
- Culminating Activity

Lesson Sequence

Lesson 1 (80 min) : Introduction to CRISPR Method & DNA Review

Lesson 2 (80 min) : DNA Modeling

Lesson 3 (80 min) : Focal Issue: CRISPR Method & Representation of CRISPR

Lesson 4 (80 min) : Written Argumentation & Culminating Activity

APPENDIX-B

CRISPR METHOD – LESSON PLANS

Lesson Plans (Outline)

Lesson (time)	Lesson Focus	Learner Objectives
1 (80 min)	Introduction to CRISPR Method & DNA	-Students will have a general idea about CRISPR method via videos. -Students will make a review about the concepts; DNA, gene, chromosome, nucleotide, replication, mutation and make connections among these concepts via animation and simulation.
2 (80 min)	DNA Modeling	- Students will create a model to represent the basic structure of DNA.
3 (80 min)	Focal Issue: CRISPR Method & Representation of CRISPR	-Students will develop an algorithm about CRISPR method in detail and show how this method works on their DNA structure they modeled in the previous lessons. -Students will create an algorithm about the effects of genetic engineering and biotechnological implementations on the environment.

		-Students will discuss that scientists are inspired by their environment and they use creativity.
4 (80 min)	Written Argumentation & Culminating Activity	-Students will analyze data and write their decisions about using CRISPR method. -Students will reflect and present their views about CRISPR method with a culminating activity.

Lesson Plan 1: Introduction to CRISPR Method & DNA

Time: 80 minutes

Goals for the lesson:

-Students will make a review about the concepts; DNA, gene, chromosome, nucleotide, replication, mutation and make connections among these concepts via animation and simulation.

-Students will have a general idea about CRISPR method via videos.

Unit Guiding Question: How might using CRISPR method affect the future of humanity?

Lesson assessments:

- Responses for Lesson Guiding Questions
- Assessment Test

Resources:

- HIV Treatment with CRISPR Method: https://www.youtube.com/watch?v=49X9r1QpMNo
- Cancer Treatment with CRISPR Method:

https://www.youtube.com/watch?v=kl_yfNn4mtA

- Designer Babies:

https://www.youtube.com/watch?time_continue=67&v=skKpMJIO73Q

- Replication (Simulation):

http://www.learningliftoff.com/high-school-science-dna-replication/#.Wha0mbSMi9Z

- Tests: Appendix C

Instructional sequence

Timing	*Activities*	*Materials/Supplies*
15 minutes	- Students watch 2 news and 1 video about CRISPR method. (Teacher want them to write the concepts that they don't know and they think new) Teacher pauses to discuss and ask questions where appropriate. Suggested discussion questions: What is HIV? (If not known, it is explained) Have one of your family members/friends/acquaintance ever had a serious disease as cancer? What if your doctor propose you to design your baby when you want a baby? How might using CRISPR method affect the future of humanity?	Videos
10 minutes	Discussion of connections between the focal issue and the content. Discussion prompts: • What are the concept you write when watching the videos? • What concept is this issue revolves around? • What science concepts do we need to know to understand CRISPR method?	

	(DNA structure: chromosome, nucleotide, gene) • CRISPR method requires DNA replication and sometimes mutation occur during replication. So, firtly, we need to make a review about these concepts to understand CRISPR method.	
20 minutes	Main concepts; DNA, gene, chromosome, nucleotide, and mutation is instructed via presentation. Suggested discussion prompts; Have someone said that you look like your mom or dad or you siblings before? How can we explain this similarities among relatives? Do you have any idea? Some people are doing a test to find their biological families. Have you heard this test? What is its name? After getting "DNA test" answer, the main concepts are reviewed.	PPT, presentation and summary paper
15 minutes	İnstruction of replication via simulation	Simulation about Replication
20 minutes	Assessment of main concepts via MEB test and giving feedbacks about tests	Test (Appendix C)

Lesson Plan 2 : DNA Modeling

Time: 80 minutes

Goals for the lesson: Students will create a model to represent the basic structure of DNA.

Unit Guiding Question: How might using CRISPR method affect the future of humanity?

Lesson assessments:

- DNA models
- Presentation

Resources: Toothpick, pipette, chopsticks, cardboard, sticky tape, adhesive, post-it, colorful papers and pencil, paper-clip, spaghetti, round pasta, elastic band, bean, clipper

Instructional sequence

Timing	*Activities*	*Materials/Supplies*
50 minutes	- Students are grouped in 5. Each group model a basic DNA structure by choosing materials on the table. (There are several materials on the table. Groups decide what they need to use when they model.)	Toothpick, pipette, chopsticks, cardboard, sticky tape, adhesive, post-it, colorful papers and pencil, paper-clip, spaghetti, round pasta, elastic band, bean, clipper
30 minutes	-Each group presents their modeling process and DNA structure to their friends. (They explains which materials they use, which material represents which part of DNA, etc.)	

Lesson Plan 3: Focal Issue: CRISPR Method & Representation of CRISPR

Time: 80 minutes

Goals for the lesson:

- Students will develop an algorithm about CRISPR method in detail and show how this method works on their DNA structure they modeled in the previous lesson.

-Students will create an algorithm about the effects of genetic engineering and biotechnological implementations on the environment.

-Students will discuss that scientists are inspired by their environment, they use creativity and scientific knowledge is subjective.

Unit Guiding Question: How might using CRISPR method affect the future of humanity?

Lesson assessments: Presentation

Resources: DNA models, toothpick, pipette, chopsticks, cardboard, sticky tape, adhesive, post-it, colorful papers and pencil, paper-clip, spaghetti, round pasta, elastic band, bean, clipper

- CRISPR Method

https://www.youtube.com/watch?v=52jOEPzhpzc

- Genetic Engineering

https://www.youtube.com/watch?v=0Hp4L6nyHgY

Instructional sequence

Timing	*Activities*	*Materials/Supplies*
20 minutes	- Students watch a video that explains CRISPR method in detail. Teacher pauses to discuss and ask questions where appropriate to be sure that they have a clear understanding about how scientists are inspired to	Video: CRISPR Method

	develop this model and how the method works. Suggested discussion questions: What is Cas-9? What is the function of Cas-9? How do we make an analogy between CRISPR method and cut & paste method we use in daily life? Which part of CRISPR method is related to "cut" / "paste"? Were scientists inspired by anything when they develop the method? How did scientists get inspired from bacteria? It has been known that bacteria cell uses Cas-9 to protect themselves from viruses for so long. However, this method is developed recently. How can we interpret this situation? Can we say that scientific knowledge is subjective in some ways? Can we say that scientific knowledge is based upon observation and inferences of the scientists? Can we say that scientific knowledge is the product of creative thinking?	
5 minutes	Discussion of connections between the focal issue and genetic engineering.	

	Discussion prompts: • We say that CRISPR method is a newly developed method? Which field of science developed this method? • Do you have any idea about what genetic engineering does?	
15 minutes	- Students watch a video that explains genetic engineering and relates it with CRISPR method. Teacher pauses to discuss and ask questions where appropriate to ask questions. Suggested discussion questions: What do genetic engineers work on? What changes has genetic engineering brought to our lives? Can you give examples?	Video: Genetic Engineering
40 minutes	- Students are told that they are genetic engineers and they need to show how CRIPSR works to the public in order to make them knowledgeable for the issue. Students are grouped as in the second lesson. They represent CRISPR method on the DNA models they prepared previously. - Each group present their CRISPR representation to their friends.	DNA models, oothpick, pipette, chopsticks, cardboard, sticky tape, adhesive, post-it, colorful papers and pencil, paper-clip, spaghetti, round pasta, elastic band, bean, clipper

Lesson Plan 4: Written Argumentation & Culminating Activity

Time: 80 minutes

Goals for the lesson:

Students will

- analyze data and write their decisions about using CRISPR method,
- share the experience they gained throughout the unit with their friends with the help of a culminating activity.

Unit Guiding Question: How might using CRISPR method affect the future of humanity?

Materials: Cardboards, colorful pencils

Lesson assessments:

- Written Arguments
- Drawing about the future after using CRISPR method or the theatre play

Instructional sequence

Timing	*Activities*	*Materials/Supplies*
20 minutes	- Students write their arguments and last decisions about using CRISPR method or not.	
60 minutes	**Culminating Project** As a culminating activity, students have 2 choices; one is picturing the experience and the other is playing a theatre. 1st Choice: Picturing the experience	Cardboards, colorful pencils

	1st Step: Evaluation of Sample Picture Students are shown a "Super Baby" picture (as a sample) that a magazine draw to illustrating the CRISPR method and its affects in humanity. Then, they have a class discussion about the picture. Discussion prompts for teacher; -What do you see in this picture? What is it about? -Can you understand the approach of the drawer from the drawing? Do you see a negative or positive approach for using CRISPR method? -Which negative aspect the drawer emphasizes? *2nd Step: Drawing* Students are grouped in two. They draw their expected future after using CRISPR method on a cardboard as in the sample picture. *3rd Step: Presentation* Students present their works to their friends. <u>2nd Choice: Theatre</u>	

	-Students prepare a theater play about their expected future after using CRISPR method. -They present their plays.	

MEB - OBJECTIVE COMPREHENSION TEST

KAZANIM KAVRAMA TESTİ

Test 1

8. SINIF

FEN BİLİMLERİ

DNA ve GENETİK KOD-1

1. Aşağıda bir nükleotiti oluşturan yapılar ve bu yapılara ait şekiller gösterilmiştir.

Şekil	Temsil ettiği yapı
A	Adenin bazı
T	Timin bazı
G	Guanin bazı
C	Sitozin bazı
P	Fosfat
D	Deoksiriboz şeker

Bu yapılar kullanılarak şekildeki gibi bir nükleotit yapılmıştır.

Buna göre bu nükleotidin karşısına aşağıdaki şekillerden hangisi gelmelidir?

A)


B)


C)


D)


2. Aşağıda bir nükleotidin yapısı gösterilmiştir.

Buna göre bu nükleotit ile ilgili olarak,

I. Adenin nükleotidi olarak adlandırılır.

II. Yapısında deoksiriboz şekeri bulunur.

III. Bu nükleotidin karşısına her zaman guanin nükleotidi gelir.

ifadelerinden hangileri doğrudur?

A) Yalnız I. B) I ve II. C) II ve III. D) I, II ve III.

MEB 2016 - 2017

3. Aşağıda bazı canlılara ait resimler verilmiştir.


Öglena


Eğrelti otu


İnsan

Buna göre bu canlıların bir hücresindeki DNA molekülünde aşağıda verilenlerden hangisi kesinlikle ortaktır?

A) Nükleotit sayıları

B) Nükleotit çeşidi sayısı

C) Fosfat molekülü sayısı

D) Adenin nükleotidi sayısı

4. **Bir nükleotidin yapısında aşağıdakilerden hangisi bulunmaz?**

A) Gen B) Baz C) Şeker D) Fosfat

5. Çevremize baktığımız zaman insanların birbirinden farklı olduğunu görürüz. Yeşil gözlü sarı saçlı insanlar, mavi gözlü kıvırcık saçlı insanlar...

Bütün insanların hücrelerinde DNA bulunmasına ve hepsinde adenin karşısına timin nükleotidi, guanin karşısına sitozin nükleotidi gelmesine rağmen bu farklılık neden kaynaklanıyor olabilir?

İnsanlardaki bu durum - - - - farklı olmasından kaynaklanmaktadır. Bu yüzden de insanların dış görünüşleri birbirlerine benzemez. Bahsedilen olay dış görünüşü etkilediği gibi başka farklılıkların da nedenidir.

Yukarıdaki paragrafın doğru olabilmesi için boş bırakılan yere aşağıdaki ifadelerden hangisi gelmelidir?

A) DNA eşlenmesinin

B) nükleotit çeşidinin

C) nükleotit dizilimin

D) hücrede DNA'nın bulunduğu yerin

6.

Yukarıdaki yapı ile ilgili aşağıdakilerden hangisi yanlıştır?

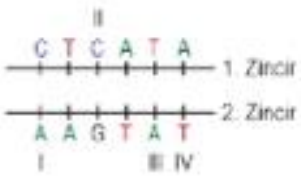
A) Nükleotit içerir.

B) Kalıtsal özellikleri taşır.

C) İçeriğinde genler bulunur.

D) Bütün canlılarda eşit sayıda bulunur.

7. Aşağıda bir DNA molekülü verilmiştir.



Bu molekülde I, II, III ve IV numaralı bazların hangisinde eşleşme hatası yapılmıştır?

A) I. B) II. C) III. D) IV.

8. **Genler ile ilgili,**

I. Ebeveyn özellikleri yavrulara genler ile aktarılır.

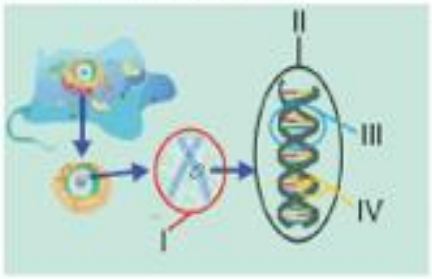
II. Bütün genlerde nükleotitlerin diziliş sırası aynıdır.

III. Bir kromozom üzerinde çok sayıda gen bulunabilir.

ifadelerinden hangileri doğrudur?

A) I ve II. B) I ve III. C) II ve III. D) I, II ve III.

9. Aşağıda canlıların genetik yapısı ile ilgili olan yapılar numaralandırılarak gösterilmiştir.



Buna göre numaralandırılmış yapılarla ilgili aşağıdaki ifadelerden hangisi yanlıştır?

A) I numaralı yapı tür içindeki sağlıklı bireylerin hepsinde aynı sayıda bulunur.

B) II numaralı yapı hücrenin yönetici molekülüdür.

C) III numaralı yapı canlılardaki kalıtsal bölgeleri tayin eden gen bölgeleridir.

D) IV numaralı yapı organik baz olarak adlandırılır.

10. I. DNA'nın iki ipliği fermuar gibi açılmaya başlar.

II. Nükleotitler birbirinden ayrılan iplikçerdeki nükleotitlerle karşılıklı olarak eşlenir.

III. Sitoplazmada serbest dolaşan nükleotitler DNA'nın açılan zincirlerinin karşısına gelmeye başlar.

IV. Bir DNA'dan aynı kalıtsal özellikte iki yeni DNA oluşur.

DNA eşlenmesi ile ilgili olayların gerçekleşme sırasının doğru olabilmesi için hangi numara ile gösterilen ifadelerin yer değiştirmesi gerekir?

A) I ve III

B) II ve IV

C) II ve III

D) I ve IV

APPENDIX-D

MEB – PERMISSION LETTER

T.C.
İSTANBUL VALİLİĞİ
İl Millî Eğitim Müdürlüğü

Sayı : 59090411-44-E.11027017 06.06.2018
Konu: Anket ve Araştırma İzin Talebi

Sayın: Büşra AKKAŞ

İlgi: a) 28.05.2018 tarihli ve 10306667 Gelen Evrak No'lu dilekçeniz.
b) Valilik Makamının 01.06.2018 tarih ve 10786713 sayılı oluru.

"Sosyobilimsel Konulu Temelli Öğrenme Bağlamında Ortaokul Öğrencilerinin Argümantasyon Gerekçelerinin İncelenmesi" konulu araştırma çalışmanız hakkındaki ilgi (a) dilekçe ve ekleri ilgi (b) valilik onayı ile uygun görülmüştür.

Bilgilerinizi ve söz konusu talebiniz; bilimsel amaç dışında kullanmaması, **uygulama sırasında bir örneği müdürlüğümüzde muhafaza edilen mühürlü ve imzalı veri toplama araçlarının kurumlarımıza araştırmacı tarafından ulaştırılarak uygulanılması,** katılımcıların gönüllülük esasına göre seçilmesi, araştırma sonuç raporunun müdürlüğümüzden izin alınmadan kamuoyuyla paylaşılmaması koşuluyla, gerekli duyurunun araştırmacı tarafından yapılması, okul idarecilerinin denetim, gözetim ve sorumluluğunda, eğitim-öğretimi aksatmayacak şekilde ilgi (b) Valilik Onayı doğrultusunda uygulanması ve işlem bittikten sonra 2 (iki) hafta içinde sonuçtan Müdürlüğümüz Strateji Geliştirme Bölümüne rapor halinde bilgi verilmesini rica ederim.

M. Nurettin ARAS
Müdür a.
Müdür Yardımcısı

EK:1- Valilik Onayı
2- Ölçekler

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CURRICULUM VITAE

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EDUCATION

Degree	Department	University	Date of Graduation
Undergraduate	Science Education	Boğaziçi University	22.06.2016
High School		Maçka Akif Tunçel A.T.L	09.06.2011

WORK EXPERIENCE

Year	Corporation/Institute	Enrollment
09.2017/11.2017	Harmantepe Ortaokulu	Science Teacher

PUBLISHMENTS

Conference Papers

1. Akkaş, B., Sarıkaya, E. and Koca, E, E., (2017). Students' Cognitive Structures about Science Learning in Schools: A Case Study about Word Association Test (WAT), YEAUK, İstanbul.

2. Akkaş, B., (2018). Investigating the Middle School Students' Supporting Reasons During Argumentation in the Context of SSI – Based Instruction, ULEAD, Manisa.