EXPLORING MANIFESTATION OF CRITICAL THINKING SKILLS AND DISPOSITIONS ON ARGUMENT AND COUNTER ARGUMENT DEVELOPMENT ABOUT A SOCIOSCIENTIFIC ISSUE

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by
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ABSTRACT

EXPLORING HOW CRITIAL THINKING SKILLS AND DISPOSITIONS OF MIDDLE SCHOOL STUDENTS REFLECT ON ARGUMENTATION ABOUT SOICIOSCIENTIFIC ISSUES

The main purpose of this study is to investigate how divergent critical thinking skills and dispositions of middle school students reflect themselves on argument development and counter argument development about a socioscientific issue which is determined as plastics use. This study utilized the instrumental multi case approach within qualitative research methodology. A total of 19 seventh grade students from a private school in Istanbul participated in this study during the 2020-2021 education year. The Cornell Critical Thinking Test (CCTT) was used to measure critical thinking skills, and the California Critical Thinking Disposition Inventory (CCTDI) was applied to determine critical thinking dispositions of the participants. Students were ranked from the highest critical thinking skills and disposition level to the lowest based on the results of these tests. In order to form homogeneous divergent multiple cases, sub sample of 6 students were selected: 3 students as having high level of critical thinking skills and dispositions (Group 1), and 3 students as having low level of critical thinking skills and dispositions (Group 2). The students in both groups read the plastics use text prepared by the researcher and her advisor and developed an argument through guided questions. Later students were interviewed to extend and elaborate arguments they have and given written counter argument to read and respond to. Similar with argument development process, semi-structured interviews were conducted with the students to get verbal explanation. In data analysis process, written and verbal arguments of the students were transcribed in digital platform and developed arguments were coded as claim, data, warrant, backing and rebuttal which are the main components according to TAP model. According to the Rubric 1 prepared for this study by adapting from the analytical framework developed by Şahin (2014). The same process was applied for developed counter arguments, and claim, data, warrant, backing and identifying counter argument components were coded and scored according to Rubric 2 prepared for this study. The tables and graphs were formed with the scores taken from each component for both Group 1 and Group 2 for their developed argument and counter arguments separately. Along with analysis of the tables and graphs, structure and content of the arguments were examined qualitatively, and the arguments and counter arguments were compared both in group and between groups. Also, the last versions of analysis of the arguments made by the researcher and the advisor who made independent ratings were compared and it was found that inter rater reliability is 91,5 % in terms of coding the components and scoring them. Based on the overall analysis of the developed arguments, the result showed that there is no major difference between the groups in terms of argument development. Specifically, average scores of the groups calculated for argument development process are quite close with each other. When each component is taken into consideration, it is seen that the students in each group were able to use scientific data, include warrants by relating with data and claim, and used rebuttals by justifying or supporting the claim it is defended. The only difference is detected from the backing component between the groups in argument development process. That is, the students in Group 1 used strong and clear backings while the students in Group 2 used clear, partially true or did not use backings. Similarly, the results gained from the analysis of counter arguments showed that there is no major difference between the groups, and their average scores are quite close with each other. According to analysis of each component, the similar results are stated with the results of argument development process. The major difference is only detected from the backing component between the groups, and the students in Group 1 were able to use strong and clear backings for their warrants compared with the students in Group 2 who were able to use at most partially true backings. Overall, the study has implications for the integration of the SSI scenario designed for this study, and SSI-based argumentation to middle school science instructions for enhancing critical thinking.

ÖZET

ORTAOKUL ÖĞRENCİLERİNİN ELEŞTİREL DÜŞÜNME BECERİLERİNİN VE EĞİLİMLERİNİN SOSYO-BİLİMSEL KONULARLA İLGİLİ ARGÜMANTASYONLARINDA NASIL YANSIDIKLARININ İNCELENMESİ

Çalışmanın temel amacı ortaokul öğrencilerinin farklı seviyelerdeki eleştirel düşünme beceri ve eğilimlerinin plastik kullanımı olarak belirlenen sosyobilimsel bir konu hakkında geliştirdikleri argümanlara nasıl yansıdığını araştırmaktır. Bu araştırmada, nitel araştırma yöntemlerinden araçsal çoklu durum çalışması uygulanmıştır. Çalışmaya 2020-2021 eğitim öğretim yılında İstanbul'da bir özel okulda öğrenim görmekte olan toplam 19 yedinci sınıf öğrencisi katılmıştır. Katılımcıların eleştirel düşünme becerilerini ölçmek için Cornell Eleştirel Düşünme Testi, eleştirel düşünme eğilimlerini belirlemek için California Eleştirel Düşünme Eğilim Ölçeği uygulanmıştır. Öğrenciler, bu testlerin sonuçlarına göre en yüksek eleştirel düşünme beceri ve eğilim düzeyinden en düşüğe doğru sıralanmıştır. Farklı seviyelerdeki homojen durumlar oluşturmak için, eleştirel düşünme beceri ve eğilimleri yüksek düzeyde olan 3 öğrenci (Grup 1) ve düşük düzeyde eleştirel düşünme beceri ve eğilimleri olan 3 öğrenci (Grup 2) olmak üzere 6 öğrenciden oluşan alt örneklem seçilmiştir. Her iki gruptaki öğrenciler, araştırmacı ve danışmanı tarafından hazırlanan plastik kullanım metnini okudular ve rehberli sorularla bir argüman geliştirdiler. Daha sonra öğrencilerle, sahip oldukları argümanları genişletmek ve detaylandırmak için görüşmeler yapıldı ve okumaları ve yanıtlamaları için yazılı karşı argüman verildi. Argüman geliştirme sürecine benzer şekilde, öğrencilerle sözlü açıklama almak için yarı yapılandırılmış görüşmeler yapılmıştır. Veri analizi sürecinde öğrencilerin yazılı ve sözlü argümanları dijital ortama aktarılmış ve geliştirilen argümanlar TAP modeline göre ana bileşenler olan iddia, veri, gerekçe, destek ve çürütücü olarak kodlanmıştır. Şahin (2014) tarafından geliştirilen analitik çerçeveden uyarlanarak bu çalışma için hazırlanan Rubrik 1'e göre. Geliştirilen karşı argümanlar için de aynı süreç uygulanmış ve iddia, veri, gerekçe, destek ve tanımlayıcı karşı argüman bileşenleri bu çalışma için hazırlanan Rubrik 2'ye göre kodlanmış ve puanlanmıştır.

Hem Grup 1 hem de Grup 2 için geliştirilen argüman ve karşı argümanlar için her bir bileşenden alınan puanlar ile tablolar ve grafikler oluşturulmuştur. Tablo ve grafiklerin analizi ile birlikte argümanların yapısı ve içeriği niteliksel olarak incelenmiştir ve geliştirilen argümanlar ve karşı argümanlar hem grup içinde hem de gruplar arası karşılaştırılmıştır. Ayrıca, araştırmacı ve danışman tarafından bağımsız olarak yapılan argümanların analizlerinin son versiyonları karşılaştırılmış ve bileşenlerin kodlanması ve puanlanması açısından değerlendiriciler arası güvenirliğin %91,5 olduğu tespit edilmiştir. Geliştirilen argümanların genel analizine göre elde edilen sonuçlar, argüman geliştirme açısından gruplar arasında büyük bir fark olmadığı yönündedir. Özellikle argüman geliştirme süreci için hesaplanan grupların ortalama puanları birbirine oldukça yakındır. Her bir bileşen dikkate alındığında, her gruptaki öğrencilerin bilimsel verileri kullanabildikleri, veri ve iddia ile ilişkilendirerek gerekçeler ekledikleri ve savunulan iddiayı gerekçelendirerek veya destekleyerek çürütücüler kullandıkları görülmektedir. Argüman geliştirme sürecinde gruplar arasındaki tek fark destekleme bileşeninden tespit edilmiştir. Öyle ki, Grup 1'deki öğrenciler güçlü ve net destek kullanırken, Grup 2'deki öğrenciler net, kısmen doğru veya hiç destek kullanmamışlardır. Benzer şekilde, karşı argümanların analizinden elde edilen sonuçlar, gruplar arasında büyük bir fark olmadığını ve ortalama puanlarının birbirine oldukça yakın olduğunu göstermiştir. Her bir bileşenin analizine göre, argüman geliştirme sürecinin sonuçları ile benzer sonuçlar belirtilmiştir. Belirgin fark, yalnızca gruplar arasındaki destek bileşeninden tespit edilmiştir ve Grup 1'deki öğrenciler, en fazla kısmen doğru destek kullanabilen Grup 2'deki öğrencilere kıyasla, gerekçeleri için güçlü ve net destekler kullanabilmişlerdir. Genel olarak, çalışmanın, bu çalışma için tasarlanan sosyo-bilimsel senaryosunun ve sosyo-bilimsel temelli argümantasyonun, eleştirel düşünmeyi geliştirmek için ortaokul fen derslerine entegrasyonu için çıkarımları var.

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LIST OF ACRONYMS/ABBREVIATIONS

CCC: Crosscutting Concepts DCI Disciplinary Core Ideas

CCTDI: California Critical Thinking Disposition Inventory

CCTT: Cornell Critical Thinking Tests

CT: Critical thinking

MEB: Ministry of National Education (Millî Eğitim Bakanlığı)

NGSS: Next Generation Science Standards

NOS: Nature of Science

NRC: National Research Council

OECD: Organization for Economic Co-operation and Development PISA Programme for International Student Assessment

SSI: Socio-Scientific Issues

STS: Science–Technology–Society

TAP: Toulmin’s Argument Pattern

1. INTRODUCTION

In modern society, people face with variety of problems and dilemmas which are products of science and technology and have impact on their lives. For these issues, it is required from people to make decisions and choices (Driver, Newton and Osborne, 2000). In view of this, one of the significant aims of science education is to prepare students to take action about dilemmas that consist of scientific and technological developments, and have effect on society called as socioscientific issues or SSI. Also, it is aimed to prepare students to make decisions about these issues (Driver, Newton, and Osborne, 2000; Ratcliffe and Grace 2003).

SSI movement has been developed based on Science-Technology-Society (STS) movement (Zeidler, Sadler, Applebaum and Callahan,2009), and besides to integration of science, technology and society SSIs incorporate moral reasoning, ethical dimensions of science, and students' emotional development (Zeidler and Nichols 2009). SSIs such as genetically modified organisms, global warming, climate change, decreased biodiversity or new medical treatments tend to arise based on rapid developments in science and technology (Kolsto 2001; SadlerandZeidler 2005b; Zeidler et al. 2002). SSIs include two significant properties: (1) being related with science content, and (2) having significance in social life (Eastwood et al., 2012; Bossér and Lindahl, 2017). Thus, they are placed in different part of lives as political, economic, and ethical etc., and influence societies at personal, regional, or global levels (Lee, Yoo and Choi, 2013). Generally, SSIs are difficult issues for people to deal with because they are open-ended, ill-structured, complex and controversial dilemmas (Sadler T., 2004; Zeidler, Sadler, Simmons and Howes, 2005; Zeidler and Nichol, 2009). This makes SSIs being subject to variety of perspectives, solutions and interpretations (Sadler, 2004; Bossér and Lindahl 2017).

Integration of SSIs into the school curriculum may advance scientific literacy of students (Lin and Mintzes, 2010), and the main goal of science education is determined as to enable students to become scientifically literate individuals (Khishfe, 2017). According to definition, scientifically literate persons are able to actively take part in addressing challenges that affect the society (Khishfe, 2017). Scientific literacy includes the applications of scientific knowledge for making decision in the situations that are based on society and have science components. This vision for scientific literacy emphases uses of science by students in real-life contexts (Sadler and Zeidler, 2009). Therefore, it is effective approach to embed SSIs in science education, and through these issues to guide students to make decisions.

Turkish Science Curriculum (2018) generated by Ministry of National Education also mentioned one of the main principles of science education is to educate all students as scientifically literate, and for this principle, it put importance on including SSIs in science education. The use of them as the central theme provides students to connect science with challenging problems, to engage in argumentation, critical thinking, and informed decision-making processes which require higher order thinking skills; and to have focus on scientific and social parts of SSIs (Genel and Topçu, 2016). Also, SSI-based instructions provide student to improve their reasoning and argumentation skills which are the main skills of scientifically literate citizens (Kolsto, 2001; Lin and Mintzes, 2010).

In that point, it is advocated that argumentation is the main component of science education since resolution of scientific controversies is gained through it. That is, the process of argumentation provides students to make decision for now and in the future about these issues (Driver, Newton and Osborne, 2000) because it is defined as the capacity to relate data and evidence with theoretical claims, and the capacity to select one of the alternatives among others by reasoning criteria (Jiménez-Aleixandre, Agraso and Eirexas cited in Lazarou and Erduran, 2017). Thus, argumentation is considered as the central component for decision making process (Lin, 2014), and it is seen as affective strategy to handle with SSIs. Therefore, argumentation is the important part of SSIs (Ratcliffe and Grace, 2003; Zeidler and Nichols, 2009).

As reviewed in the literature, studies related with SSIs and argumentation are divided into two lines based on their purposes. In the first line, there are studies that aimed at investigating how argumentation-based activities or instructions with regard to SSIs influence students' conceptual understanding (e.g. Sadler, 2005; Zohar and Nemet, 2002), moral sensitivity (e.g. Fowler, Zeidler and Sadler, 2009), scientific knowledge (e.g. von Aufschneider et al., 2008), argumentation skills (e.g. Khisfe, 2013), and communication skills (Chung et al., 2016). On the other hand, the studies in the second line investigated how different students with different backgrounds make decision about the same SSI, how they make justifications about their decisions, and how they use the evidence that are given to them. For this purpose, researchers investigated content knowledge (e.g. Sadler and Donnelly, 2006); behavior, emotion, and social and political practices (e.g. Kim, Anthony and Blades, 2014); moral tendencies, family background, personal interests, experiences and religion (e.g. Chang and Lee, 2010); grade and ability (e.g. Means and Voss, 1996) etc. Besides to these differences, critical thinking is one of the significant factors that affect in the process of constructing an argument, making judgment and decision related with controversial social applications of science and technology. Therefore, it is necessary to investigate how critical thinking skills as background differences between students reflect on their decision-making.

There are number of definitions about critical thinking in the literature (Vieira and Tenreiro-Vieira, 2014). In 1988, *Delphi Committee* constitutes of 46 experts in the field of critical thinking reached a consensus about the definition of critical thinking which is also adapted by The American Philosophical Association (APA), the U.S. Department of Education. The committee defined critical thinking as:

> "…purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based." (p. 3) in *The Delphi Report*.

Also, core and required cognitive skills for critical thinking were agreed on the same panel among six related skills as analysis, evaluation, and inference.

Along with cognitive skills, critical thinking dispositions are also considered as required precondition for critical thinking (Ennis, 1985; Facione 1990; Ernst and Monroe, 2004) since a person fails to think critically due to lack of disposition (Bensley and Murtagh 2011). Critical thinking dispositions refer to commitment and tendency to act in critical way (Ennis, 1985), and according to consensus of majority in the community divided into two groups as approaches to life and living in general, and approaches to specific issues, questions or problems.

Critical thinking leads students to make judgments and decisions (Lipman, 2003 cited by Gül and Akçay, 2020) which is one of the types of thinking among three (Willingham, 2008). Also, as stated above, argumentation takes place in the center of decision-making process, and directly it is the main component of SSIs. Therefore, according to correlation between argumentation-decision making and critical thinking-decision making in the context of issue, it is explained as critical thinking has relation with argumentation because argument construction is the fundamental process of critical thinking (Moon, 2008). Considering the definitions of critical thinking in the literature, it is seen that many researchers put emphasis on relation between critical thinking and argumentation in SSIs contexts. For example, King (1995) stated that critical thinking consists of skills, the specific process as analyzing presented arguments (cited in Kim, Sharma, Land, and Furlong, 2012). Moreover, Allegretti and Frederick (1995) focused on four functions to define critical thinking: evaluating arguments constructed by others, evaluating own arguments and gaining confidence in these arguments, resolving conflicts, and understanding and arriving at resolution to complex problems. Therefore, making reasonable decisions are depended on critical thinking, and critical thinking skills like analysis of evidence, assessing claims and arguments, explanations of presenting arguments and justifying procedures (Facione, 1990) exist in the center argumentation process concerning the controversy of social applications of science and technology. The chains between critical thinking, argumentation and SSIs show the relation between them.

To sum up, one as scientifically literate citizen is required to make decisions about science-based issues that affect society. For this aim, s/he engages in argumentation process about a SSI in which reflects his/her social, economic, moral, or religion-based backgrounds. Since argument construction is the process of critical thinking, there are variety of studies that examine critical thinking skills and argumentation in SSI context. When existing studies on critical thinking and argumentation in SSI context are examined, it can be concluded as most of the studies aimed at investigating the influence of different instructional approaches related with argumentation on development of critical thinking skills and dispositions of the participants (e.g. Memiş, 2006; Dwyer, Hogan and Stewart 2011; Kim, Sharma, Land, and Furlong 2012; Duran and Dökme, 2016; Gül and Akçay, 2020). Also, some of the studies presented the measuring of critical thinking skills of students based on their argumentation qualities in SSI contexts (e.g. Akgun and Duruk, 2016). However, the problem that is still unexplored how critical thinking skills and dispositions of students which is another difference between them reflect on SSI argumentation. In other words, there is a gap in the literature about how divergent critical thinking skills and dispositions of students exhibit themselves on argumentation in SSI context. Therefore, this study aims at investigating reflection of critical thinking skills and dispositions of students on their argument development and counter argument process about a SSI.

2. LITERATURE REVIEW

2.1. Scientific Literacy

The term scientific literacy started to be used in 1950s and it was coined by Paul Hurd to refer to comprehension of science and its applications to society (Laugksch, 2000). In general, scientific literacy is usually regarded as being "public understanding of science" (Hurd, 1998; Bybee, McCrae, and Laurie, 2009). However, there are different meanings and interpretations associated with scientific literacy since variety of factors, such as views about what the public should know about science and who the public is, have effect on meanings and interpretations of scientific literacy. Thus, scientific literacy is ill-defined and diffuse concept due to differences in meanings and interpretations (Laugksch, 2000).

In the literature, there are lots of definitions about the term scientific literacy (Ogunkola, 2013). Miller (1983) stated two different meanings of scientific literacy: "to be learned" and "to be able read and write". The first meaning of scientific literacy is related with scientific knowledge. Therefore, "to be learned" means that it is significant to have scientific knowledge in order to communicate about science. The second meaning of scientific literacy is related with both reading, comprehending, and expressing abilities of individuals about scientific subjects. As stated by Ogunkola (2013), Durrant (1993) defined scientific literacy as what public ought to know about science. Hurd (1997) defined scientific literacy as "cognitive capacities for utilizing science/technology information in human affairs and for social and economic progress" (p. 411). Brewer (2008) defined scientific literacy as having enough knowledge about science for being able to judge an article in a newspaper or in a magazine or commentary on a newscast or on TV, and being able to understand what is being talked about in these sources.

In the Handbook of Research on Science Education, Roberts (2007) defined scientific literacy by categorizing different viewpoints into two "visions" and called as "Vision I" and "Vision II". The Vision I include products of science which are laws, theories; and the process of science like making hypothesis and experiments. According to this vision, science education in schools should be constructed on the base of scientific knowledge and skills which provide students to think and take an approach to scientific issues like a scientist. Vieira and Tenreiro-Vieira (2014) stated Vision I is scientist centered. According to this vision, the focus is science subject matters which are decontextualized. Since series of scientific concepts took place in documents like Science for All Americans (AAAS, 1990) and Benchmarks for Science Literacy (AAAS, 1993), these documents were compatible with Vision I for scientific literacy (Sadler and Zeidler, 2009).

On the other hand, Vision II is related with the role of science, and this role is stated as decision making and negotiation about socio-scientific issues. When scientific literacy is evaluated from the Vision II perspective, the basis of science education in schools should be scientific knowledge and skills which provide students to think and take an approach to scientific issues like a well-informed citizen about scientific issues. Also, this vision aims at integrating students into local, national, and global communities' cultural values and perspectives. Therefore, Vision II is contextual, and students take place in the center of it (Vieira and Tenreiro-Vieira, 2014). Compared with Vision I that give importance to know the science as a discipline, Vision II put emphasis on reasoning, ability to use scientific ideas, and reasoning to gather scientific literacy. In that point, the scientific literacy defined in the light of Vision II scientific literacy coincides with the Next Generation Science Standards since includes scientific practices as analyzing data, using related evidence in arguments, collecting and evaluating information (Presley, Sickel and Muslu, 2013).

According to Tsai (2018) scientific literacy consists of two actions: reading and writing. As part of science education, while reading is related with scientific reading, writing is engaged in the argumentation process. Similarly, Norris and Phillips (2003) argued the term scientific literacy as ability for reading and writing in the content of science and pointed out that these two points are the fundamental sense of scientific literacy.

It is important to explain what scientific literacy is from the point of view of varying institutions. According to National Science Education Standards, scientific literacy has been defined as follows:

> "Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusion…" (p.22).

The National Research Council (NRC) defines scientific literacy through the following five components:

- Knowledge of important scientific facts, concepts, principles, and theories;
- To be able to apply related information in daily life;
- Ability to use scientific inquiry processes;
- Understanding of main ideas about the features of science, and important interactions of science, technology and society;
- Having knowledge about the attitudes, and interests toward science.

The Program for International Student Assessment (PISA) is an international assessment program coordinated by the Organization for Economic Co-operation and Development (OECD), and aims at indicating the skills and knowledge of 15-year-old students, and assessing their science, math literacy, and also literacy in worldwide range. According to PISA, scientific literacy is defined in The PISA 2003 Assessment Framework published by OECD as:

> "The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity (p. 133)."

Therefore, it is summarized as PISA (2006) focused on specific components for the definition of scientific literacy. These are personal, social, global contexts; scientific competencies; the domains of scientific knowledge, and attitudes toward, and are shown in Table 2.1.

Table 2.1. Framework for PISA (2006) science assessment.

Name of the domain	Explanation of domain
Scientific contexts	The issues that can be confronted in daily life. Such as environmental issues, health issues, technological issues.
Scientific competencies	To reason the issues in scientific contexts, to make-decision about societal issues and to produce arguments while supporting their decisions about scientific contexts.
The scientific knowledge	"Knowledge of science" is about having the knowledge of natural world as scientific content knowledge. "Knowledge about science" is about having the knowledge about how science works. Such as scientific processes, nature of science (NOS).
Student attitudes toward science	The way of responding toward scientific issues. Such as attitudes, beliefs, interests, engagements and motivation of students.

Sadler and Zeidler (2009) advocated that scientific literacy should include understanding and practices related with "science-related situations" and this kind of view about scientific literacy takes place "at the extreme" of Vision II. When these science-related situations are formed, individuals integrate science and other "considerations". Therefore, Sadler and Zeidler (2009) constructed their researches and works in science education on the base of a SSIs framework which utilizes from psychological, sociological and developmental theory perspectives. Although these views proposed by them cause to contrast with Vision I about scientific literacy, they are highly consistent and related with the many other views in the field that evaluated as the standard for modern science education on the contrary. One of the related views in the field stated by Poulito (2008) as:

> "It is now a commonplace in science education that the study of socio scientific issues by students constitutes a prime avenue for fostering scientific literacy of a kind that will prompt young people to familiarize themselves with science in action, to develop their capacity for evaluating the information made available to them on a daily basis, to make decisions concerning controversial sociotechnical issues, and to take part in debates and discussions on sociotechnical controversies of concern to them." (Pouliot, 2008, p. 545).

Also, scientific literacy is conceptualized by relating with socio scientific issues in the field and it is stated that scientific literacy includes the abilities as analyzing, synthesizing, and evaluating information for decision making; dealing with moral and ethical issues; and understanding connections among socio scientific issues (Zeidler, Sadler and Simmons, 2005).

As stated in the previous paragraphs, scientific literacy is significant in spite of different definitions, purposes for advocating and ways of measuring it took place in the literature. It is argued that national wealth, in turn international competitiveness, being employable in many areas like sports, arts, etc., development of science, being able to understand and being skeptical about an article on a newspaper or a commentary on television, taking personal decisions like diet or vaccination are based on whether individuals are scientifically literate or not (Laugksch, 2000 and Ogunkola, 2013). Besides, scientific literacy is important in terms of society. There can be some issues related with public such as global warming, stem cells etc. and people live in this society require to discuss for dealing with these issues (Ogunkola, 2013). Scientific literate citizens have better humanistic culture and critically engage with science, since they use scientific knowledge in different context and situations which require scientific ways of thinking. When citizens do not engage with this process, they use their personal interest, experience, opinion or other people's information and beliefs in the process of making decision on and choices that have effects on both them and other citizens (Vieira and Tenreiro-Vieira, 2014). Due to these reasons, curriculum specialists have included scientific literacy in science curriculums. In Turkey, scientific literacy is included as the special purpose in the science curriculum published by The Ministry of National Education (MEB) in 2018 as in many countries. In the curriculum, involve the grades from 3 to 8, the statement "to raise scientific literate person" takes place as the main goal of science education. Due to this aim, ten objectives are listed and described, and they mostly mention related skills to be scientifically literate person. These objectives are:

- Providing main information about astronomy, biology, physics, chemistry, earth and environmental sciences, and science and engineering applications;
- Adapting scientific process skills and scientific research approach in the process of discovering nature and understanding the relationship between

human-environment and finding solutions to the problems encountered in these areas;

- Recognizing the interaction between individual, environment, and society; developing an awareness of sustainable development about society, economy and natural resources;
- Taking responsibility for daily life problems and using scientific knowledge, scientific process skills, and other life-based skills for solving these problems;
- Developing awareness about career and entrepreneurship skills related to science;
- Helping to understand how scientific knowledge is created, how this knowledge is developed by scientists and how it is used in new research;
- Raising interest and curiosity about events occurring in nature and near environment and developing an attitude towards them;
- Creating awareness about importance of safety in scientific studies;
- Developing reasoning skills, scientific thinking habits, and decision-making skills by using socio-scientific subjects;
- Providing adaption of universal values of ethics, national and cultural values and scientific ethics (p.9).

In general, these objectives are about providing students to improve their skills of decision making, scientific thinking, and argumentation through science-related social issues. Scientifically literate citizens are required to participate in public debate about the issues based on science, technology, society and environment; to make decisions and to deal with controversial problems in their daily lives (Kolsto, 2001; Lin and Mintzes, 2010), and these socially controversial issues are related with science (Tsai, 2018). Therefore, the skills which are decision making and argumentation, and socio-scientific issues that refers to the social aspect of science and the relationship between science and society are required concepts to be able to scientifically literate person. DeBoer (2000) advocated the similar approach to cultivate scientific literacy of students who should be aware of science as social and cultural force and be aware of the relationship between science and society. Aikenhead (1994) also put emphasis on technology along with science and explained the main goal of science education as to develop capacities of students to act as responsible citizens in the society that science and technology increasingly develop. Thus, students have needs to understand interactions between science technology and their society. In that point, he mentioned the aim of a science- technology-society (STS) curriculum was providing students to have knowledge about the relation between science and society, and the ability to make decisions about science-related social issues.

2.2. Science Technology and Society (STS)

At the end of 1970's, the main aim of science education researchers became reflecting the effects of science, technology and society combination (Zeidler, Sadler and Simmons, 2005). This aim was driven from the requirement for all people that be able to think, speak and take action about science related matters that have influence on society and quality of living (Solomon, 1993), and these abilities are significant and necessary for people to be scientifically literate. For the purpose of developing scientific literacy in the light of Vision II, several curriculum movements have been designed. Science-Technology-Society (STS) movement was the most widely accepted and known among related movements like public understanding of science, humanistic science education, context-based science etc. (Sadler and Zeidler, 2009).

STS movement in science education has been originated from environmentalism and the sociology of science. STS school science first took values and social responsibility into consideration for students as future citizens. Thus, conceptual framework of STS was formed by integrating two broad academic fields. The first one is the interaction of science and scientists along with social issues and institutions, and these are not engaged in scientific community. The second field is the social interactions between scientists and their communal, epistemic, and ontological values in scientific community (Aikenhead, 1994).

The National Science Teachers Association (NSTA) as part of a National Science Foundation (NSF) defined STS as teaching and learning of science in the context designed based on human experiences. In other words, STS refers to focus on real world problems included in students' perspectives, and these problems consist of science and technology components. Thus, problems in local, global, regional, national, and international levels are determined, and through individual and group activities, required actions are designed to solve these investigated issues (NSTA, 1990). Aikenhead (1994) defined STS by focusing on its aims as follows:

> "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).

As stated by Mansour (2009), Yager (1996) defined STS in a similar way with NSTA as "dealing with students in their own environments and with their own frames of reference" (p.10). This definition also means working for solution of issue and advancing for taking individual and group-based actions by starting with students and their questions and using all related sources. Mansour (2009) identified Science, Technology and Society (STS) is an interdisciplinary field of study, and according to him, it explores and understands the variety of ways for modern science and technology to shape modern culture, values and institutions, and ways for modern values to shape science and technology.

Solomon (1993) listed fundamental features of STS within science education as:

- An understanding of environmental threats to the quality of life, including global ones;
- The economic and industrial sides of technology;
- An understanding of the fallible nature of science;
- Discussion of personal opinion, values and democratic actions;
- A multi-cultural dimension (p.19).

Along with mechanism of Science, Technology and Society (STS) for all students to become scientifically literate citizens, this movement provides other significant benefits when applied in science education. In the first place, STS approach instigates students to analyze and apply concepts and processes to real situations, to extend beyond the classroom environment to their local communities. In addition, one of the benefits bring through STS education is development and promotion of students' decision-making skills, creativity, and overall science process skills (NSTA, 1990). Yager (1990) explained STS curriculum encourage students to have experience in "identifying potential problems, collecting data with regards to the problem, considering alternative solutions, and the consequences based on a particular decision" (as cited in Amirshokoohi, 2010). Besides to problem solving skills and developing scientific understanding, one of the major goals of STS reform is to foster critical thinking skills of students as well.

By the late 1970s, many science education researchers agreed on science would become more meaningful to students when placed in the context in which it affects technology and in turn technology directs society. However, STS movement was insufficient, and this was explained by Zeidler, Sadler and Simmons (2005) as:

> "While STS education typically stress the impact of decisions in science and technology on society, it does not mandate explicit attention to the ethical issues contained within choices about means and ends, nor does it consider the moral or character development of students" (p.359).

Also, STS movement was lack of putting attention to the quality of social interactions and reflective discourse which are closely related with the formation of conscious and justice principles (Zeidler, Sadler and Applebaum, 2009). Therefore, even though knowledge and understanding of the inter-relationship between science, technology, and society are major elements for gathering scientific literacy, these interconnections do not exist independently of students' personal beliefs. As a result, STS approach has been remodeled and substantially improved by adding a missing component which is consideration of moral and ethical development of each student (Zeidler, Sadler and Simmons, 2005).

2.3. Socio-Scientific Issues (SSIs)

SSIs require a degree of moral reasoning and the evaluation of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues (Sadler, 2004a; Zeidler, 2003). They are described as open-ended, complex, and controversial dilemmas that do not have certain answers (Sadler, 2004; Zeidler, Sadler, Simmons and Howes, 2005; Zeidler and Nichol, 2009). Bossér and Lindahl (2017) described SSI as "value-laden, contentious and subject to multiple interpretations" (p. 372). There are three common components that cause SSIs to become controversial:

(1) different viewpoints, biases, backgrounds, and values of individuals,

(2) conflict between several number of groups who have different interests, and

(3) inadequate and limited evidence (Gül & Akçay, 2020).

Along with these characteristics, there are two important elements for an issue to be SSI. The first one is, a SSI is required to relate with science topics. The second criterion is that the issue has to be significance in social life (Bossér and Lindahl, 2017). Sadler and Zeidler (2005) also pointed out these criteria of SSIs and briefly defined them as "the complex interactions of science and society" (p.72).

Similarly, Ratcliffe and Grace (2003) stated SSIs have a basis on science and they are within limits of scientific knowledge many dimensions of SSIs. Also, they defined other dimensions of socio-scientific issues as:

- compromising of making decision and forming opinion processes at personal and societal level;
- being reported by media;
- dealing with information which are incomplete due to conflicting or incomplete scientific evidence;
- addressing dimensions at local, national, and global level;
- requiring risk calculation and some understandings of probability;
- involving cost-benefit analysis;
- considering sustainable development;
- involving moral and ethical reasoning.

In addition, socio scientific issues include scientific claims and arguments; ethical, political and epistemological perspectives (Kolstø, et al., 2006).

At this point, it is important to state some examples for SSIs for the sake of clarity. SSIs that many people may confront and experience in their daily lives are such as genetic engineering (Walker and Zeidler, 2007; Zohar and Nemet, 2002), environment-based issues (Patronis, Potari, and Spiliotopoulou, 1999; Osborne, Erduran, and Simon, 2004), genetic modification (Chung, Yoo, Kim, Lee, & Zeidler, 2016), global warming (Sadler, Chambers and Zeidler (2004), and nuclear power usage (Yang and Anderson, 2003; Wu and Tsai, 2007).

SSI movement drawn from Science-Technology-Society (STS) movement (Zeidler, Sadler, Applebaum, & Callahan, 2009). As stated above, the main aim of the STS approach includes integration of science, technology and society in science education for students' meaning learning. Also, the National Teacher Association (NSTA) (1982) mentioned that having knowledge about the relationship between science, technology and society is one of the main properties of scientifically literate person. However, STS approach had a deficiency due to lacking ethical and moral constructions (Aikenhead, 1994). These components are important to consider because integration of them in an interdisciplinary science curriculum provide achievement of scientific literacy (Zeidler, 1984; Zeidler, Walker, Ackett and Simmons, 2002). Therefore, a new shift or framework of STS has become necessary for moral and ethical development of students, and so enabling students to be scientific literate individuals. This framework that should be involved in science education is SSIs. Unlike STS education which integrates only science, technology, and their inter-relationship, SSIs consider ethical dimensions of science, moral reasoning, and emotional development of students (Zeidler and Nichols, 2009). Therefore, as Zeidler et al. (2002) pointed out they are the broader term because it includes all that STS submit and also the ethical dimensions of science, the moral reasoning of children, and the emotional development of the students.

For the need of replacing STS with SSI is rationalized by Zeidler, Sadler, Simmons and Howes (2005) 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).

While explaining the reason for replacement, they attached importance to "functional scientific literacy" of students. As stated in the beginning of this chapter, Vision II is an approach involving personal decision about science and social issues that are contextually embedded, and Zeidler and Keefer (2003) and Zeidler and Sadler (2011) give countenance to the Vision II approach of scientific literacy in a socio scientific issue-based context because this vision promotes what they term as "functional scientific literacy" (Karışan & Zeidler, 2017).

For this aim, to achieve a functional view of scientific literacy, Zeidler et al. (2005) claimed that there is a need to develop a coherent conceptual framework and this framework should be flexible enough to enable multiple perspectives for educators and curriculum specialists to understand moral development of students. One framework proposed by Zeidler and Keefer (2003) and this framework that is derived from a cognitive-moral reasoning perspective address SSI discourse with regards to the psychological, social, and emotive growth of children. This initial model gives acceleration for the development of a SSI framework, so Zeidler, Sadler, Simmons, and Howes (2005) extended and revised the model according to research conducted by science education community and related research external to science education and this model is shown in Figure 2.2.

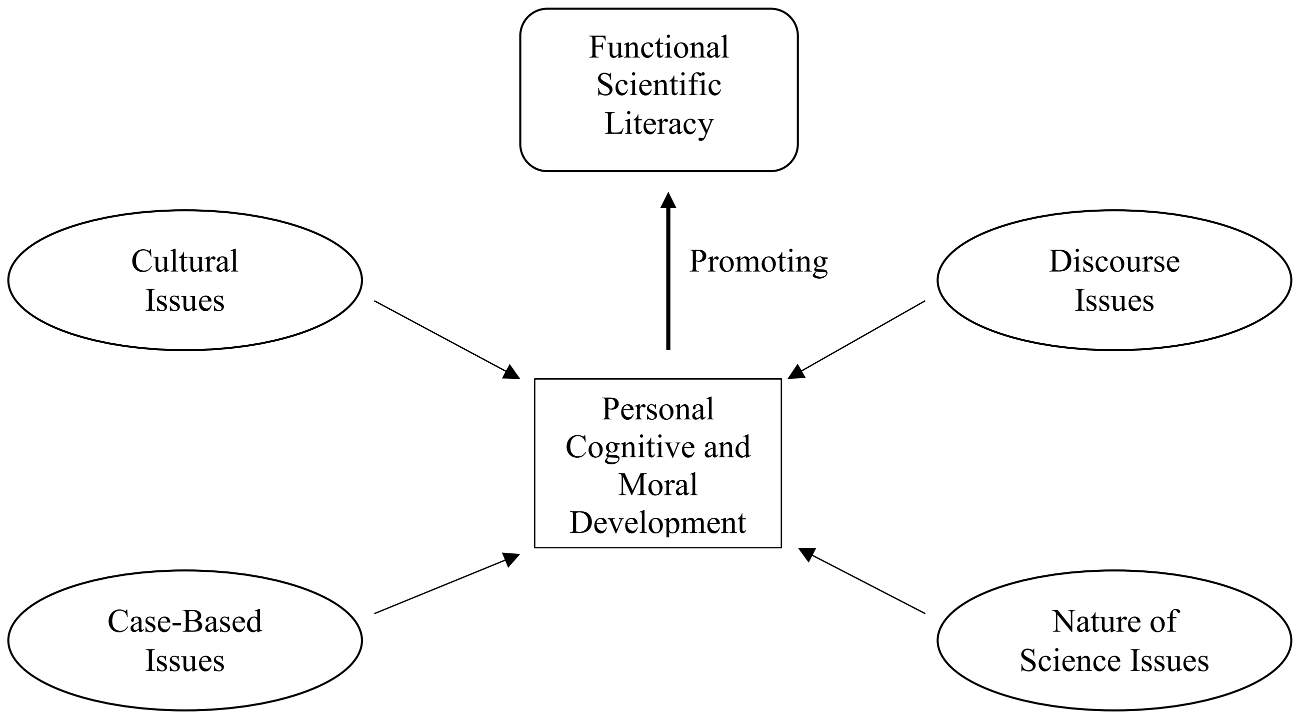

Figure 2.1. Socioscientific elements of functional literacy (Adapted from Zeidler and Keefer, 2003).

Figure 2.2 shows the main socio-scientific elements - cultural issues, case-based issues, discourse issues and nature of science issues- that promote functional scientific literacy. The elements of SSI also make contribution for learners to gather personal, moral, and cognitive development (Karışan & Zeidler, 2017). Besides, these elements identify four areas of pedagogical importance that are in the center of SSI teaching. It can be thought as these elements make contribution students to develop them intellectually and in turn, aid in informing pedagogy in science education for promoting functional scientific literacy (Zeidler, Sadler, Simmons, & Howes, 2005).

The model has some similarities with the properties of STS listed above. For example, the element “discourse issues” in the model refers to “discussion of personal opinions and values” feature of STS in the list. “Nature of science issues” take place in STS as “some understanding of the fallible nature of science”. “Case-based issues” means “the economic and industrial sides” and “cultural issues” are related with “multi-cultural dimension” according to STS perspective. However, unlike STS, there is an extra component which is “Personal, Cognitive and Moral Development” in the middle of the model. When the Figure 1 is analyzed in a careful way, it can be said that all other four components are related with this component located in the middle. With the contribution of four components and promoting personal, cognitive and moral development of students, functional scientific literacy can be gathered. Therefore, application of SSI is considered as an important strategy in science education to improve students’ scientific literacy (Sadler & Zeidler , 2005).

In science education, it is now usual that when students study with SSIs, they get the main pathway to foster scientific literacy of a kind (Zeidler and Nichols, 2009). The research conducted by Fowler, Zeidler and Sadler (2009) also showed that students’ moral sensitivity, and moral development in overall increase through socio-scientific issues-based teaching. The way of incorporating socio scientific issues helps to educate students who are looking for the truth, being open-minded, analytical, systematic, judicious, and increasingly confident in their reasoning (Zeidler & Nichols, 2009). Kolsto (2001) pointed out that SSIs enable students to gain insight about the way of people that how they use science and develop their potential in terms of consuming scientific information. In that point, similar type of advances was mentioned for students’ themselves. That is, integrating SSI strategies into science education creates opportunity for students to reevaluate their prior understanding and restructure their conceptual understanding of subject matter by way of their personal experiences and social discourse (Karışan & Zeidler, 2017). This approach also prompts students to familiarize themselves with science in action, to enhance their capacity about evaluating the information that is submitted to them on a daily base, to make decisions related with controversial sociotechnical issues, and to participate in debates and discussion on sociotechnical controversies that concern them (Zeidler & Nichols, 2009).

Discussion process and debate of controversial socio scientific issues in science education motivate students to develop many of the skills and dispositions related with critical thinking. The main critical thinking skills as analysis, inference, explanation, evaluation, interpretation, and self-regulation (Facione, 2007) will be encouraged by socio scientific units, and the critical thinking dispositions will be also prompted associated with them (Zeidler & Nichols, 2009). Besides, discussion of SSI during science education can be beneficial for students to notice that science is related with something from real life. This was also advocated by Evagorou, Osborne and Jimenez-Aleixandre (2012) and they stated SSIs provide students to identify human dimension within the practice of science and recognize relations of science to everyday life, this also explain the reason why they should be part of school science. Related with this achievement, other contribution of studying with SSIs is that students ready for life as citizens in a society who frequently experiences new and controversial science- related issues and who are required to have ability in order to deal with them. Enabling students to gain this ability is an important and one of the main goals of science education. Based on the purpose that educating and preparing the citizens of tomorrow, students are required to enhance their skills about arguing ill-structured and complex issues, and so constructing an awareness related with existence of different perspectives for the same issues (Rundgren, Eriksson, & Rundgren , 2016). In addition, the idea which is thoughtful decision-making about SSISs is fundamental for democratic societies has been argued as well (Kolstø S. D., 2001). Bossér and Lindahl (2017) explained that integration of SSI in science lectures make contribution to development of students in terms of content knowledge, moral and ethical sensitivity, and higher-order thinking skills which is significant for controlling conscious decision-making process and taking action related with SSI. Along with these opportunities, integration of SSI provides students to enhance their interests and motivation.

Controversial nature and the components explained above as causes of controversial nature of SSI require students to think critically about presented issues, and to discuss them with people who show different approach. However, controversial issues bring up new problems for both citizens, experts, and politicians and promote them to participate in decision-making process. In other words, these listed properties cause to evaluate scientific information which are contradict with each other and to make decisions about SSIs to be complex and compelling process for students (Albe, 2008) . This situation was also explained and revealed by Perkins, Farady, and Bushey (1991) through comparing SSI reasoning with scientific reasoning. They stated that scientific results are explained and presented with formal reasoning and logic even though the results are gathered at the end of informal reasoning. Also, constructed premises through formal reasoning do not change. Unlike formal reasoning, when additional information about socio-scientific issues are given and integrated into the process, it is possible that premises can change, and results are not formed in an explicit way. According to Zeidler (2003), the decision-making process for socio-scientific issues should be depended on argumentation by taking into account the value aspects of the issues. Therefore, argumentation should be considered as the significant part of SSI due to the decision-making process and multi-perspective and multi-disciplinary features of SSI.

2.4. Argumentation

Recent science education literature has stressed that argumentation plays an important role in the classroom (Sadler, 2006; Organization for Economic Co-operation and Development (OECD), 2012), and various definitions about argumentation exist in science education literature.

Kuhn (1991) defined argumentation as “an assertion with accompanying justification” (p.12). Similar with the definition of Kuhn (1991), Means and Voss (1996) described an argumentation as a conclusion which is supported with at least one reason. Berland and McNeil (2009) defined scientific argumentation similar with Jimenez-Aleixandre and Erduran (2008) and stated scientific argumentation as both the written and spoken products and processes. While argumentative product consists of a claim which has been justified, argumentative process involves a dispute or debate between people as social meaning.

As stated by Lazarou and Erduran (2017), Jiménez-Aleixandre, Agraso and Eirexas explain argumentation as “the capacity of relating data and evidence to theoretical claims, the capacity of choosing among several alternatives using reasoned criteria” (2004, p.2).

Van Eemeren and Grootendorst (2004) stated definition of argumentation as the “a verbal, social and rational activity aimed at convincing a reasonable critic of the acceptability of a standpoint by putting forward a constellation of propositions justifying or refuting the proposition expressed in the standpoint” (2004, p.1). That is, argumentation includes social and rational characteristic along with verbal side. In the definition, verbal activity is related with activities through language use, social activity is directed at people as a rule, and rational activity is related with intellectual considerations. While verbal and social properties of argumentation have contribution to students’ communication skills, rationality of argumentation provides students to enhance cognitive process skills like argument construction (Felton, 2004).

Van Eemeren and Grootendorst (2004) also pointed out another significant property of argumentation which is belonging to a specific point of view regarding certain issues. The one who has this standpoint through argumentation, defends it to other people who advocate opposite view or different standpoint for convincing them. Kuhn and Udell (2003) also defined argumentation in a similar way as “the dialogic process in which two or more people engage in debate of opposite claims.” in which there exist evaluation and justification of claims for scientific knowledge” (p.1245).

According to Driver, Osborne and Newton (2000), argumentation can be seen as an individual activity by means of thinking and writing; or argumentation can be considered as a social activity or social act that occurs within a group or specific community through negotiation. Hunter (2007) stated that argumentation constitutes of related assumptions and conclusions for analysis of a problem.

There are four key characteristics determined by Berland (2008) for argumentation process as:

1. Individuals state and defend their claims.
2. Individuals question one another’s claims and defense them.

3. Individuals evaluate one another's claims and defense them.
4. Individuals revise their own claims and other's claims (Berland and McNeill, 2009).

There are some argumentation models place in the literature. One of the most used models is Toulmin's Argument Pattern (TAP). It was developed by Stephen Toulmin in 1958, and published in his book, "The Uses of Argument". This model describes fundamental components of argumentation which are data, claim, warrant, backing, rebuttal, and qualifier. Also, functional relationships between these components are represented in the model. In Figure 2.3, Toulmin's argument pattern is shown.

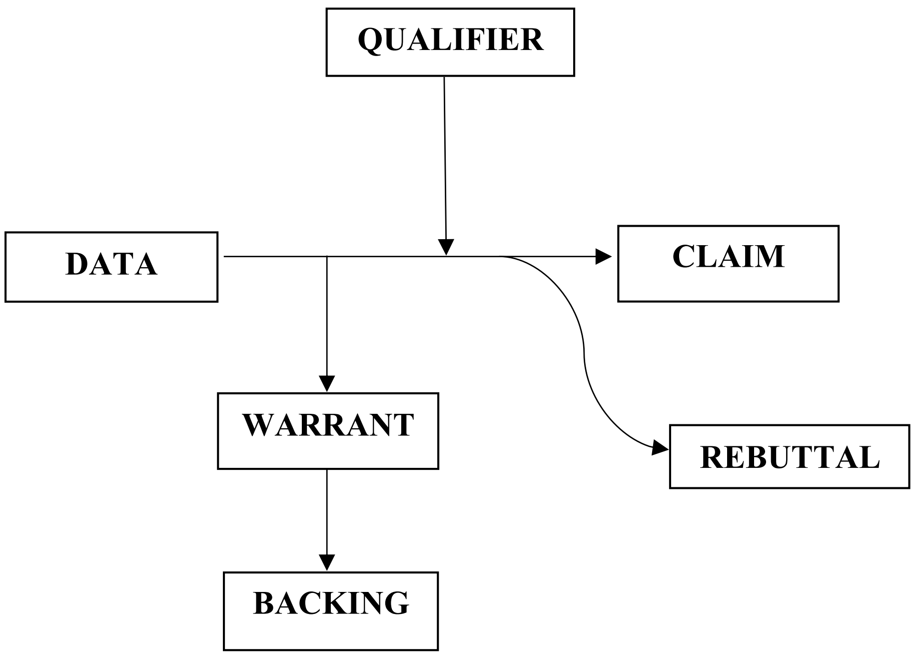

Figure 2.2. Toulmin's argument pattern (TAP) (Adapted from Toulmin, 1958) .

The components in the model can be listed and explained as follows (Toulmin, 1958; Simon 2008; cited in Erduran, 2004):

- **Claim:** is an assertion related with values that people hold and about what exists. Claims are stated in an explicit way for general acceptance.
- **Data:** is a statement used as evidence for support of the claim. That is, data are specific facts.
- **Warrants**: are statements that provide a link between the data and the claim. The warrant explains the relationship between these components.

- **Backkings:** are the assumptions that aim at strengthening the warrants. They are often not stated explicitly in an argument, and they are required when warrants are not accepted.
- **Rebuttals:** are statements that are contradicted with the data, warrant, backing or qualifier of an argument. Rebuttals are extraordinary situations that refute validity of the claims.
- **Qualifiers:** are phrases that indicate the conditions for the claims to be true. That is, qualifiers define the rational strength of the claims and limit conditions for the applicability of the claims.

In detail, the argument model developed by Toulmin (1958) consists of three main components as “claim”, “data/grounds” that support the claim, “warrants” that strength the connection between the data and the claim. In addition to these essential components, there are components called as “backing”, “qualifier” and “rebuttal” in the model. Qualifiers and rebuttals are used to make level of an argument into higher level, and rebuttals are used for circumstances in which claims do not hold true. This is also mentioned by Osborne (2010) as existence of rebuttals in arguments shows the highest quality since using rebuttals require abilities of comparing, contrasting, and differentiating the lines of reasoning. Toulmin stated that the first three components must take place in an argument while the last three components have contribution to validity of the argument (Erduran, Simon, and Osborne, 2004; Simon, 2008).

As a result, TAP provides theoretical perspective for the basis on argument. Also, it enables to conceptualize the meaning of argument (Simon, 2008). (TAP) is suitable to be used in order to teach the skills of argumentation to students and teachers (Dawson and Venville, 2010). Besides, TAP is the main analytic tool for evaluating students’ argumentation qualities in scientific and socio scientific contexts (Sadler and Fowler, 2006). However, Erduran, Simon, and Osborne (2004) emphasized that this pattern has some methodological difficulties and ambiguities in terms of determining claim, data, warrant and rebuttal, and backing separately even though these components are defined one by one.

Argumentation has become a common aim of science education curriculums in many countries (Öztürk and Doğanay, 2019). The main purpose that lay behind integration of argumentation in science education is to get students to argue as scientists, comprehensively is to develop students' skills related with producing evidence for supporting their perspectives (Sandoval and Millwood, 2008). In addition, as stated by Bernald and McNeill (2009), Duschl et al. (2002) discuss argumentation as a central goal of science education because through the argumentation, focus of science classrooms can alter from rote memorization to engagement in scientific practices that knowledge-based claims are constructed and justified by students. Jiménez-Aleixandre and Erduran (2007) proposed many advantages related with disciplinary, social, and personal epistemological perspectives that are derived from including argumentation in science education. These advantages are relating with supporting:

- the improvement competency in terms of communication and critical thinking,
- the scientific literacy achievement and strengthening students to use science language in writing and talking,
- the inclusion of students in practices for scientific culture and the improvement of epistemic criteria for evaluating knowledge,
- the development in reasoning, and the making choice of theories or position considering rational criteria (cited in Akkaş, 2018).

Research conducted about argumentation in science education have been advocated by philosophical and cognitive perspectives about the role of argument. According to philosophical perspective, science includes theories and construction of them which are explanations of disputable phenomena. In addition, advance of science occur through dispute, conflict, and argumentation. Thus, in the center of science and scientific discourse, arguments about interpretation of evidence and validity of knowledge claims take place. From a cognitive perspective, significant property of reasoning and thinking is argument. In detail, when students are engaged in argumentation, it is provided for them to enrich the relationship between evidence and claim, to appreciate the significance of justification in scientific argumentation (Simon, 2008). These different perspectives have inclined researchers towards developing theoretical and methodological frameworks related with the conception and analysis of argumentation in science (Simon, 2008; Osborne, Erduran, and Shirley, 2004; Zohar and Nemet, 2002).

When argumentation is embedded in school science instruction, it becomes a promotive approach for developing skills of students related with critical thinking, reasoning, and decision making on science and SSIs (Kim et al. 2014; Driver et al. 2000; Osborne et al. 2004; Sadler 2004). Students are guided to evaluate related data and evidence for supporting or refuting claims in the process of argumentation. Also, they construct their personal based explanations for relating data and evidence with hypothesis. Therefore, the confidence of students about using science-based language and forming criteria to evaluate knowledge and to construct explanations are strengthened with the association between claims, evidence, and justification in argumentation (Jimenez-Aleixandre and Erduran, 2007 cited in Kim et al., 2014).

2.5. Socioscientific Argumentation

Current reforms about science education focused on that the goal of science education does not only include teaching of scientific concepts to students, but also provide students to understand problems related with society (Erduran and Jimenez-Aleixandre, 2007 cited in in Kim et al., 2014). These societal problems are addressed as SSIs. In that point, it is important to point out that social, verbal and intellectual features of argumentation are helpful for students to engage in ill-structured problems. Therefore, argumentation is in the center of SSIs (Belland, Gu and Armbrust, 2015). This is also advocated by Driver, Newton and Osborne (2000) because they defined argumentation as the central component of decision-making process. Since nature of SSIs are controversial and one of the main features of SSI are decision making process, it is important to develop students' decision-making skills on these issues. Considering that argumentation improves these abilities, it can be said that argumentation is an appropriate and effective strategy in dealing with SSIs (Topçu and Atabey, 2017) Also, Sadler (2004) indicated SSIs present appropriate contents that can be equipped with students’ argumentation skills. In addition, integration of argumentation based on SSI context into science lectures in schools guide students to argue and evaluate the issue in terms of social, ethical, and scientific (Ratcliffe, 1997). According to Able (2007), argumentation about SSIs motivates students and increase their interests in these issues in the lectures. With the integration of argumentation in SSI, it is also opportunity for students “to practice for citizenship” as stated in scientific literacy (Driver et. Al., 2000; Zeidler and Nichols, 2009). That is, several aspects of scientific literacy can be achieved through including SSI argumentation in science education. Similarly, Sadler and Zeidler (2009) indicated scientific literacy should be one of the main goals for all students and based on this reason, they related SSIs with argumentation within the scientific literacy framework. Moreover, frameworks designed for argumentation are widely utilized in science education literature to analyze reasoning in the context of students who engage in socioscientific discourse.

In that point, it is fundamental to differ SSI argumentation from scientific argumentation. With respect to context, the type of argumentation can be either scientific argumentation or SSI argumentation. As citated by Çapkınoğlu, Yılmaz and Leblebicioğlu (2018), Jiménez-Aleixandre and Erduran (2008) defined scientific argumentation as “the connection between claims and data through justifications or the evaluation of knowledge claims in light of evidence, either empirical or theoretical” (p.13). The process of scientific argumentation includes attempts to explain a natural phenomenon or to propose a meaningful and acceptable answers for the questions that stated in a research. On the contrary, students utilize and include social, economic, moral, or religion-based evidence in the SSI argumentation process, rather than using evidence which are knowledge-based. Therefore, the solution of SSIs is discussed and a decision about the issue is made at the end of the argumentation process. Especially, making decision about SSIs means making a choice and advocating only one side of the issue (Çapkınoğlu, Yılmaz and Leblebicioğlu, 2018).

When existing studies in the literature are taken into consideration and evaluated, it can be determined that there are two lines of research in terms of purpose. In the first line, researches deal with how certain classroom activities, including argumentation (e.g. Albe, 2008; Dawson and Venville, 2010; Jiménez-Aleixandre and Pereiro-Munoz, 2002), decision-making (e.g. Grace, 2009; Papadouris and Constantinou, 2010; E. Pedretti, 1999), and other unspecified activities with regard to socio-scientific issues (e.g. Y. Wu and Tsai, 2007; Yoon, 2008), shape and affect students’ performance in terms of argumentation skills, content knowledge, scientific literacy (Cavagnetto, 2010) moral sensitivity, and other factors. Among these activities, it is seen that most of the studies conducted about SSIs focus on argumentation (Topçu, Muğaloğlu and Güven, 2014), and in recent years, researchers have focused on the analysis of argumentation discourse in classroom environment in science education in their studies (Jiménez-Aleixandre, Rodríguez, and Duschl 2000; Osborne, Erduran, and Simon 2004a).

There are number of studies conducted based on the first line, and among these studies one of them was conducted by Khisfe (2013). In this study, it was aimed to explore the influence of explicit argumentation instruction based on SSI on students' argumentation skills, and to investigate the transfer of argumentation skills that students gain from one SSI context into another SSI contexts. The sample of the study consisted of 121 seventh grade students, two groups as Treatment I and Treatment II were formed. For 8 weeks, the students in each group were engaged in treatment about the water usage and safety, but the students in Treatment I group attended to the additional explicit argumentation instruction. For assessing students' learning and transfer of argumentation skills, open-ended questionnaire, and interviews about two SSIs were applied. The results showed that explicit argumentation instruction in the context of the SSIs enhanced the quality of argumentation skills of students in Treatment I group, that is the students support their arguments by including more than one justification after explicit argumentation instruction through SSI. Also, in the study the importance of SSI contexts was emphasized as providing an optimal condition for argumentation.

Along with development in argumentation skills, moral sensitivity of students can be promoted through science learning experiences designed on the base of SSIs and argumentation. Fowler, Zeidler and Sadler (2009) put emphasis on relationship between moral sensitivity and SSIs. In the study, the participants consisted of 11^{th} and 12^{th} grade students, and they divided into groups as the comparison and treatment. For the comparison group, two classes were formed and while one of them was made up of students with superior academic performance, and the other one consisted of students with diverse histories of academic performance. The same procedure was applied for the treatment group. In the comparison classes, the instructions were designed based on traditional teaching methods along with labs, and discussion of content related issues. On the other side, the lectures for the classes of treatment group were constructed on the base of using SSIs within the content along with the argumentation. Results showed that moral sensitivity of students in the treatment groups increased at a greater level than the comparison groups for the scenario about genetic modification.

Also, the importance of SSI argumentation was determined for the development of scientific knowledge through the study conducted by von Aufschneider et al. (2008). In this study, one of the purposes was to investigate cognitive development of junior high school students by using video and audio documents taken from small group and classroom discussions in the lessons designed based on argumentation about science and SSI contexts. Data were analyzed for determining development of students' scientific knowledge by drawing on a schema to specify both the content and level of abstraction of students' meaning making. The results showed that argumentation-based lectures about science and SSIs make students to enhance their existing knowledge and elaborate their understanding at high levels of abstraction. Also, this study showed that engaging in argumentation provide students to develop their thinking which construct basis for further learning.

Moreover, Tsai (2018) investigated the effect of argumentation of SSIs on students' scientific competencies and attitudes about sustainability. In this study, the researcher presented the SSIs- Online-Argumentation Pattern (SOAP) as a pedagogical strategy for guiding students to online argumentation process about SSI. Two quasi-experiments were conducted in the study. For the first experiment about scientific competency, 127 high school students were divided as 77 participants for experimental group, and as 50 participants for comparison group. In the second experiment, a total of 68 undergraduate students formed the groups. While the SOAP strategy was implemented in the experimental group, traditional textbook-based lectures which includes similar SSIs, such as genetically modified organism and nuclear power were applied for the comparison group after both groups took Scientific Competence Test. The results showed differences between the experimental and comparison group in terms of scientific competencies. The mean of scientific competency of the experimental group was higher than competency of the comparison group in the test. The results also showed that the SOAP strategy leads to differences in sustainability attitude of undergraduate student. That is, the mean of sustainability attitude of the experimental group was higher than the score of the comparison group.

Chung et al. (2016) focused on promoting students' communication skills through SSIs which provides to increase peer interactions, stimulate reasoning of students, and form shared social knowledge. Based on these properties of SSI, the study was designed in order to investigate to what extent SSI instruction on gene modification (GM) technology have contribution to enhance 132 ninth grade students' communication skills. About 4 weeks, SSI based instruction about the GM technology is implemented and data were taken from small group discussions happened in classrooms, semi-structured interviews with the student and instructor, and pre-and post-scores on the Communication Skills Questionnaire (CSQ). The results showed that SSI instruction have significant impact on students' ability related with understanding the main ideas stated by others, and valuing others' perspectives, and developing active arguments. Therefore, the study indicated that SSI based instructions have inevitable potential in terms of developing and promoting students' communication skills in the classroom context.

In the literature, it is suggested that the development of argumentation skills of students may have effect on their conceptual understanding (Sadler, 2004; Dawson and Venville, 2010). Zohar and Nemet (2002) conducted a case study with 9^{th} grade students from two different schools and explored fostering students' knowledge and argumentation skills through dilemmas in human genetics. The participants were grouped as experimental group consisted of 99 students and comparison group of 87 students. The students in the experimental groups were taught genetics which includes subtopics as genetic counselling, inheritance, gene therapy and genetic cloning. Also, explicit argumentation skills as developing and justifying arguments and counter arguments, bioethical principles and practices using these skills were integrated into lectures of experimental group through discussion of ten moral dilemmas. On the other hand, the students in comparison group were taught a traditional genetics topic. Results showed that the students in the experimental group used their biological knowledge to develop their arguments' quality about bioethical dilemmas. Also, their scores were statistically significant higher scores compared with the scores of students in comparison group in a genetic test consists of 20 multiple choice questions. Therefore, it was concluded that teaching of argumentation skills through moral dilemmas improve students' conceptual understanding and argumentation.

As a result, analysis of these research show that engaging in argumentative issues enhance students' argumentation skills, content knowledge, moral sensitivity, communication skills, scientific competencies and attitudes about sustainability.

On the other side of the coin, in the literature about argumentation through SSI contexts, there are also large number of studies that focus on exploring a variety of factors have influence on performance of students in SSI argumentation including content knowledge (e.g. Sadler and Donnelly, 2006; Sadler and Fowler, 2006; von Aufschnaiter, Erduran, Osborne and Simon, 2008), and such personal dispositions as attitudes or moral sensitivity (e.g. Dawson and Soames, 2006; Fowler, Zeidler, and Sadler, 2009; Sadler and Donnelly, 2006; Tomas, Ritchie, and Tones, 2011) process of middle school and high school students or pre-service science teachers. This is the second line of research in terms of purpose. As a whole, in these studies, it was investigated how values, qualities and experiences of individuals make contribution to their decision making and argumentation quality about SSI (Chang and Chiu, 2008; Kolstø, 2006; Sadler and Zeidler, 2005; Rundgren et al., 2016). It is required to investigate individual differences between students while constructing arguments and counter arguments Considering the individual differences is also important for designing appropriate and differentiates instructional materials and adapting teaching strategies (Lin and Mintzes, 2010).

When the studies conducted about content knowledge and argumentation, it can be seen that these two variables affect each other positively (Sadler and Donnelly, 2006; Sadler and Fowler, 2006; von Aufschnaiter, Erduran, Osborne and Simon, 2008). For example, Sadler and Fowler (2006) stated that one of the main factors that affects the way of argumentation in SSI context is content knowledge and investigated how students apply scientific content knowledge about genetics on SSI argumentation about genetic engineering. Three distinct groups attended to the study: high school students with variable genetics knowledge, college nonscience majors with little genetics knowledge, and college science majors with advanced genetics knowledge. In each group, there were 15 students, and interviews were conducted with the participants. During the interviews, participants determined their own positions concerning the three scenarios about gene therapy and cloning. According to analysis of data, science majors exhibited higher quality in argumentation, and give references to specific science content knowledge to justify their claims.

Sadler and Donnelly (2006) put emphasis on effect of morality on SSI argumentation along with the effect of content knowlegde. They investigated how content knowledge and morality have contribution to the argumentation quality in the SSI context about genetic engineering. For this aim, they conducted this study with 56 high school students, and each participant completed the tests about content knowledge and moral reasoning at the beginning of the study.

Then, interviews were carried out with the participants, and were scored based on a rubric for argumentation quality. According to both qualitative and quantitative analysis of the data, the results about content knowledge showed that content knowledge is fundamental for SSI argumentation as investigated by Sadler and Fowler (2006), but there is not any linear relationship. According to this result, they proposed a model called as “Threshold Model of Knowledge Transfer” and stated that at least two knowledge thresholds are postulated for improvement of argumentation. In terms of results about morality, even though quantitative analysis showed that there are no statically significant relationships among moral reasoning and argumentation quality, qualitative analysis showed that the participants construed the issues about genetic engineering as moral problems in the discussion. This model was supported by other researchers whose studies asserted that argumentation practice of learners is affected by their content knowledge related with SSI without engaging morality (e.g., Dawson and Schibeci, 2003; Patronis et al., 1999; Yang and Anderson, 2003).

Kim, Anthony and Blades (2014) stated that “argumentation on SSIs goes beyond the scientific knowledge.” On this basis, they conducted a study to examine the argumentation skills of preservice teachers during group discussions to make decisions about a highly contentious, local SSI. The participants were eight preservice teachers and attended to instructions about argumentation in variety of topics during six classes. Then, it was required from the participants to select science-related topics in the local community that are important to be discussed. The chosen topics were the need for a sewage treatment facility and the effectiveness of the local landfill facility. The participants were equally divided into two discussion groups, and the groups were called as a sewage group and landfill group which are compatible with the issues. Data of this study were taken from the group discussions, and argumentation schemes, critical moves, and patterns of dialogue were revealed from the arguments of the participants. The conclusion was drawn as students do not only utilize scientific knowledge, but also use different dimensions of knowledge including human behavior, emotion, and social and political practices for constructing argumentation.

Chang and Lee (2010) identified the students' tendencies in terms of their moral reactions and attitudes when they get to make a decision about SSIs. The participants of this study were thirty college students, and data were gathered through individual interviews related with the issues of human cloning, genetic engineering, and animal dissection/ experimentation. The results showed that most of the participants in the study included their own values, worldviews, and feelings in both implicitly and explicitly when talking about SSI. Also, the participants' backgrounds like religion, and family background, personality, past experiences, personal interests, and prior knowledge had influence on their reactions. Moreover, some tendencies revealed in responses of the participants in decision making process, and these tendencies are including personal values, confusing with incompatible values, being overwhelmed due to lots of aspects to consider, and trying to be independent from the issues.

Çapkınoğlu, Yılmaz and Leblebicioğlu (2018) evaluated the students' quality of argumentations in relation to local SSI, and determined major variables that vary the quality of argumentations. In this study, the participants were 36 seventh grade students, and as data tool five local SSIs based on local environment were selected: an artificial lake, chicken coops, leather tanneries, base stations, and hydroelectric power plants. The participants were divided into three groups in order to implement different argumentation activities about the same local issues. These are outdoor groups who attended to field trips for experiencing the local issues, newspaper groups who get positive and negative information through local newspapers, and presentation groups who learned through informative presentations. After students get sufficient data from their own learning sources, they constructed argumentation about the selected issues. Results showed that there are two major variables that argumentation quality of the students vary according to these variables: data sources provided for the learning groups, and SSIs that are discussed by the students. In terms of the first variable, it was stated that different data sources like field trip, newspaper and presentation have impact on differences in argumentation qualities of the students. According to the second finding, the selected SSIs have effect on differences in students' argumentation quality, and the students construct high quality of argumentations related with local SSIs.

Decision making based on SSI also is related with nature of science which has contribution on scientific literacy and informs debate that happening on the base of SSIs. In other words, it is advocated that nature of science conceptualizations have influence on interpretation and evaluation of conflicting evidence in SSI context during decision making process. Sadler, Chambers, and Zeidler (2004) have investigated how students conceptualize the aspects of nature of science called as NOS, and how they interpret and evaluate information that are contradict with each other about SSI. The participants, high school students, were engaged in open-ended questionnaires about global warming and interviews for the exploration of NOS conceptualizations and SSI decision-making. The results of study presented that interpretation and evaluation of conflicting evidence for decision making were in SSI context affected by some of the factors related to NOS such as data interpretation, social interaction along with students' prior knowledge, personal relevance, and scientific knowledge.

Among the variables that can affect argumentation skills, Means and Voss (1996) explored the relation of argumentation skills to students' grade, ability and knowledge levels. For this aim, they studied with three levels of students as intellectually gifted, average, or below within the grades 5,7,9 and 11 for the first experiment; and 90 students from grades 8,10 and 12 who were designated as gifted, average, or low ability were attended to the second experiment of the study. Three tasks about everyday problems were given to the participants, and the students suggested solutions and gave justifications for these problems. According to the results, argumentation reasoning performance of gifted students were determined as distinctly superior to average and low-ability students. Also, in terms of performance-grade relations, it was found that performance directly increase with grade level. The results pertaining the knowledge which includes both subject matter knowledge and personal experiences show that knowledge is significantly related with number and type of reasons that constructed by the participants, but knowledge does not measure acceptability of arguments. When the findings were interpreted on the base of two-component model of reasoning skills in which one component is informal reasoning and the other one is knowledge, it was presented that without appropriate reasoning skill and knowledge, the participants who have average or lower ability levels get information with little or no application of reasoning skills.

Topçu and Atabey (2017) investigated the effect of field trips based on SSIs on argumentation quality of students. 31 seventh grade students were participated to the study, and these students were assigned as one group. Before the field trips to thermal, wind and hydroelectric power plants, the participants completed the written argumentation forms consist of text about the plants and questions to present their arguments. individually about these power plants. After the field trips to these plants, the same argumentation forms were fulfilled by the participants. According to analyzed data, it was found that SSI-based field trips have contribution on improvement of students' argumentation quality because the number of students presenting second and third level of evidence and reasoning which are evaluated as high level increased, and the number of students who present first level of evidence and reasoning decreased. In addition, the study showed that argumentation quality of the students develops depend on field trips about SSIs.

In the literature, it is stated that intellectual baggage which involves prior knowledge, values and past experiences has a dominant influence on decision making and SSI argumentation. The study conducted by Rundgren, Eriksson and Chang Rundgren (2016) focused on investigating the relationship between the knowledge, values, and experiences use in their SSI argumentation. Seven science major students which are in the year of their upper secondary were engaged into argument development and decision-making processes relating to an authentic SSI about environmental toxins. A multi-disciplinary instructional module was designed for the development of students' skills to argue about complex SSI, and data were collected during this instructional module through (1) group discussions, (2) students' written reports on their decision making, and (3) semi-structured postexercise interviews with individual students. The results showed that the students made different decisions by taking different arguments into account about the Baltic Sea fish contamination issue even though the same information were accessible for all of students. In the study, it was stated that to give different weightings to different aspects of the issue such as health risks, economic, environmental or cultural considerations is dependent on their background knowledge, values, and experiences.

Sadler and Zeidler (2002) conducted a study to investigate influence of moral considerations on SSI decision-making. Moral aspect is recognized prescriptions related with human welfare, justice and rights. In the study, it was mentioned that SSIs have moral aspect inherently due to the standards of these issues such as being objective, prescriptive and generalizable. Especially, the issue of gene therapy and cloning include many moral factors, and the decision makers of these issues are the main arbiters of morality. Therefore, the study aimed at exploring to what extend the students interpret genetic engineering issues as moral problems during decision making process. The study was conducted with twenty college students, and they participated in the interviews with a series of genetic engineering scenarios derived from gene therapy to cloning issues. Thus, the interviews provide the researchers to reveal students' ideas, reactions and feeling about the issues which are gene therapy and cloning. As a result, moral considerations as well as series of other factors like personal experiences, family biases, background knowledge, and popular culture emerged in decision-making about SSI.

It is important for students to be able to make decisions from different perspectives about the issues that they encounter in real life and to be able to intervene in the processes in cooperation with the society. These skills for students can be revealed through socio-scientific argumentation activities. In that point, Patronis, Potari, and Spiliotopoulou (1999) advocated that students are able to develop arguments and make decisions when they encounter with a situation or issue that they are familiar within their daily lives. In their study, they explored the ways in which students make decision about a real-life problem, and also examined the quality of arguments constructed by students in individual, group and class discussions. The real-life problem was about the planning of a major road where the school was situated. Some of the students supported the design accepted by government that they planned based on safety rules. Other students advocated to construct a bridge over the school road, and both advantages and disadvantages of this idea were discussed. Results showed that students are able to develop arguments and make proper decisions when they faced with the issue that they are really in.

In conclusion, when the conducted studies explained in the previous paragraphs are considered and evaluated as a whole, there are various aspects and variables that affect students' argumentation and decision making about SSIs. Students' prior experiences, SSI context familiarity, moral considerations, nature of science conceptualizations and prior knowledge are main variables that construct the huge body of SSI argumentation literature. However, along with these factors, there is also one significant element that takes place in the process of constructing an argument, making judgment and decision related with controversial social applications of science and technology: Critical thinking (National Research Council, 2007; Lin and Mintzes, 2010; OECD, 2001; Wang, Chen, and Hong, 2017; Gül and Akçay, 2020). That is, critical thinking could be considered as a fruitful framework to examine SSIs and to make decision about these issues (Yacoubian and Khishfe, 2018). The reason why critical thinking is one of the main elements of decision making originate from critical thinking's property that it consists of certain set of skills as analyses, evaluation, and inference (Dwyer, Hogan and Stewart, 2011). Therefore, it is necessary to detail definition and properties of critical thinking, its relationship with scientific literacy, SSIs and argumentation, and studies conducted based on critical thinking in science education literature.

2.6. Critical Thinking

Philosophy and psychology which are two primary academic disciplines forms the bases of literature on critical thinking (Lewis and Smith, 1993). Sternberg (1986) has also added the field of education to critical thinking literature as the third strand (Lai). Since 1980's, the promotion of critical thinking became one of the most significant and remarkable issue in science education accordance with an increase in interest on critical thinking (Vieira, Tenreiro-Vieira and Martins, 2011). Thus, critical thinking constitutes the vast area of the literature and over the past decades, many researchers have conducted research about critical thinking and dispositions (e.g. Facione et al., 1995; Ernst and Monroe, 2004; Gül and Akçay, 2020).

In the literature, a wide range of views and definitions exists as to what critical thinking is. There is not a universally agreement about definition of critical thinking. This kind of variety also causes difficulty for researchers and teachers to have consensus about key components and skills of critical thinking (Facione et al., 1995; Ernst and Monroe, 2004; Dwyer, Hogan, and Stewart, 2011; Vieira and Tenreiro-Vieira, 2014).

Being accepted as the 'father' of modern critical thinking, John Dewey made a breakthrough with his classic book, *How We Think*, in which he developed a new notion 'reflective thinking' in 1910, and used this term for critical thinking by defining as "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (as cited in Stewart and Hogan, 2011, p.2).

Glaser (1941) defined critical thinking as an attitude of being inclined to consider problems and subjects, which coincide with one's experiences, in a thoughtful way; a knowledge of the methods for logical enquiry and reasoning; and some abilities for applying those methods. According to him, critical thinking requires a persistent and constant effort to analyze beliefs or knowledge that is supposed in the lens of evidence for supporting it and its further conclusions that have inclined to. It also requires some abilities related with

- recognizing problems,
- finding applicable tools to solve these problems,
- collecting and organizing relevant information,
- recognizing assumptions and values that are not stated,
- understanding and using language in accuracy, clear and discriminatory way,
- realizing the existential and non-existential logical relationships between propositions,
- arriving at guaranteed conclusions and generalizations,
- testing the conclusions and generalizations that one draws,
- reconstituting one's ways of beliefs relying on wider experiences, and
- constructing certain and correct judgments for specific things and qualities in everyday life (Glaser, 1941).

Ennis (1985) defined critical thinking as "reflective and reasonable thinking that is focused on deciding what to believe or do" (p.45). According to him, there are variety of cognitive skills that make contribution to decide what to believe or what to do rationally. These skills were listed as to focus on a question, analyze arguments, ask and answer questions and/or clarification, judge a source's credibility; judge observation reports deductions, inductions, making, value judgments, definitions; identify assumptions, and decide taken action and interact with others.

Allegretti and Frederick (1995) presented the definition of critical thinking on the base of four functions as evaluating others' arguments, evaluating one's own arguments and gaining confidence in own arguments, resolving conflicts, and understanding and arriving at resolution to complex problems. Similarly, as cited by Kim, Sharma, Land, and Furlong (2012), King (1995) stated that critical thinking consists of skills, the specific process as analyzing presented arguments, making inferences, stating logical results, and evaluating each relevant elements along with possible outcomes of each decision in a critical way.

From the perspective of Kurfiss (1988), critical thinking is an investigation when one aims at exploring a situation, problem, phenomenon, or question to come to a hypothesis or conclusion which includes relevant and available information, and so justification of this hypothesis or conclusion can be done demonstratively. Therefore, the outcomes of a critical thinking are twofold: one of them is a conclusion or hypothesis, and the other one is the justification which is offered for support. At this point, Kurfiss (1988) stated that these outcomes are often presented in the form of an argument, and justification is required for the ill-defined nature of problems called as socio scientific issues to which critical thinking is applied. Since conclusions cannot be tested, one who arrives at a conclusion needs adding supporting reasons to present its plausibility.

In 1988, a committee which is known as *Delphi Committee* and constitutes of 46 experts in the field of critical thinking, gathered in order to discuss about definition of critical thinking and necessary skills to think critically. According to findings from this meeting, the report was formed namely as *The Delphi Report* and written by Facione (1990). In the report, critical thinking was defined as:

> "…purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based." (p.3).

Moreover, experts in the project defined and described who an ideal critical thinker is as follows:

> "The ideal critical thinker is habitually inquisitive, trustful of reason, fair-minded in evaluation, willing to reconsider, open-minded, honest in facing personal biases, prudent in making judgements, and reasonable in the selection of criteria" (Facione, 1990, p.3).

The American Philosophical Association (APA) adapted the definition of good critical thinking described in Delphi Report (1990). This made the definition to become a widely accepted definition. Along with APA, the U.S. Department of Education used the same definition for the framework of educational goals (Dwyer, Hogan and Stewart, 2011). As stated by Facione (1990) in the Report, Delphi experts made remarkable consensus on the skills and sub-skills of critical thinking. These are presented in Table 2.2 by adapting from the Delphi Report (1990, p.6).

Table 2.2. Consensus list of core skills of critical thinking and sub-skills.

Skills	**Sub-Skills**
Interpretation	• Categorization • Decoding Significance • Clarifying Meaning
Analysis	• Examining Ideas • Identifying Arguments • Analyzing Arguments
Evaluation	• Assessing Claims • Assessing Arguments
Inference	• Querying Evidence • Conjecturing Alternatives • Drawing Conclusions
Explanation	• Stating Results • Justifying Procedures • Presenting Arguments
Self- Regulation	• Self-examination • Self-correction

Mainly, there are three core and necessary cognitive skills for critical thinking that were overwhelmingly agreed on the Delphi panel and took place in the report. These skills are analysis, evaluation, and inference. In the Delphi Report, description of these skills was included as following (Facione, 1990):

- **Analysis:** This skill refers to identify the intended and actual inferential relationships among divergent form of representations like statements, questions, concepts, or descriptions in which the aim is expressing beliefs, judgments, experiences, reasons, information, or opinions.
  i. **Examining ideas:** include to determine the role of expressions in the argumentation context; to define terms; to compare and contrast ideas, concepts or statements; to identify issues; to specify the components and to conceptually determine the relationships of them with each other and also with the whole.
  ii. **Detecting Arguments:** refer to determine whether a reason or reasons are expressed supportively, or they object to some claim, opinion, or point of view in a set of statements, descriptions, questions, or graphic representations or not.
  iii. **Analyzing Arguments:** to determine and differentiate the intended main conclusion, premises and reasons supporting the main conclusion, the further premises and reasons drawn as backup for the premises, additional unexpressed assumptions or presuppositions, conclusions of the reasoning, and any items that take place in the expressions under consideration that is not intended to be taken as part of the stated reasoning or the intended background.

- **Evaluation:** This skill is to assess whether a person's perception, experience, situation, judgments, belief, or opinion are credible or not. Also, it is the ability to assess the actual or inferential relationships among different form of representations like statements, descriptions, questions etc. in terms of their logical strength.
  i. **Assessing Claims:** to recognize relevant factors related with assessing the degree of credibility that is attributed to information or opinion; to assess questions, information, principles, rules, or procedural directions in terms of their contextual relevance; and to assess acceptability and confidence level of the probability or truth that take place in experience, situation, judgment, belief, or opinion-based representations.

ii. **Assessing Arguments:** refer to judge whether assumed acceptability of given argument's premises justify one's acceptance**;** to develop questions or objections and to assess them whether they point out weaknesses in the argument; to determine the bases of argument whether consist of false assumptions or presuppositions and to determine their degree of effect on strength of argument; to make judgment between reasonable and fallacious inferences; to determine acceptability of the argument; to determine to what extent possible additional information have effect on to strength or weak an argument.

- **Inferences:** This skill provides one to determine required elements for presenting reasonable conclusions; to construct conjectures and hypothesis; and to gather reasonable conclusions from statements, evidence, judgments, beliefs, descriptions, questions, or other forms of representation.

i. **Querying Evidence:** to recognize premises that require support and to make a strategy as a formula for getting information that lie behind the support in particular, and to make judgment for the information which is related with deciding given alternative question, issue, theory or hypothesis is acceptable, plausible or having relative merits and to determine plausible strategies which are investigatory in order to gather that information.

ii. **Conjecturing Alternatives:** to formulate a variety of alternatives to resolve an issue, to set multiple suppositions about a question, to design alternative hypotheses related with an event and to improve a series of different plans for achieving some specified goals. It is also the ability to develop presuppositions and make project regarding with decisions, positions, policies, theories or beliefs' large variety of possible consequences.

iii. **Drawing Conclusions:** to apply appropriate inference modes while determining which position, opinion, or point of view one should gain for a given particular topic or issue; to draw inferential relationships, conclusions or the presuppositions of a set of statements, descriptions, questions or other form of representations; to develop multiple sub-species of reasoning; and to determine which possible outcomes are most strongly supported by the available evidence, or which outcomes should be rejected by the given information.

Halpern (2013) defined critical thinking as “the use of those cognitive skills or strategies that increase the probability of a desirable outcome” (p.450). He used the term critical thinking to define as purposeful, reasoned and goal-directed thinking since cognitive skills or strategies are used for increasing the likelihood of a desired outcome. The term goal-directed thinking is explained as the kind of thinking, which is attached to solving problems, formulating inferences, making decisions and calculating probabilities.

Willingham (2008) explained the point of view of cognitive scientists about critical thinking, and stated that critical thinking has a subset of three types of thinking: reasoning, making judgments and decisions, and problem solving, and there are three key features of critical thinking: effectiveness, novelty, and self-direction. Based on these views, he defined critical thinking as “seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning dispassionately, demanding that claims be backed by evidence, deducing and inferring, conclusions from available facts, solving problems, and so forth” (p.8). According to him, the ability to think critically are related with having adequate content knowledge, and it is also required to recognize and solve the problems by executing variety of solutions. Therefore, content knowledge of students about the issue affects their performance on critical thinking or argumentation in the context of the issue (Lin and Mintzes, 2010).

Besides to cognitive skills, most researchers also agree that critical thinking dispositions take place for critical thinking (Ennis, 1985; Facione 1990). Ennis (1985) stated that critical thinking dispositions reflect a critical spirit which is made of a trend, commitment, and tendency for acting in a critical way and then which applies critical thinking abilities accordance with critical thinking criteria and standards (Vieira and Tenreiro-Vieira, 2014). Similarly, Bensley and Murtagh (2011) pointed out the importance of assessing both critical thinking skills and dispositions together. They explained the reason as: a person who has requisite critical thinking skills may still not think critically if lacking the disposition, and vice versa. One should have certain skills as analyzing, reasoning, problem solving, decision making and evaluation in order to perform critical thinking (APA, 1990) and for using these critical thinking skills, the initial requirement is to prompt critical thinking dispositions (Ernst and Monroe, 2004). In other words, one’s critical thinking disposition is a required precondition because it directly and greatly influences critical thinking capability. Also, disposition is significant to determine whether greater skill for making mature judgments is related with a strong disposition or not, even though disposition is not a skill (Yüksel and Alcı, 2012). The critical thinking skills and dispositions toward critical thinking also present the achievement in which degree individuals have required skills as problems solvers (Ernst and Monroe, 2004).

John Dewey, known as father of critical thinking, indicated three dispositions which are essential in critical or reflective thinking: objectivity, sincerity and responsibility. Ennis (1985) examined the concept of critical thinking dispositions as well since assumed that critical dispositions are as significant as critical thinking abilities. In considering critical thinking dispositions, he listed some of the dispositions as being open-minded, paying attention to the total situation, seeking reasons, looking for alternatives; being sensitive to the feelings, level of knowledge and degree of sophistication of others; and trying to be well informed. Additionally, Halpern (2013) stated critical thinking dispositions includes the willingness to plan, to accept errors of other people, and to change mind; having persistence, being mindful, and seeking consensus.

As a summary, it is seen that critical thinking consists of both cognitive skills and dispositions. Even though there are variety of definitions about critical thinking, properties about cognitive skills and dispositions in the literature, some of the researchers put emphasis on similar points. Defining critical thinking by focusing on ill-defined nature of problems defined as SSIs (Kurfiss, 1988) and decision-making about the complex problems (Facione, 1990, Kursiff, 1998; Halpern 2013); also identifying, analyzing and assessing of arguments about these issues (Ennis, 1985; Facione, 1990, Allegretti and Frederick, 1995; Kursiff, 1998; Willingham, 2008) presented that critical thinking, argumentation and SSIs are related concepts with each other.

2.6.1. Assessment of Critical Thinking Skills and Dispositions

As with the multivariate definitions were developed and offered for critical thinking, way of assessing critical thinking skills is also disputable and assessment tools of critical thinking tend to include multiple divergent themes. Therefore, lots of several standardized tests and self-reports have been constructed for assessing critical thinking skills and dispositions since 1940. Developed tools have differences in terms of properties such as age of test-takers, specifically focused point that the test intends to assess, or types of questions that take place in the tool (Ku, 2009; Lai, 2011). On the other side of the coin, the assessments have number of common key themes such as reasoning, analysis, argumentation, and evaluation. In the literature, there are approximately 20 different tools have been developed to assess total or various components of critical thinking.

In today's educational system, the most widely used tools for assessing critical thinking skills and dispositions can be listed as: The Watson-Glaser Critical Thinking Appraisal, The Ennis-Weir Critical Thinking Essay Test, The California Critical Thinking Skills Test, The California Critical Thinking Disposition Inventory, and The Cornell Critical Thinking Test.

The Watson-Glaser Critical Thinking Appraisal was constructed and proposed by Watson and Glaser (1980). In time, the test has been revised and so many updates were applied to the test. It is a multiple-choice test and consists of 80 questions. Specifically, it is used to evaluate five levels of critical thinking ability which are assumptions, interpretation, inference, deductions, and evaluation. Young adults and above constitute the target participants who can participate in The Watson-Glaser Critical Thinking Appraisal.

Robert Ennis and Eric Weir constructed Ennis-Weir Critical Thinking Essay Test in 1985. The description of the test was given as:

> "General test of critical thinking ability in the context of argumentation…the test is intended to help evaluate a person's ability to appraise an argument and to formulate in writing a response, thus recognizing a creative dimension in critical thinking ability" (p.1).

The test was developed to evaluate critical thinking ability of participants by engaging them into appraising argument and into formulating in writing a response context. According to this purpose, written information like a letter composed of eight paragraphs is presented to the test-takers, and it is expected from them to write an essay. It is appropriate to use for assessing critical thinking abilities of high school and college students (Kobrin, Lai and Sato, 2016).

The California Critical Thinking Skills Test (CCTST) was developed based on consensus definition of critical thinking in Delphi Study by Peter Facione (1990). It is used to evaluate inference, analysis, deduction, and induction skills of the participants. The test includes 34 multiple choice items, and for each item there are four or five options. Test-takers should select one of the options for the follow-up question of each item which consists of a short text. The scores of test-takers are calculated as the total number of correct answers. It is appropriate to use this test for college level students.

The California Critical Thinking Disposition Inventory (CCTDI) constructed by Noreen C. Facione, and Peter Facione (1992) aims at measuring the dispositions of subjects regarding with engaging problems and making decisions thorough critical thinking. The test consists of 75 items and focuses on seven subscales as truth-seeking, inquisitiveness, open-mindedness, maturity, systematicity, self-confidence and analyticity. It is appropriate to use for adults.

The initial version of the Cornell Critical Thinking Test was published in 1971, and the new version of the test was developed by Ennis and published in 1985. The test assesses five critical thinking skills which are deduction, induction, observation, credibility, and assumptions. The test does not measure value judging and dispositions. There are two different forms of the test: Level X and Level Z forms. While level X should be used for elementary and secondary school students, Level Z is suitable to be used for advanced high school/college students and adults.

2.7. Argumentation, Critical Thinking and Socioscientific Issues

For over two decades, the relationship between critical thinking and argumentation has been revealed (Lin and Mintzes, 2010), and as cited by them, Moon (2008) explained the relationship between argumentation and critical thinking as constructing an argument is the fundamental process of critical thinking.

Critical thinking consists of a set of cognitive skills that are used for making decisions about complex situations (Paul and Elder, 2007) and for solving ill-structure problems (Kuhn, 1999). As stated in previous paragraphs, six key critical thinking skills and their sub-skills that emerge from Delphi study (1990) of expert views are:

1. "Interpretation of Information
   clarifying meaning, categorization, decoding significance
2. Analysis of Evidence
   examining ideas, identifying, and analyzing arguments
3. Evaluation
   assessing claims and arguments
4. Inference
   querying evidence, conjecturing alternatives, and drawing conclusions
5. Explanation
   stating results, justifying procedures, presenting arguments
6. Self-regulation
   self-examination and self-correction" (p.6).

On the other side, argumentation process is related with the abilities about constructing argument, using evidence to both support the argument and counter arguments of others. Therefore, argumentation mostly relies on the processes as analysis and evaluation of evidence and make inferences. That is, the second and fourth critical thinking skills as listed above take place on the base of argumentation process. In addition, O'Rourke (2005) explained how critical thinking is relate with argumentation in the similar way. Students identify and evaluate an argument, use evidence for supporting the claims and counterclaims in argumentation process, thus they implement significant parts of critical thinking. Similarly, Lubben, Sadeck, Scholtz, and Braund (2010) advocated argumentation as a part of critical thinking and generating or evaluating SSI argumentation can be considered as an appropriate tool for assessing critical thinking skills of students.

Austin J. Freeley, David L. Steinberg (2008) explained relation between argumentation and critical thinking based on decision making. Individuals face with variety of situations or challenges that present us with choices like buying high performance SUV car or hybrid car, using plastics or paper. All these SSIs require individuals to make decisions, and according to them decision making is "a thoughtful process of choosing among a variety of options for acting or thinking". The ability of making reasonable and ethical decisions is depended on the critical thinking ability, and in the book critical thinking was explained by connecting with argumentation as "critical thinking enables one to break argumentation down to its component parts in order to evaluate its relative validity and strength".

Cavagnetto (2010) suggested that participation of students in argumentation provides them to develop their critical thinking skills. Similarly, Jiménez-Aleixandre and Puig (2012) stated that argumentation has significant contribution to the development of critical thinking. According to them, it is important and necessary to be a critical thinker for being able to develop independent ideas and to be able to active in a democratic society. Therefore, they draw attention to the notion that one of the contributions of argumentation on educational goals is support the development of critical thinking, and they proposed characterization of the components of critical thinking and its connection with argumentation as shown in Figure 2.4.

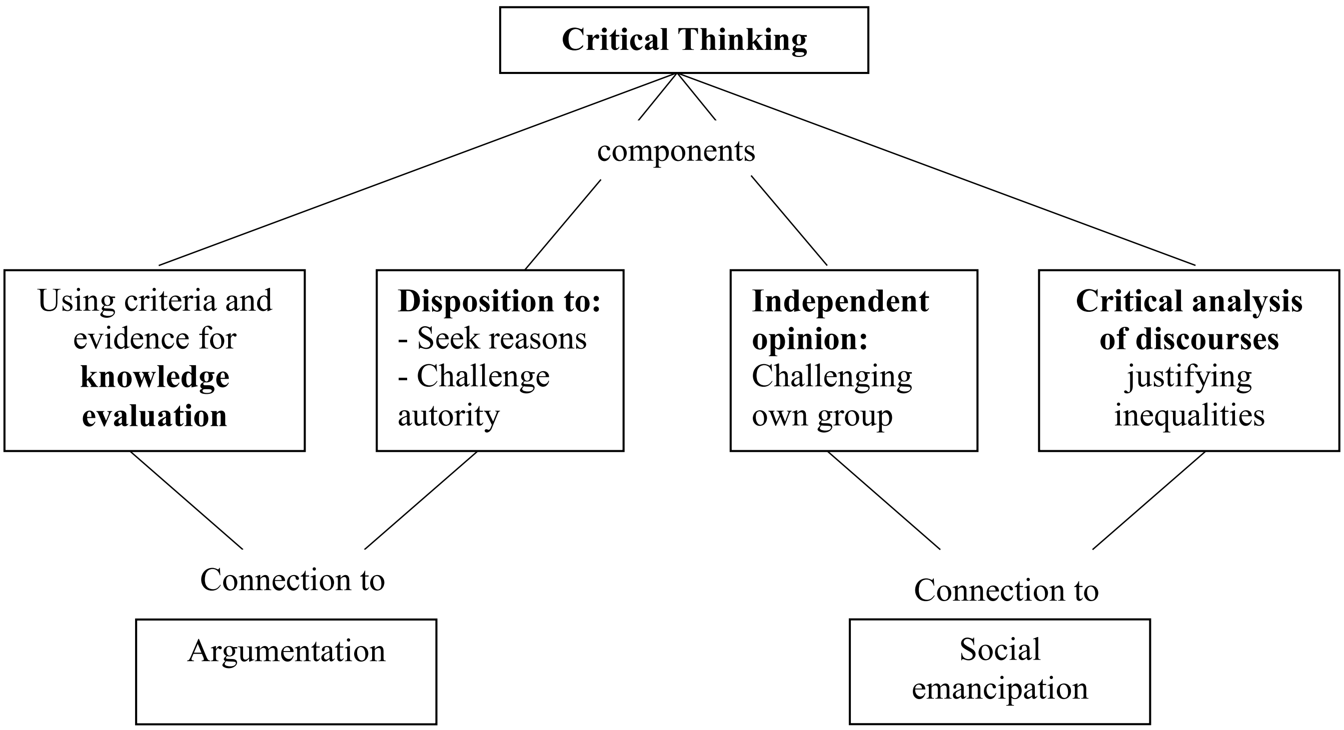

Figure 2.3. A characterization of the components of critical thinking (Adapted from Jiménez-Aleixandre and Puig, 2012).

There are four components of critical thinking. The first component is related with being able to evaluate knowledge on the base of available evidence. The second component is about dispositions as seeking reasons for own and for others' claims, and challenging the authority. These two components of critical thinking are part of argumentation.

In this proposal, Jiménez-Aleixandre and Puig (2012) considered the nature of contexts, and stated that the nature of context can change the contributions of argumentation to critical thinking. Therefore, they examined the contributions of argumentation to the four components of critical thinking in two types of contexts. The first one is argumentation about SSIs, and the second context is argumentation and decision-making about these issues. As shown Figure 2.5, argumentation about scientific issues was placed in one end of a spectrum, and argumentation about socio-scientific issues took place at the other side without making distinction between the contexts.

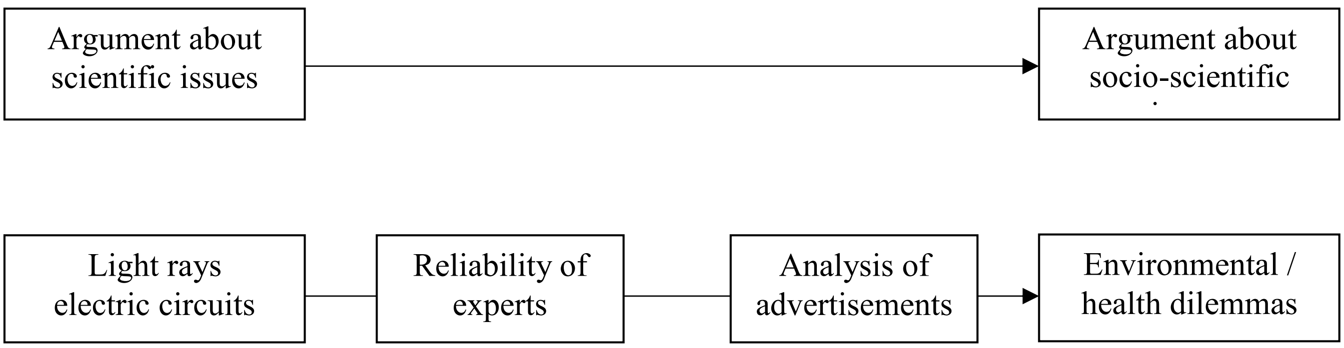

Figure 2.4. Spectrum of argumentation in different contexts (Adapted from Jiménez-Aleixandre and Puig, 2012).

While scientific issues are 'value free' or 'value laden' as stated by Aikenhead, (1985), SSIs consist of social debate, personal or political decision making related with controversies. According to their examination about contributions of argumentation on critical thinking, they determined that the first two components of critical thinking are developed equally if they are supported in both scientific and socio-scientific contexts. Ford and Yore (2012) emphasized that students show critical thinking and make an argument when they engage in interesting challenge (cited in Lin and Mintzes, 2010). Therefore, both critical thinking and argumentation are depending on context (Cavagnetto, 2010). As a result, it can be said that SSIs are linked to critical thinking skills and argumentation skills.

2.8. Existing Studies on Critical Thinking and Argumentation in SSI Context

In the literature, there are variety of studies related with critical thinking skills that conducted as descriptive and experimental studies in Turkey and abroad. When the conducted studies are analyzed, it can be stated that they were made at middle school, high school, and college level. Also, according to the literature, most of the studies focused on investigating the influence of teaching methods, and instructional approaches, on development of critical thinking skills and dispositions of the participants. Among the studies related to critical thinking, a review and explanation of some basic and logical studies are given below.

Dwyer, Hogan and Stewart (2011) investigated the effects of argument mapping-infused and hierarchical outline-infused critical thinking training on undergraduate psychology students' critical thinking performance. Argument mapping (AM) is defined as representation of a text-based arguments by using a 'box-and arrow' style flow-chart. Through this kind of representation, the structure of the argument becomes explicit for readers since propositions within the argument are organized and all the connections amongst propositions within the argument are presented. Also, hierarchical outline (HO) is representation of structure of an argument as a linear flow of text and a box-and-arrow format is not used. The participants of this study consisted of eighty-one undergraduate psychology students and they were engaged into three sub-groups as an argument mapping group, an outlining group, or a control group. Before the intervention period, critical thinking ability of all three groups were measured using The California Critical Thinking Disposition Inventory (CCTDI; Forms B) as baseline measure at the pre-test session. Then, the first two groups were attended to 16 hours critical thinking seminars over the course of eight weeks. Difference between the groups in terms of seminars were based on method of presentation (i.e. argument mapping-infused or hierarchical outline -infused CT training). The participants in third group called as control group were not entered into any critical thinking seminars. At the end of the course of eight week, the same test (CCTDI; Forms B) was applied to the participants as the post-test. According to the results, it was stated that the participants in argument mapping (AM) group get better results from evaluation and inductive parts at their post-tests compared with the participants in the control group reasoning. In addition, results showed that the participants that attend to the study in outlining group have better performance in terms of analysis and inductive reasoning when compared with the performance of control group. However, when AM and HO groups were compared with each other, it was found that there were no significant differences.

Kim, Sharma, Land, and Furlong (2012) studied on influence of active learning modules in which group-based learning, authentic tasks, scaffolding, and individual reports are embedded. The first module of active learning is group-based learning in which students use dialogue and social interaction with each other. Therefore, since group interactions and discussions enable students to synthesize and evaluate data, it is opportunity for them to carry out tasks which are beyond their capacities. The authentic tasks, the second one, are required for engaging students into critical thinking process for solving ill-structured, unclear and open-ended problems. The third one of the active learning, that is scaffolding, is explained as support for cognitive process of students in complex tasks. It is significant for students to facilitate their critical thinking. Inclusion of this external support, students are guided to ask thought-provoking questions, to use their prior knowledge related with the subject, and to find out solutions for the problem in a purposeful way. The last one is individual reports, and these reports provide students to identify problems in the context which promote reflective and critical thinking. The sample of this study consisted of one hundred fifty-five undergraduate students who registered to the course of geoscience in a public university. For gathering data, two instructional modules – Active Learning Modules I and II – about hurricane and global warming were designed and applied to the participants for 6 weeks. The results showed that average critical thinking level of the participants fit with the "developing" category, but scores on individual reports showed statistically significant increase. Therefore, it is suggested that active learning strategies applied in this study were useful to enhance students' critical thinking.

By considering the assumption that there is close relation between critical thinking and argumentation, Lin (2014) conducted a mixed type of study to explore whether there is differences in performance of critical thinking skills between science and non-science undergraduate students during reading, critiquing and responding to science news reports or not. The participants consisted of 52 science majors and 52 non-science majors, and each participant chose and submitted a science news report and wrote their comments about its contents. Argument elements—claims and warrants, counterclaims and warrants, rebuttals, qualifiers, and evidence were analyzed in their argumentation and the quality or performance of critical thinking was determined based on the combination of argument elements in their comments. As a result, it was revealed that there is significant difference between science and non-science majors in terms of their critical thinking performance, and science majors showed high level of performance because they used and formulate more evidence to support their arguments or rebut the arguments in the news that did the non-science majors.

In addition to the studies abroad, various studies related with critical thinking skills were conducted in Turkey. For example, Demiral and Çepni (2018) put emphasis on effect of critical thinking along with content knowledge, motivation and self-efficacy on students' argumentation based on the study they conducted with pre-service science teachers. In this study, they examined argumentation skills of the participants about genetically modified foods (GDOs). After the content knowledge test about GDOs and critical thinking scale were applied to the 20 pre-service science teachers, the participants were engaged into argumentation process through the scenario related with GDOs. According to analysis of gathered data, the result was stated as there are significant differences in terms of skills about data, warrant, rebuttal, and counter claim between the participants. The reason behind this difference was determined as content knowledge, motivation, self-efficacy, and critical thinking skills as well.

Memiş (2006) conducted a study for investigating the effect of Argument- Based Inquiry (ABI) Approach on the ability of students to learn about optics and to demonstrate critical thinking of college students as compared to the traditional laboratory teaching method. In the study, it was stated that ABI is an approach and includes significant components of language in the learning process of science education as discussion, identification of ideas in written form, applying oral explanation, and comparing acquired knowledge gained from effective reading and reading through a personal bias. Moreover, ABI approach guides students to develop their thoughts in a "question-claim-evidence" structure and advocate them in written and oral language form of activities. When ABI approach is integrated into the learning environments, students get opportunities for asking questions, designing experiments to find answer for these questions, making observations, forming claim related with their questions based on their observations, collecting data during their experiment process, and making discussions and reflections in a written form in terms of change in the opinions during the process. These reasons construct the base and ration of this study and it becomes apparent to investigate how ABI approach have influence on critical thinking skills. The study was designed as quasi-experimental and pre/post-test design with 44 third year students in science teaching department in the subject of Optics during 7 weeks. Students in both control groups made experiments by using the traditional laboratory approach, the students in the treatment group performed activities using ABI approach. Data were collected through information test about Optics and CCTDI before and after the activities from both groups. According to the results, the study showed that ABI approach at the university level provide students to get success in learning optics, and to increase their capacities for and tendencies towards critical thinking compared to the traditional method.

Duran and Dökme (2016) also conducted the study about critical thinking skills. They focused on investigating the impact of inquiry-based learning (IBL) about the Particulate Subject of Matter on critical thinking skills. IBL is a method applied for teaching science and enables students for asking questions, finding out related information, and seeking alternative ideas for the solution of real-life problems. Through this instructive approach called as IBL, students can gain opportunity to acquire knowledge and develop their critical thinking skills by discovery and investigation in the environment designed as authentic. Therefore, students become more active learners in terms of enhancing their skills related with using scientific process, and improving critical thinking skills by engaging in discussions and activities. These properties of IBL construct the rationale of this study, and the aim was determined as investigating the effect of an activity set developed based on IBL approach on critical thinking skills of 6^{th} grade students about the unit “Particulate Structure of Matter”. The study was designed based on semi-experimental pretest and posttest control group, and according to this design there are two groups as control group which engaged in traditional lectures and experimental group in which students attend to learning process through guided-inquiry method. In both groups, ‘Critical thinking skills scale’ was applied to 90 students in total before and after the lectures. The results showed that there is a significant difference between the two groups. This means that IBL intervention has a significant and positive effect on improvement of critical thinking levels of students in science and technology courses.

Akgun and Duruk (2016) aimed at determining critical thinking dispositions of pre-service science teachers and investigating the possible effects of some variables like personal and social factors that have effects on critical thinking skills and dispositions. This study was constructed on the base of development and changes in critical thinking dispositions according to social environments and the relationship between these environments. Therefore, the researchers examined the investigation of effects of social factors on critical thinking dispositions. For this aim, 346 preservice science teachers from different universities were selected as the sample of this study through convenience sampling. Data were collected from the participants by applying California Critical Thinking Disposition Inventory (CCTDI), and were analyzed through ANOVA, independent samples t-test and tukey test. According to the results, it was stated that there is not any significant difference between preservice science teachers in terms of their critical thinking dispositions result from the factors as gender, grade, school and authority at home. On the other hand, it was found that social factors like making decision independently and receiving academic guidance affect pre-service science teachers' critical thinking dispositions.

Gül and Akçay (2020) examined the impacts of new socio scientific issues-based instruction model on pre-service science teachers' critical thinking skills and dispositions. In the study, the significant common point about SSI was stated as it is a useful tool to engage students into societal discussions about matter of modern science and to provide students to be democratic citizenship of the world which is also the main aim of scientific literacy. In that point, it was advocated that the main required element of decision making is developed critical thinking skills to analyze and critique arguments since critical thinking guides students to construct good judgments and decisions. Therefore, SSI based instruction in science education is a useful method to increase and improve students' critical thinking skills as analyze, evaluate, and inference SSI related information. Due to lack of studies investigated the impacts of SSI based instruction intervention on critical thinking skills and dispositions of students, this study was designed as pretest-posttest quasi-experimental study for examining the how SSI based instruction could have influence on the critical thinking skills and dispositions. The study conducted with 90 pre-service science teachers attend to environmental course. The participants were grouped as the control in which traditional instruction was implemented and experimental group in which SSI based instruction was applied. The Ennis-Weir Critical Thinking Essay Test and California Critical Thinking Disposition Inventory were given to the participants before and after the instructions to take data. The results showed that post test score of the participants in experimental group increased and there is a statistically significant difference in terms of critical thinking skills and dispositions scores between the groups.

As explained in the previous paragraphs, various studies have been conducted related with critical thinking skills. These examined studies in the literature combined both critical thinking, argumentation and SSIs. According to the studies, critical thinking skills of students can be developed through different instructional approaches and modules. The studies in the literature also present that critical thinking skills of students can be measured and compared through analyzing their argumentation qualities in SSIs – based contexts. Moreover, the results taken from the conducted studies show that some personal and social factors, being science or non-science students have effect on critical thinking skills and dispositions of students in SSI argumentation process. Conversely, there is also one study investigated the effect of students' both content knowledge, motivation, self-efficacy, and critical thinking skills on their argumentation. However, there is a gap in investigating reflection of solely critical thinking skills and dispositions of students on their argument development and counter argument development about SSIs. In other words, this study will make contribution to this limited literature, and present how divergent critical thinking skills and dispositions of middle school students reflect themselves on argument development and counter argument about plastics use.

3. SIGNIFICANCE OF THE RESEARCH STUDY

SSIs are defined as open-ended, complex and controversial dilemmas that do not have specific answers (Zeidler, Walker, Ackett and Simmons, 2002). For example, cloning, global warming, and genetically modified foods can be given as examples of SSIs as they may lead to different views in society (Sadler, 2004).

The Socio-Scientific Issues movement aims to engage students in decision-making about current social issues embedded in scientific contexts. (Zeidler, Sadler, Applebaum, and Callahan, 2009). Decision-making regarding SSI is seen as one of the most important parts of science literacy, which is the ultimate goal of science education in schools. At this point, decision-making includes the process of determining and evaluating students' arguments.

Discussion or argumentation is defined as the central component of the decision-making process (Lin, 2014). Research has shown that involving students in discussion can support making informed decisions on socio-scientific issues. Through discussion processes, students are encouraged to evaluate data and evidence to support or disprove claims, and to create personal statements that link data and evidence to hypotheses or theories (Kim, Anthony, and Blades, 2014). Moreover, argumentation has been recognized as a promising approach to supporting students' critical thinking, reasoning, and science literacy development.

On the other hand, critical thinking is also a useful framework for handling the SSI decision-making process because critical thinking consists of a specific set of skills such as analysis, evaluation and inferences, and tendencies to make reasonable decisions. Therefore, it makes this understanding critical in the construction of scientific insights and in socio-scientific issues, problem solving and decision-making (Gül and Akçay, 2020). Osborne J. (2014) put attention to the notion of critique and assumed as a core feature of science. It is also at the center of Next Generation Science Standards (NGSS), that is adapted by many states in the US in today’s educational system. According to Osborne J. (2014) pointed out in the US National Research Council (2012a) in their report on Education for Life and Work, it is highly significant to develop ability of students related with undertaking the cognitive process of complex reasoning which consists of critical thinking, non-routine problem solving, and constructing and evaluating evidence-based arguments. Besides critical thinking skills, evaluation of critical thinking dispositions is also important because a person with the necessary critical thinking skills may not think critically even if he lacks disposition and vice versa (Bensley and Murtagh, 2012).

Hence, constructing an argument is the fundamental process of critical thinking. With critical thinking, their arguments in a scientific text are examined and evaluated. Students are considered to perform important parts of critical thinking - able to examine and evaluate an argument for or against a claim - identify and evaluate an argument, the degree of supporting evidence, and possible counter- claims (Lin, 2014). Therefore, when future citizens of democratic society get involved in socio scientific activities and argumentations for making good decisions and judgments, this set of skills and dispositions may become beneficial resources.

When the literature on argumentation and critical thinking skills is examined, it can be said that there are not many studies focusing on the correlation of argumentation and critical thinking skills. At that point, it can be stated that it is important to discover individual differences such as critical thinking skills and dispositions between students while developing argument and counter argument. That is, it is necessary to investigate how critical thinking skills and dispositions reflect in the process of developing argument and counter argument about SSIs. However, individual differences in argumentation quality among students, such as critical thinking skills, was not sufficiently investigated in the studies. Within this respect, this study is a qualitative study, and aims at investigating how divergent critical thinking skills and dispositions of middle school students reflect themselves on argument development and counter argument development about plastics use. The findings might provide a basis for teachers 'material development on SSIs, including students in the argumentation process, and taking into account students' critical thinking skills when the curriculum is reshaped according to science literacy.

4. STATEMENT OF THE PROBLEM

In general, the aim of this study is to investigate the relationship between divergent critical thinking skills and dispositions and argument development and counter argument development about SSI. This study particularly investigates the following research questions:

How do divergent critical thinking skills and dispositions of 7^{th} grade students exhibit themselves on arguments and counter arguments about plastics use?

i. What are the level of critical thinking skills and dispositions of 7^{th} grade students?

ii. What are the differences between divergent cases of 7^{th} grade students with low and high level of critical thinking skills and dispositions in terms of developing arguments and counter arguments about plastics use?

5. METHODOLOGY

This chapter includes the research design, the study group of the research, data collection procedure and instruments, and the analysis of data.

5.1. Research Design

The aim of this study is to investigate how divergent critical thinking skills and dispositions of middle school students reflect themselves on argument development and counter argument development about plastics use. Instrumental multi case study in qualitative research methods is adapted for this study. In that point it is necessary to define what a case is and types and attributes of case study. Stake (1995) stated case is "a specific, a complex, functioning thing.", and according to him case is "an integrated system" that "has a boundary and working parts" (p.2). Merriam (1998), defined case by considering Smith's (1978) view of case as "a bounded system" and Stake's (1995) view as "an integrated system". By focusing on these points mentioned for case, she defined it as "a thing, a single entity, a unit around which there are boundaries" (p.27), and also she pointed out case can be a person, a program, a group, a specific policy and so on. As for case study, it was defined by Crowe et al. (2011) as "a research approach that is used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context. It is an established research design that is used extensively in a wide variety of disciplines, particularly in the social sciences." (p.1). Similar with this definition and view, Yin (2002) mentioned that case study can be used to explain, describe or explore events or phenomena that occur in the everyday contexts. Therefore, case study is purposive in social sciences and human services (Stake, 2005 p.2). When these definitions and properties of case study are taken into consideration, it becomes proper for this study to be designed based on case study in qualitative research methods. The reason is that the aim of this study is to explore reflection of divergent critical thinking skills and dispositions of students on argument development and counter argument development about plastics use, and the cases are students with high level of critical thinking skills and dispositions, and students with low level of critical thinking skills and dispositions. These cases are bounded by argument development processes and SSI context about plastics use.

Stake (1995) has characterized three main types of case study depend on the purpose of study, and these are intrinsic, instrumental, and collective case study. Case study becomes intrinsic when researchers aim at better understanding and learning the case in which they have genuine interest. In intrinsic case study, the case represents particular problem, that is why the main interest is the case itself in the study. In this kind of study, the aim does not learn about other cases or problems, or not construct a theory. Instrumental case study is used when the aim is accomplishing something rather than understanding the case in the study. That is, the case is not the prime interest, rather the case is selected as “maximized what we can learn” (Stake, 1995, p.4). Thus, the case provides researchers to reach the external interest (Baxter and Jack, 2008). In collective case study, several cases are examined for understanding the similarities and differences between the cases. In other words, it is suitable for researchers to explore differences within and between cases by comparing the cases with each other. Similar in nature and description with this type of case study, Yin (2002) determined multiple-case study under the category of types of case study organized depend on number.

Therefore, since two cases, students with high level of critical thinking skills and dispositions, and students with low level of critical thinking skills and dispositions, are analyzed to investigate divergence in argument development and counter argument development and are compared with each other, it is seen that the design of this study is compatible with instrumental case study. In other words, the cases are not prime interest in this study, the importance of the cases result from the fact that they provide investigation of reflection of divergent critical thinking skills and dispositions on argument development and counter argument development. Along with identifying the “case” and the specific “type” of case study to be adapted to study, it is required from researchers to consider the number as whether a single case or multiple case study is conducted for better understanding the phenomenon (Pamela Baxter and Susan Jack, 2008). In this study, there are two cases defined in the beginning of the paragraph to be analyzed and compared with each other. Therefore, among case study types defined by Stake (2005) and Yin (2002), multi-instrumental case study approach is adapted to this study.

5.2. Participants

The participants of this study are the students from the private middle school located in Istanbul, Turkey. In the school, there are 19 seventh grade students and all students form the initial sample. In that point, a purposeful sampling strategy is used because highly academically motivated students are selected to get informative and detailed answers and explanations during argument development and evaluation process. The students are academically motivated because:

- School, from which participants are, gives importance to academic successes of students. To enroll in this school as a student, it is required to take a selective exam consists of multiple-choice questions related with Turkish, Mathematics, Science, Social Science and English for enrolment. According to score of students that get from this exam, they get a chance to enroll in the school.
- Also, students take a psychometric assessment in order to investigate their way of learning, skills and predispositions during the registration period.
- From 5th grade to 8th grade, the school guides students to work hard for getting accepted into one of the most successful and qualified high schools in terms of academic success.
- When compared with other private schools in Istanbul, the students work for high school entrance exam with a competitive approach and intensive work schedule that applied in both weekdays and weekends.

Therefore, it can be said that the students form the sample of this study have sufficient academic success, skills, sense of responsibility, motivation for working hard and academic success. When the mission and nature of the school, profile of the students are considered and the aim of this study are evaluated as a whole, the participants are selected from this private middle school. By this way, it becomes appropriate to investigate the manifestation of critical thinking skills on argument and counter argument development since the participants have sufficient level of academic successes, motivation, and sense of competition. Based on the critical thinking skills and dispositions measurement, sub sample of 6 or 8 cases will be selected: 3 or 4 students as having low critical thinking level with close critical dispositions (Group 1), and 3 or 4 students as having high critical thinking level with close critical dispositions (Group 2). Therefore, homogeneous divergent multiple cases are formed based on the purpose of this study which is explore how divergent critical thinking skills and dispositions reflect themselves on argument development and counter argument development.

5.3. Data Sources

5.3.1. Cornell Critical Thinking Test Level X

Cornell Critical Thinking Tests (CCTT) were developed by Robert H. Ennis in 1962. This test includes two measurement tools: the first one is called as Level X and the second one is namely as Level Z. While the Level Z is appropriate to use for the measurement of the thinking skills of talented secondary school students and bachelor degree students or those who are in graduate level, the Level X is developed for the students whose grade level is ranging from 4 to 14. CCTT- Level X was developed by Ennis and Millman in 1985 and it is the most widely used test among primary and high-school students for measuring critical thinking skills.

According to reports in the CCTT Administration Manual, the reliability of the CCTT - Level X ranges from 0,67 to 0,90.

The time that is envisaged for the application of the test is 50 minutes for the participants who are secondary school and above students. Also, the test suggested to be completed within 64 minutes for primary education level students.

The test Level X consisted of 71 articles, and it was designed as multiple-choice test. For each item, there are three choices and one key answered. Also, in the test, there are instructions and examples along with their solutions in all dimensions of the scale to make contribution for students to easily understand and answer the items. The articles were grouped under 4 dimensions as: deducing by way of inductive reasoning, deducing by way of deductive reasoning, judging the reliability of the observations and sources, and defining (determining) the assumptions within the statements. The explanation and details of each dimension can be given as:

- Deducing by way of inductive reasoning: There are 23 questions in this dimension of the test.
- Deducing by way of deductive reasoning: There are 14 questions in this section.
- Judging the reliability of the observations and sources: There are 24 questions in this section.
- Defining (determining) the assumptions within the statements: There are 10 questions in this section.

Total scores were calculated by way of coding the students' correct answers to the questions in the test by "1", and false ones by "0".

5.3.1.1. Adaptation of the CCTD into Turkish. It was adapted to Turkish by Akar, Acun, Gülveren and Yüce.

5.3.2. California Critical Thinking Disposition Inventory (CCTDI)

California Critical Thinking Disposition Inventory (CCTDI) was developed by Facione, Facione and Giancarlo in 1994, and used in order to determine the critical thinking dispositions of the students. It was characterized initially based on the outcomes and consensus about description of critical thinker in the Delphi Report.

The CCTDI includes 75 items which state familiar opinions, beliefs, values, expectations, and perceptions. In the statements, it is not expected from test-takers to have college level content knowledge because the aim of inventory is to determine the critical thinking dispositions of the students. Responses were designed based on a 6-point Likert-type scale as strongly agree, agree, slightly agree, slightly disagree, disagree, and strongly disagree.

The 30 minutes is sufficient for administering the test even though most of the respondents complete it in less than 20 minutes.

The CCTDI consists of seven sub-scales as: Truth-seeking, Open-mindedness, Analyticity, Systematicity, Confidence in Reasoning, Inquisitiveness and Maturity of Judgment.

Each of the sub-scales is related with different aspects of disposition towards critical thinking. According to Facione, Facione and Giancarlo (1994), definitions of each sub-scale were presented in the Table 5.1.

Table 5.1. Sub-scales of the CCTDI and their descriptions.

Sub-Scales	Definitions
Truth-seeking	Truth-seeking is a disposition related with seeking the best knowledge in a context, being eager to ask questions, behaving honest and objective in terms of maintaining inquiry although the findings do not support one's own interests or prejudiced views, and being able to reassess new alternative information and evidence. In the CCTDI, there are 12 statements for measuring the truth-seeking disposition.
Open-mindedness	This scale refers having tolerance to different views by being sensitive to one's own possible bias. People who are open-minded attach importance to live in a pluralistic and democratic society in which people have a variety of religious, political, social, cultural, and personal beliefs and backgrounds. There are 12 items among all statements in CCTDI for measuring open-mindedness disposition.
Analyticity	Analyticity aims to value the reasoning practice and evidence use for resolving problems, foreseeing possible difficulties in concepts and practices, and being continually ready for the potential need for intervention. There are 11 items in the scale to measure analyticity disposition.
Systematicity	This subscale is related with being organized, disciplined and eager for inquiry. The person inclined toward being systematic advocates to focus on question in the first place and giving answer for the question in the second step. In addition, systematic people are not distracted easily. Totally,11 items measure systematicity in CCTDI.

Table 5.1. Sub-scales of the CCTDI and their descriptions (cont.).

Sub-Scales	Definitions
Confidence in Reasoning	Confidence in reasoning provides a person to trust one's judgment, and to be a leader of others while resolving problems. In the scale, there are 10 items measuring confidence in reasoning disposition.
Inquisitiveness	This subscale refers to one's intellectual curiosity and desire to learn and to know. In CCTDI, there are10 items used for measuring inquisitiveness.
Maturity of Judgment	Maturity of judgment is a disposition related with being able to realize complexity of the encountered issue. 10 items in CCTDI are used for measuring maturity of judgment.

According to Facione, Facione, and Giancarlo (1998) stated scoring for each subscale as people with a score lower than 40 have low critical thinking disposition at that dimension, and those with a score above 50 have high critical thinking disposition. Since the scale consists of 7 sub-scale, people with a score less than 280 (40 x 7) have low general critical thinking disposition, and those with a score more than 350 (50 x 7) have critical thinking disposition when the scale is evaluated as a whole. It has been suggested that this instrument is designed to measure the overall disposition profile of students, not their disposition for each subscale.

5.3.2.1. Adaptation of the CCTDI into Turkish. California Critical Thinking Disposition Inventory (CCTDI) was adapted to Turkish by Kökdemir (2003). After the study conducted with 913 students, he reduced the number of subscales from 7 to 6, and the Turkish version of the scale consists of 51 items rather than 75 as in the original version. These six subscales are Truth-seeking with seven items (6, 11,20, 25, 27, 28, 49); Open-mindedness with twelve items (5, 7, 15, 18, 22, 33, 36, 41, 43, 45, 47, 50); Analyticity with ten items (2, 3, 12, 13, 16, 17, 24, 26, 37, 40); Systematicity with six items (4, 9, 10, 19, 21, 23); Inquisitiveness with nine items (1, 8, 30, 31, 32, 34, 38, 42, 46), and Maturity and Self-confidence with seven items (14, 29, 35, 39, 44, 48, 51).

In terms of scoring, Kökdemir (2003) stated that for all subscales, the lowest and highest possible values are fixed. For each subscale, the minimum score is 10, and the maximum score is 60. Therefore, when the Turkish version of the scale is measured as a whole, people with a score less than 240 (40 x 6) have low general critical thinking disposition, a score between 240-300 is evaluated as medium critical thinking disposition, and those with a score more than 300 (50 x 6) have high disposition. In the scale, the items numbered 05, 06, 09, 11, 15, 18, 19, 20, 21, 22, 23, 25, 27, 28, 33, 36, 41, 43, 45, 47, 49, 50 are calculated as reverse scoring. Moreover, according to Kökdemir (2003) the internal consistency coefficients (alpha) of the sub-scales varies from .61 to .80. In addition, the total consistency of the scale was found as .88.

5.3.3. SSI Text related with Plastics Use

For this study, SSI text about plastics use prepared by the researcher of this thesis and her advisor to utilize as data collection tool (Can, Büçkün, Güven, 2021). There are two version of the text: Local Plastics Use and Global Plastics Use. The Local text consists of general properties of plastics; positive and negative effects of plastics usage on health and environment by including data based on Kocaeli, Turkey. Similarly, the Global text also include general properties of plastics; positive and negative effects of plastics usage on health and environment, but the information are given based on global data. In this study, the local text is used since local data are more familiar for the participants (Appendix A).

In the literature, there are some fundamental elements and criteria for SSI scenarios, and they were taken into consideration during the preparation process of the text Plastics Use. In the first place, the literature pointed out that current SSI which also overlaps with the science education curriculum should be selected. Thus, the chosen subject can be familiar with the lives of the students, in order to increase interest, motivation and participation (Jarvela and Reninger, 2014). The subject of SSI scenario designed for this study was determined as plastics use since the use and recycling of plastics take place in the 7th grade science education curriculum designed by Ministry of National Education (MEB, 2018).

As stated by Atabey, Topçu and Çiftçi (2008) according to their content analysis, SSI scenarios should include objective and equal number of advantages and disadvantages about the issue, and it is important to give presented information in variable orders as advantage/ disadvantage and disadvantage/advantage, so that students are not directed to one of the opposite thoughts. Therefore, the text prepared for this study include objective, and equal number of positive and negative data in terms of health and environment.

The third fundamental criterion for SSI scenarios is that the text should be clear, understandable, suitable for the grade and reading level of the students. Also, text do not contain high-level concepts in order to provide students to examine and use concepts (Güven and Muğaloğlu, 2020). Therefore, it was paid attention to construct the SSI scenario about plastics use with suitable data, understandable concept, and compatible with level of 7th grade students.

As the last step, a text evaluation rubric was created within the framework of the criteria stated in the literature. The evaluation rubric is shown in the Table 5.2 below:

Table 5.2. The text evaluation rubric.

There is a clear difference between Local and Global texts.
The text content is appropriate for the age of groups in terms of reading and understandability.
Presented text on the use of plastics in terms of advantages and disadvantages is balanced.
Health and environment sub-dimensions in the text are presented in a balance when compared to each other.
The use of plastics as a SSI is handled appropriately in the text.
In the text, advantages, and disadvantages about the use of plastics are given in an objective way without making directing.
The text offers sufficient contents for students to create arguments from different positions.

The text and evaluation form were sent to four expert educators in science education upon their evaluation. The text has been revised based on their feedbacks about sufficiency of content in terms of presented information, and their offers to make the text more understandable, fluent, and textually appropriate. Thus, their expert panels were used to establish content validity.

In the final draft, it was determined that the text, developed in line with the feedback, is suitable for its purpose and meets the necessary criteria and can be able to students to participate in an efficient argumentation process. Through the pilot study conducted with the students who did not engage in this study as participants, it was concluded that the material was suitable for its purpose.

5.3.4. Counter-Argument Texts

By the purpose of this study, the students are guided to evaluate the counter argument that defends the opposite position compared to their positions regarding the use of plastic. Therefore, two counter argument texts were prepared by the researcher of this study namely as Argument 1- Advocating Plastics Use and Argument 2-Rejecting plastics use are shown in Appendices C and D.

The counter argument texts were prepared based on the Plastics Use Text designed for this study, and each text consists of the data, warrant, backing and rebuttal components defined in TAP model. The level of arguments in these texts are equal. That is, in each counter argument text, there are two scientific data about plastics which take place in Plastics Use Text: one of them is about the health, and the other one is related with environmental aspect. For linking the claim and data, two warrants for both aspects take place in the texts. In addition, the arguments include clear and understandable backings for strengthening the warrants, and strong rebuttals for justifying or supporting the claim the argument defends. Moreover, as considered in the preparation process of Plastics Use Text, appropriateness for the age of groups in terms of reading and understandability are taken into consideration while forming these counter-argument texts.

5.3.5. Questions Regarding with Plastics Use

Each of the texts, which are SSI scenario about Plastics Use and Counter-Argument Texts, was followed by questionaries consist of sets of questions relating to argumentation.

In the first, the questionnaire namely as ‘What Do You Think About Plastics Use?’ (Apprendix A) is prepared by the researcher of this study and her advisor for integrating students to generate an argument about the plastics use, as well as justify their argument after reading the text Plastics Use. This questionnaire is arranged to guide students to select their claim among the choices which are Strongly Disagree, Disagree, Agree and Strongly Agree in the first question, and then to present their warrants, backings, possible warrants of counter arguments, and rebuttals, respectively in the second, third and fourth questions. Except the first question, remain three questions are formed as open-ended questions which are answered by the students as short paragraphs. The second questionnaire (Appendix E) is constructed to engage students in counter argument development process. This questionnaire is applied to the participants after they read the text which advocates the counter position about plastics use compared with their claimed position. For guiding students to evaluate counterargument and to make justification, they are asked to explain about the warrants of one who advocates opposite claim about plastics use in the first place. Subsequently, the following questions are related with evaluation of counterargument’s warrants, whether participant changes his/her claim or not, and what the reasons are to change previous decision or not to change. Through these open-ended questions, the students are motivated to identify counter argument, make justification for their claims by using data, warrants, and backings.

During the formation and design of these questionaries, structure and type of the questions were adapted from the questionnaires used by Khishfe (2013) in his study, and they were revised to make compatible with the topic plastics use. Also, pilot-testing of the questionnaires were also done with 7th grade students who did not participate in this study.

5.4. Data Collection

In the beginning of the data collection process, 19 seventh grade students attained to the CCTT and to the CTDI at different days. The tests were shared with the students through Google Forms. The reason why the test was applied in online platform is due to COVID-19 pandemic, and thereby due to replacing face-to-face teaching and education by digital online formats. The students started with the tests at the same time by linking via Microsoft Teams, the program that the school utilize from for the online education period, and opening their voice and camera. Therefore, I as the researcher of this study observed the students to be sure that the students completed the tests on their own, and without getting any help or support. The answers of the students were gathered from Google Forms as an excel file, and appropriate scores were given according to the answers given by each student for each question in this file. According to the total scores, the students were listed from the highest score to the lowest score taken from the Critical Thinking Tests. Then, 3 students who have high critical thinking level with close dispositions form Group 1. In addition, 3 students who have low critical thinking level with close dispositions are selected to form Group 2. The reason why two groups are formed according to critical thinking level of students is to get homogeneous groups and be able to compare these two groups with each other based on argument quality. Students in these groups attend to argumentation and decision-making process individually.

In the second stage, argument development process was applied to the students through online platform in the same way with application of critical thinking skills and dispositions tests, and so the students took the SSI text about plastics use and the guidance questions in the form (Appendix B) respectively via Google Forms. Then, it is expected from the students to construct their arguments and justify them with guidance through the questions in the form. After the participants complete the form and write their own arguments and justifications to the questions, the researcher of this study guides them to explain their written expressions verbally in a semi-structured interview. Interviewing is defined by Creswell (2012) as a procedure, and in this procedure the participants are asked open ended questions which are parallel with the research questions stated in the study and the answers of the participants participated in interviews are recorded by using a recorder. Since the research questions are constructed for exploring reflection of critical thinking skills on argument and counter argument developments, it is required depth explanations of the participants, so individual interviews time were adapted to this study and implemented as the data source. An individual interview refers to interviewing with only one participant at a single time and also it is called as one-on-one interview (Creswell, 2012). Therefore, the participants are asked similar questions with the questions take place in the form and related questions according to their answers, and so detailed explanations are gathered for each question.

In the next stage, based on the position that the participants support, counter argument is presented to them in individual interviews. For this part of the data collection process, two possible arguments along with components based on TAP about plastics use were developed by the researcher of this thesis and her advisor presented in Appendices C and D. During the interviews, the proper argument in terms of advocating the opposite idea compared with the participant's argument in the written form is presented to the participants via Google Forms. The aim of this application is to engage students into process related with evaluating the given argument, justifying the possible reasons why other people claim this opposite argument, and to develop counter argument. For this aim, the question form presented in Appendix E is shared with the participants after they complete the opposite argumentation. Similar with the previous process which is argument development, semi-structured interviews conduct with the participants individually, and it is expected from them to explain their written expressions take place in the written form.

As a result, the participants engage in both argument and counter argument development process. Also, data is collected from students through both in a written form and oral form. Since both written and oral ways are used for data collection process, more detailed explanations can be gathered from each participant.

5.5. Data Analysis

In the first place, scores of the participants that get from the California Critical Thinking Disposition Inventory and Cornel Critical Thinking Test are calculated. For each test, total scores of the participants and the scores that they get from each sub scale are calculated. During scoring process, the rules stated in the literature and explained in the previous chapter are applied on nineteen 7th grade students' tests. The scores taken from each test are put in separate tables on Excel, and the name of the participants are replaced with the numbers from 1 to 19 in each table. The sorting of the participants on these tables are filtered according to their scores and they are listed from the highest score to the lowest one.

As the first step of argument analysis process, verbal expressions of each participant are transferred to written form and saved in digital platform. Therefore, written data and oral explanations of the participants are reunited, and the whole data set is constructed as written form. At that point, the aim is to analyze the written arguments of six students by coding the main components (data, warrant, backing and rebuttal) stated in the TAP argumentation model which is the indicator of quality of argumentation (Erduran, Simon and Osborne, 2004). Therefore, the argument and counter argument structures of the students are determined based on TAP model by using descriptive analysis, and tables and graphs are prepared for each component in the arguments. In addition, for the analysis of components detected in developed arguments and counter arguments about plastics use, content analysis is applied in order to analyze the arguments qualitatively.

In this study, the rubric is prepared by adapting the rubric used by Şahin (2014) in her doctoral thesis study. Related parts in this rubric are revised for this study. The table 5.3. presents the last version of the analytic rubric called as Rubric 1 that includes main components of argumentation, and it is designed to use in this study for assessing the quality of arguments developed by the students.

Table 5.3. Analytical framework for assessing the quality of argument development.

Components	Sub-Dimensions	Description	Points
Data	Detailed Scientific Explanation / Data	Uses multiple scientific data	3
	Scientific Explanation / Data	Uses a scientific data or term	2
	General Explanation	Does not use any scientific data or terms; use general explanation	1
	No data	Does not provide any data or justification	0
Warrant	Detailed Scientific Warrant	Includes more than one scientific warrant that related data and claim	3
	One Scientific Warrant	Includes only one scientific data	2
	General explanation/ Warrant	Includes only a general explanation or description of the situation	1
	No warrant	Does not relate data and claim, or includes inappropriate logical inference	0
Backing	Present (Strong)	Uses more than one and clear and understandable backings	3
	Present (Clear)	Uses one and clear and understandable backing	2
	Present (Partially True)	Uses a backing in which certain part is true	1
	No backing	Does not use any backing	0
Rebuttal	Present (Strong)	Produces more than one rebuttal by justifying or supporting the claim it is defended	3
	Present (Clear)	Produces a rebuttal by justifying or supporting the claim it is defended	2
	Present (Weak)	Uses only rebuttals against the claim that is defended	1
	No rebuttal	Does not use any rebuttal against the claim it is defended	0

For assessing the quality of students' counter argument developments, it is required to construct the second rubric by enabling the equality with the first rubric in terms of components, sub-dimensions, and scoring. Since the participants are expected to identify data and warrants of counter argument differently from the argument development process, the second rubric needs to have different component instead of rebuttal component. According to this situation, the second rubric is designed as including the first three components are same as present in the first rubric. These components are related with how the participants develop counter argument to opposite claim. The last component and its sub-dimensions are constructed based on counter-argument identification for assessing in which degree the participants detect argument of opposite claim. Therefore, the Table 5.4. presents the last version of the rubric namely as Rubric 2 constructed for using in this study to evaluate quality of students' counter argument developments.

Table 5.4. Analytical framework used for assessing the quality of counter argument development.

Components	Sub-Dimensions	Description	Points
Data	Detailed Scientific Explanation / Data	Uses multiple scientific data	3
	Scientific Explanation / Data	Uses a scientific data or term	2
	General Explanation	Does not use any scientific data or terms; use general explanation	1
	No data	Does not provide any data or justification	0
Warrant	Detailed Scientific Warrant	Includes more than one scientific warrant that related data and claim	3
	One Scientific Warrant	Includes only one scientific data	2
	General explanation/ Warrant	Includes only a general explanation or description of the situation	1
	No warrant	Does not relate data and claim, or includes inappropriate logical inference	0
Backing	Present (Strong)	Uses more than one and clear and understandable backings	3
	Present (Clear)	Uses one and clear and understandable backing	2
	Present (Partially True)	Uses a backing in which certain part is true	1
	No backing	Does not use any backing	0
Identifying Counter Argument	Detailed Scientific Explanation / Data	Identifies multiple scientific data and warrants of counter argument	3
	Scientific Explanation / Data	Identifies a scientific data and warrant of counter argument	2
	General Explanation	Express counter argument in general	1
	No Counter Argument Identification	Incorrectly identify counter argument or does not identify it	0

As seen in these tables, the rubrics consist of four main components, and they are also divided into sub-dimensions based on the criteria as number of times using related component, quality, and content of these components in terms of being clear, strong, partially true etc. In the first component, the data found in the arguments of the students are evaluated considering whether they are scientific or expressed as general, and for scientific data different scores are given according to the number of times using in the arguments. In the second component, warrants included in arguments are assessed according to the scientific data they contained, and different scores are determined based on number of scientific data. The third component, backing is evaluated by considering existence of backings, and number of backings in the arguments. The fourth component in the rubric one, namely as rebuttal, is evaluated only for the participants' developed arguments. For this component, the criteria are whether the participants use rebuttals or not, and whether they use more than one rebuttal or only one rebuttal by justifying or supporting the claim it defends. The fourth component in the rubric two namely as identifying counter argument is evaluated only for the participants' counter argument developments. The evaluation of this component is based on considering whether the participants identify counter argument or not, and if they detected counter argument, it is considered that whether they make expression by including scientific data and warrants of counter argument or state it in general.

The reason to construct the rubrics with related sub-dimensions is to differentiate the students from each other under the circumstances in which two students use the same component in their argument, but one of the students integrates more than one about this component in his/her argument or use them in a more comprehensive, clear and strong way. Therefore, it is required to present the differences between these students in terms of quality and level about using this stated component. Since the number of participants is highly limited in this study, analyzing the components in the participants' arguments and placing them in the related sub-dimensions provide the researcher of this study to acquire more detailed results and to gather differences between the participants' uses of components. Moreover, depending on differences in the descriptions of each sub-dimension, points are assigned from 3 to 1 for sub-dimensions in each component. Therefore, the lowest score a student can get from each argumentation process is 0 and the highest score is 12 according to the rubrics.

Based on the rubrics presented above, the arguments of six students are analyzed and coded as data, warrant, backing and rebuttal in their arguments; the sub-dimensions for each component that the participants use are determined; and the points corresponding to determined sub-dimension are assigned to the participants. The same process is applied for counter arguments developed by the participants, but component namely as identifying counter argument replaced with rebuttal as stated in the second rubric. The developed arguments and counter arguments of each participant are analyzed one by one, and the coding process is repeated for five times for each student and for each argument type. After the components with sub-dimensions are detected, the scores that the participants get from each component and total scores for each participant are put in a table on excel and the graphs and tables that show the ratios of each component are formed.

The example sentences from the participants' developed arguments and counter arguments that are given below in the Table 5.5. and Table 5.6. respectively in order to present coding and scoring process of data.

Table 5.5. Categorization of components from developed arguments.

Components	Sub-Dimensions	Description	Points
Data	Detailed Scientific Explanation / Data	Uses multiple scientific data. *There are different kind of plastics and their effects on environment are different from each other, and plastics can be recycled (Student 14).*	3
	Scientific Explanation / Data	Uses a scientific data or term. *Plastics are the materials that can be recycled.*[1]	2
	General Explanation	Does not use any scientific data or terms; use general explanation. *Plastics are the materials that have high level of quality (Student 3).*	1
	No data	Does not provide any data or justification	0
Warrant	Detailed Scientific Warrant	Includes more than one scientific warrant that related data and claim. *If we use plastic, we make strong buildings. Since it is cheap and provides less fuel consumption, we can produce cars in this way and ensure the efficient use of energy resources. Advantages such as increasing hygiene with medical equipment are obtained (Student 14).*	3
	One Scientific Warrant	Includes only one scientific data. *The use of plastics in the field of health ensures that these materials are disposable and therefore hygienic. Therefore, the use of plastics plays an important role in protecting human health.*[2]	2

[1] Since there were no students get points in this category, example from students could not be given.

[2] Since there were no students get points in this category, example from students could not be given.

Table 5.5. Categorization of components from developed arguments (cont.).

Components	Sub-Dimensions	Description	Points
Warrant	General explanation/ Warrant	Includes only a general explanation or description of the situation. *Plastics damage the nature due to its irresponsible use (Student 3).*	1
	No warrant	Does not relate data and claim or includes inappropriate logical inference. *Plastics are used in the construction industry. Thus, it provides 70% better protection of our health (Student 4).*	0
Backing	Present (Strong)	Uses more than one and clear and understandable backings. *Plastics have positive effects on health, such as hygiene. Also, by supporting recycling and using non-harmful types, we reduce carbon dioxide emissions and thus prevent global warming. (Student 14).*	3
	Present (Clear)	Uses one and clear and understandable backing. *The environment and sea are more polluted. Health of fishes are negatively affected by the pollution since they unknowingly feed on them and die. Such harmful effects should be considered because once living things begin to die, there is no going back (Student 13).*	2
	Present (Partially True)	Uses a backing in which certain part is true. *Living things, especially our Earth are dying. If we do not have a life to live, there is no meaning to make our life easier with plastics. Due to dying of living thing global warming also happens, and the World gradually disappears (Student 17).*	1
	No backing	Does not use any backing.	0

Table 5.5. Categorization of components from developed arguments (cont.).

Components	Sub-Dimensions	Description	Points
Rebuttal	Present (Strong)	Produces more than one rebuttal by justifying or supporting the claim it is defended. *In order to support the use of plastics, people are required to be conscious. This means it is necessary to increase the production of healthy and reduced plastics types, and to increase the recycling rate. After all, there is no alternative to plastic. For example, it is not logical and not possible to make cars and computers from metal due to heaviness of metals and resulting these technological devices to be heavy (Student 14).*	3
	Present (Clear)	Produces a rebuttal by justifying or supporting the claim it is defended. *If there is a material that can be recycled and decomposes rapidly in nature, I use it instead of plastics (Student 4).*	2
	Present (Weak)	Uses only rebuttals against the claim that is defended. *Although plastics are useful to us in our daily lives, they have a huge impact on the pollution of the seas. Because of those plastics, the water obtained from the sea can create adverse effects on human health. At the same time, the life of the fish is in danger because of this. If people use plastics carefully, I advocate the use of plastics. If people are more careful and less used, less plastics is produced, then I can advocate the use of plastics (Student 13).*	1
	No rebuttal	Does not use any rebuttal against the claim it is defended.	0

Table 5.6. Categorization of components from developed counter arguments.

Components	**Sub-Dimensions**	**Description**	**Points**
Data	Detailed Scientific Explanation / Data	Uses multiple scientific data. *Only 15% of plastics can be recycled, and they cause to marine pollution (Student 13).*	3
	Scientific Explanation / Data	Uses a scientific data or term. *Small plastic particles are found in body of fishes and the microscopic plastic particles are spread in the air (Student 4).*	2
	General Explanation	Does not use any scientific data or terms; use general explanation. *Plastics have variety of advantages for both health and environment (Student 2).*	1
	No data	Does not provide any data or justification	0
Warrant	Detailed Scientific Warrant	Includes more than one scientific warrant that related data and claim. *Only 15% of plastics can be recycled. However, as the text mentions about environmental pollution, I understand that this is not an adequate recycling, therefore it causes environmental pollution. The environment and marine life are harmed (Student 13).*	3
	One Scientific Warrant	Includes only one scientific data. *The effects of plastics vary depending on how we use it. There are points where the plastics cannot be replaced, for example in certain items and systems. We need to find an alternative; we cannot just switch to another existing material. For example, we cannot make CDs from metal, or from wood and glass, but t it can be made from plastic-based products (Student 14).*	2

Table 5.6. Categorization of components from developed counter arguments (cont.).

Components	**Sub-Dimensions**	**Description**	**Points**
Warrant	General explanation/ Warrant	Includes only a general explanation or description of the situation. *If we stopped using plastic, what would we use instead of plastic? There is no clear answer. We do not know what the harms and benefits of other substances are. Maybe it will reduce environmental pollution, but there will be other bigger damages. It is dangerous to recommend other substances and ban plastics without knowing alternatives (Student 2).*	1
	No warrant	Does not relate data and claim or includes inappropriate logical inference. *Less plastics would be used in hospitals since patients sick from plastics. The water is also polluted, if it were not polluted and becomes unusable, there would be no need for water savings. Poultry is poisoned by plastics, and after we eat them, it does not become important that the food comes to us in a hygienic process (Student 17).*	0
Backing	Present (Strong)	Uses more than one and clear and understandable backings. *When the chemicals in the materials frequently used in daily life, cause the deterioration of the health of living things. Environmental pollution and deterioration in the ecosystem also endanger the survival of living things on earth.*[3]	3

[3] *S*ince there were no students get points in this category, example from students could not be given.

Table 5.6. Categorization of components from developed counter arguments (cont.).

Components	Sub-Dimensions	Description	Points
Backing	Present (Clear)	Uses one and clear and understandable backing. *The use of a different material for thermal insulation in buildings may cause more fuel consumption, water consumption and the release of toxic gases into the atmosphere, thereby disrupting the balance of the ecosystem (Student 2).*	2
	Present (Partially True)	Uses a backing in which certain part is true. *In the future, there will be drought due to the plastics. How will we live if we cannot reach water? The use of plastics should not be supported in a place where life is in danger (Student 13).*	1
	No backing	Does not use any backing	0
Identifying Counter Argument	Detailed Scientific Explanation / Data	Identifies multiple scientific data and warrants of counter argument. *Small pieces float in the air and adversely affect human health. Dioxin was found in the eggs and milk of chickens growing around the factories where plastics was burned, and it was determined that there was an increase in respiratory tract and liver diseases (Student 4).*	3
	Scientific Explanation / Data	Identifies a scientific data and warrant of counter argument. *If there is a material that can be recycled and decomposes rapidly in nature, I use it instead of plastics (Student 4).*	2
	General Explanation	Express counter argument in general. *The plastics have lots of advantages for health and environment.*[4]	1
	No Counter Argument Identification	Incorrectly identify counter argument or does not identify it.	0

[4] Since there were no students get points in this category, example from students could not be given.

Each participant's response was analyzed to categorize his/her argumentation components into proper sub-dimensions. In that point, it is significant to state that the participants constructed their arguments and counter arguments through the guidance of the questions in the form and the interview process. Therefore, when the whole data set that reunited the written forms are considered and analyzed, it is seen that the structure of arguments and counter argument developed by the participants are not in organized form. In other words, the components -data, warrant, backing, rebuttal and identifying counter argument- are detected in different parts of argumentation. The main reason of this issue is derived from participants' lack of experiences about argumentation. In order to eliminate this issue, both written and oral responses of the participants are configured, and the main components are detected from the different parts of the expressions and responses. The researcher of this study compounds these components to form structured arguments.

Based on the rubrics explained above, developed arguments and counter arguments of the participants were analyzed for 5 different times by the researcher of this study. Also, the adviser of researcher analyzed the twelve written arguments developed by six participants in order to achieve the trustworthiness. When the last versions of analysis of the arguments made by the researcher and the advisor who made independent ratings were compared, it was found that there was 91,5% of consistency in terms of coding the components and scoring them. This means that there was 8,5% of the difference about the codes and scores in total, and this nonconcurrence was resolved by discussion. According to consensus reached about the determined nonconcurrence, the analysis of arguments was revised by the researcher, and also revision of the graphs and tables which were constructed based on codes and scores of arguments were completed as final step of data analysis process.

6. RESULTS

In this chapter, results are presented under two main parts: scores and level of the students' critical thinking skills and dispositions for the first sub-question of this study, and the results obtained from the analysis of the students' argument development and counter argument development for the second sub-question. In the second part, the results determined for argument development and counter argument development are presented under two separate sections. The first section is related with the results for argument development and presented in the order as: the results of Group 1, the results of Group 2, and the results related with differences between the Group 1 and Group 2 for argument development. The second section is related with the results of counter argument development and the results are explained in the same order with the first category.

6.1.Finding Regarding the Critical Thinking Skills and Dispositions of the Students

6.1.1. Findings Regarding the CCTT - Level X Scores of the Students

In this section, total scores of the participants and their scores that get from each sub-dimension of the test are shared. For scoring, "1" point is given for the correct answers, and "0" point is for the wrong answers. To ensure privacy of the students, numbers are assigned to them from 1 to 19 rather than using their names and surnames.

Table 6.1. Total scores of the participants from CCTT (Level X).

Assigned Number of Students	Total Score
Student 2	59
Student 14	54
Student 3	53
Student 9	53
Student 19	50
Student 10	50
Student 8	46
Student 1	44
Student 16	44
Student 6	43
Student 18	42
Student 5	41
Student 15	41
Student 11	39
Student 13	38
Student 7	38
Student 4	30
Student 17	29
Student 12	14

As shown in the Table 6.1., the student with the highest score was the Student 2 got 59 points from the test. The lowest score as 14 belongs to Student 12. In the table, it is seen that some students have equal scores such as Student 3 and 9 with 53 points, Student 1 and 16 with 44 points, Student 5 and 15 with 41 points, and Students 13 and 7 with 38 points.

CCTT - Level X applied for determining critical thinking skills of the participants consists of 6 sub-dimensions as deducing by way of inductive reasoning, deducing by way of deductive reasoning, judging the reliability of the observations and sources, defining the assumptions within the statements. Along with total scores, the scores of each participant got from each sub-dimension were also calculated and given in the Table 6.2. below.

Table 6.2. Scores of the participants from Sub-Dimensions of CCTT (Level X).

	Sub- Dimensions			
Assigned Number of students	**Deducing by way of inductive reasoning**	**Deducing by way of deductive reasoning**	**Judging the reliability of the observations and sources**	**Defining the assumptions within the statements**
Student 2	21	16	12	10
Student 14	17	14	12	11
Student 3	17	12	14	10
Student 9	18	18	12	5
Student 19	13	14	14	9
Student 10	17	12	12	9
Student 8	11	13	12	10
Student 1	11	16	10	7
Student 16	15	12	9	8
Student 6	16	12	7	8
Student 18	13	12	9	8
Student 5	15	13	8	5
Student 15	18	9	8	6
Student 11	12	13	9	5
Student 13	13	13	7	5
Student 7	15	10	7	6
Student 4	10	12	4	4
Student 17	5	14	5	5
Student 12	3	6	4	1

Student 2 whose total score is the highest score among the participants got also the highest score from the sub-dimension which is deducing by way of inductive reasoning compared with the participants of this study. For this sub-dimension, among the scores of participants, Student 12 got the lowest score which is 3. In addition, the highest score from deducing by way of deductive reasoning dimension is belonging to Student 9, and the lowest score from the same sub-dimension is belonging to Student 19 as seen in the sub-dimension which is deducing by way of inductive reasoning. From the sub-dimension namely as judging the reliability of the observations and sources, Student 3 and Student 19 got the equal score which is 14. Similarly, the scores of Student 4 and Student 12 are equal and 4 which is lowest score compared with the scores of participants. The highest score got from the sub-dimension defining the assumptions within the statements is belonging to Student 14 as 11 points. From this sub-dimension, Student 12 got the lowest score among the scores of participants, and his/her score is 1.

6.1.2. Findings Regarding the CCTDI Scores of The Students

In this section, total scores of the participants and their scores that get from each sub-scale of the test are shared.

According to Facione, Facione and Giancarlo (1998), people with a score of less than 40 for a sub-scale are evaluated as having low critical thinking dispositions in that scale, and people who have over 50 for this sub-scale is evaluated as that they have strong critical thinking dispositions. Therefore, since Turkish version of the inventory adapted by Kökdemir (2003) have 6 sub-scales, a score less than 240 (40 x 6) is categorized as low level of critical thinking disposition, a score between 240-300 is evaluated as medium level of critical thinking disposition, and those with a score more than 300 (50 x 6) have high level of critical thinking disposition. Based on this explanation and calculation procedure, the total scores of the participants are calculated and given in the Table 6.3. below.

Table 6.3. Total scores of the participants from CCTDI.

Assigned Number of Students	**Total Score**	**Level**
Student 3	305	High
Student 2	303	High
Student 14	301	High
Student 7	247	Medium
Student 19	245	Medium
Student 13	239	Low
Student 1	235	Low
Student 15	235	Low
Student 16	235	Low
Student 9	231	Low
Student 11	231	Low
Student 17	227	Low
Student 5	226	Low
Student 10	225	Low
Student 8	224	Low
Student 12	221	Low
Student 6	218	Low
Student 18	211	Low
Student 4	177	Low

Kökdemir (2003) adapted the test into Turkish stated that for all subscales the lowest and the highest possible scores are fixed. Thus, for each subscale, the standard minimum score is fixed as 10, and the standard maximum score is fixed as 60. According to scoring process, score of the students participated in this study According to scoring process, the scores of each student from each sub-dimension of the test are shown in the Table 6.4. below.

Table 6.4. Total scores of the participants from sub-scales of CCTDI.

	Sub- Scales					
Assigned numbers of students	**Truth-seeking**	**Open-mindedness**	**Analyticity**	**Systematicity**	**Inquisitiveness**	**Maturity and self-confidence**
Student 3	44	73	52	40	54	42
Student 2	44	72	61	38	46	42
Student 14	46	52	61	49	51	42
Student 7	32	66	51	21	52	25
Student 19	28	59	55	26	49	29
Student 13	32	56	50	25	40	34
Student 1	31	39	56	27	42	36
Student 15	31	52	56	26	38	32
Student 16	31	52	56	26	38	32
Student 9	34	66	47	19	39	28
Student 11	33	57	49	28	37	25
Student 17	27	62	49	28	43	19
Student 5	26	58	52	23	39	27
Student 10	32	54	49	25	39	26
Student 8	31	55	51	27	43	17
Student 12	27	53	46	24	40	29
Student 6	22	59	49	25	35	29
Student 18	31	61	44	19	39	18
Student 4	34	56	36	17	24	9

Since the total scores of students with assigned numbers as 2, 3 and 14 are 305, 303, and 301 respectively, their critical thinking disposition are stated as high level. Student 7 and Student 19 have medium level of critical thinking disposition since their total scores are 247 and 245 respectively. Critical thinking disposition level of rest of the students are determined as low level since the scores are less than 240.

6.1.3. Findings Regarding Construction of the Groups

For construction of Group 1, it is required to select the students who have high critical thinking skills with high level of critical thinking disposition at the same time. In order for Group 2, the students with low level of critical thinking skills and dispositions at the same time. Therefore, in this part, the total scores of students getting from CCTT and total scores, and levels of students based on CCTDI are matched side by side in the Table 6.5. below in order to determine the students in Group 1 and Group 2.

Table 6.5. Matching of scores taken from CCTT (Level X) and CCTDI.

Assigned Number of Students	Total Score Getting from CCTT	Total Score Getting from CCTDI	Critical Thinking Disposition Level
Student 2	**59**	**303**	**High**
Student 14	**54**	**301**	**High**
Student 3	**53**	**305**	**High**
Student 9	53	231	Low
Student 19	50	247	Medium
Student 10	50	225	Low
Student 8	46	224	Low
Student 1	44	235	Low
Student 16	44	227	Low
Student 6	43	226	Low
Student 18	42	245	Medium
Student 5	41	218	Low
Student 15	41	235	Low
Student 11	39	231	Low
Student 13	**38**	**239**	**Low**
Student 7	38	247	Medium
Student 4	**30**	**221**	**Low**
Student 17	**29**	**211**	**Low**
Student 12	14	177	Low

When the table is taken into consideration, it is seen those 3 students at the top of the table (student 2, student 14 and student 3 respectively) have highest critical thinking scores, and also their critical thinking dispositions take place in high level based on their disposition inventory scores. Therefore, Group 1 is formed with these three students who have high critical thinking skills with high critical thinking dispositions. In a similar way, Group 2 is required to form with students whose critical thinking skills score is lower among the participants and whose dispositions are also low. When the Table 6.5. is examined, it is clearly seen that the critical thinking skills results of students whose assigned numbers are 13, 4 and 17 are low among the participants. In addition, their critical thinking dispositions are stated as low based on the disposition inventory. Therefore, these students with low level of critical thinking skills and dispositions are determined as the members of Group 2. In that point, it is required to explain why the students assigned numbers with 7 and 12 are not included in Group 2. The reason related with student 7 is based on inconsistency between the critical thinking skills and dispositions. That is to say, while he/she got relatively low among the participants and exactly same total score with student 13 from the critical thinking test, his/her critical thinking disposition is determined as medium. However, Group 2 is formed with the students whose both critical thinking skills and dispositions are low at the same time. On the other side, the reason why Student 12 is not be in the Group 2 comes from his/her critical thinking skills score. Among the scores of participants, 14 points are quite low and take place out of the normal probability plot drawn with the scores of participants of this study, and the Graph 6.1. is shown in the below.

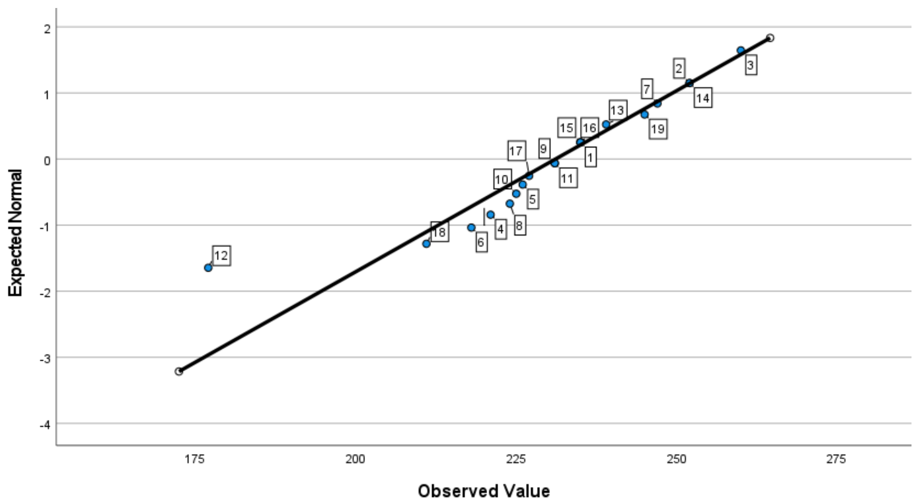

Figure 6.1. Normal Q-Q plot of total score of the participants.

6.2.The Findings Regarding with Argument Development and Counter Argument Development of the Students

In this part, results of the 7th grade students with high level and low level of critical thinking skills and dispositions in terms of argument and counter argument development about plastics use take place. The results are presented in two sections: Argument Development and Counter Argument Development. In the Argument Development section, results related with analysis of arguments developed by Group 1 and Group 2, and results regarding with differences in terms of argument development between Group 1 and Group 2 are explained in a detailed way. In the second section namely as Counter Argument Development, the results for Group 1 and Group 2, and the differences between the groups are presented in the same order with the first section.

6.2.1 Argument Development

According to scores shared and explained in the first part of this chapter, three students numbered as 2, 14 and 3 with high critical thinking skills and disposition, and three students numbered as 13, 4 and 17 with low critical thinking skills and disposition participated in the argument development process regarding plastics use. Written arguments and verbal expressions about their arguments are collected from the participants individually, and these developed arguments are analyzed based on the Rubric 1. Each participant's score that gets from each component and their total score are determined, and two separate tables are formed with the scores: the first one is for Group 1 consists of the participants who have high level critical thinking skills and dispositions, and the second one is for Group 2 includes the participants with low level critical thinking skills and dispositions. In addition to the tables, line graphs are formed for both Group 1 and Group 2 by using the data in the tables.

<u>6.2.1.1. Results of Group 1 for Argument Development.</u> The Table 6.6. and Figure 6.2. show the scores of each participant in Group 1 taken from each sub-dimension according to argument development process, and average scores calculated for each component and for total score take place in both the table and graph.

Table 6.6. Argument development scores of group 1.

Students with Assigned Numbers	**Data**	**Warrant**	**Backing**	**Rebuttal**	**Total Score**
Student 2	3	3	2	1	9
Student 14	3	3	3	3	12
Student 3	1	1	2	3	7

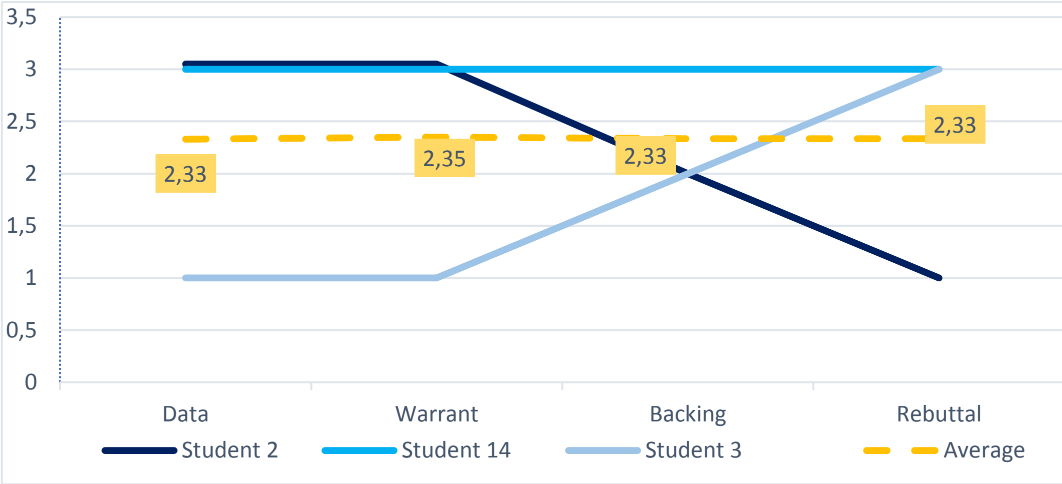

Figure 6.2. Argument development scores of group 1.

In the first place, it is required to point out that all the students in Group 1 chose their claims as "The use of plastics should not be banned." In other words, the participants with high level of critical thinking skills and dispositions advocated use of plastics according to the scenario about plastics use.

Data: According to analytical analysis of these table and graph, each student in Group 1 utilizes data in their argument. While Student 2 and 14 use multiple scientific data, Student 3 includes general data in his/her argument.

When these data in the participants' arguments are examined, it is seen that some of the data in the arguments are explained in the scenario, and some of them do not exist. The data used by Student 2 during the argument development is:

"Using plastics in buildings saves up to 70% of heat."

In this sentence of the argument, the data was presented as heat-saving thanks to plastics use in building, and this scientific explanation are given in the plastics use scenario. On the other hand, the data stated by Student 14 is not mentioned in the scenario:

"*There are different kind of plastics and their effects on environment are different from each other.*"

In this developed argument, the data is existence of different kinds of plastics. Along with the variety of plastics, its light weight, and having high level of quality are another data stated by the students in Group 1 even though these data are not in the scenario.

In addition, implicit data citation is observed among some of the students' arguments. In other words, among the students in Group 1, it is indicated that some of the data are not cited specifically from the scenario about plastics use. Example related to this result about data, written in the argument of Student 2 is:

"Plastics are the materials that have high level of quality."

In the scenario, plastics are not defined as highly qualitative materials, rather its advantages are explained as providing heat and water saving, and hygiene by using in medical devices. However, Student 2 interpreted these scientific data of plastics as a whole property and stated the data as being highly qualitative material by attributing to these advantages.

Moreover, the students in Group 1 present Students in Group 1 tended to use only data related to the claim that is support for plastics use and they decided at the beginning of argumentation process. Therefore, data in their arguments

Warrant: Secondly, as shown in the table, each student in Group 1 use warrant component in their arguments, and the same students get identical scores with the scores taken from data component.

When the warrants in the students' arguments are examined, the first result is that the students who got the highest score from warrant component and this component included warrants by considering specific examples and situations explained in the text about plastics. For example, the warrants of Student 2 is:

"..... For example, why did they build the plastics factories in the region where the chickens are raised? If it were in a further place, these factory creatures would not have been harmed."

In addition, it is stated in the previous paragraph as an example that Student 3 used implicit data in the argument. Related with this result, it is seen that same student included warrants in implicitly. Specifically, the warrant of Student 3 written in the argument is:

"*Plastics damage the nature due to its irresponsible use.*"

In this statement, the warrant is unconscious use, and the reason to state this warrant as implicit is because Student 2 examined the disadvantages of plastics use according to the scenario and interpreted the results of these disadvantages on environment by connecting the reason which is unconscious use. Therefore, even though the scenario puts emphasis on environmental pollution due to throwing on the nature and lack of recycling explicitly, the student stated these warrants implicitly as unconscious use.

Backing: In terms of backing component, it is seen from the table that all participants in Group 1 support the warrants in their arguments. While Student 14 used more than one and clear and understandable backings, Student 2 and 3 included one clear and understandable backing in their arguments.

According to examination of content of these backings, the first result is related with being identical of these backings. This means that all the students in this group emphasized that the environment and ecosystem balance could be preserved due to the recyclability property of plastics. Additionally, Students 14 supported the plastics use by considering global warming and stated that:

"By supporting recycling and using non-harmful types of plastic, we reduce carbon dioxide emissions and thus prevent global warming."

Moreover, Student 2 who included in implicit data and general warrant and get the lowest score from this component in the group was able to establish a clear and understandable backing as:

"*Because the negative effects of plastics use are due to unconscious use, we must first teach people how to use it consciously. We should tell them that plastics are the materials that are recycled. If we explain not to throw them into the environment, plastics* *become a material that should be used. Because the advantages of plastics are benefited, and the disadvantages are solved through conscious use and increasing recycling."*

It is seen from the statements that the ways of usage of plastics and attitudes that should be developed to solve negative effects of plastics on environment are the backings of Student 2. That is, s/he advocated the claim by considering increasing advantages of plastics and solving the disadvantages of them. Therefore, this kind of clear and understandable backing shows that s/he was able to put support for the claim in an appropriate level about plastics use even though s/he has an implicit understanding of data and warrant usage.

Rebuttal: As shown in the table, only the Student 2 got 1 point from this component, and the other students got full points.

When rebuttal components of the students are evaluated, the first result is stated as the students did not mention under which conditions they could change their claims. In other words, they created rebuttals against the opposite claim by focusing on solutions of negative aspects of plastics, but did not explain possible conditions or changes in plastics use in order for rejecting plastics use. The rebuttal component of Student 2 is given below:

> *"Of course, there are negative aspects of the use of plastic. The negative effects of plastics on the environment, human and animal health are also important, but there are also positive aspects of the use of plastic, so if we can prevent the negative aspects, we can benefit from the use of plastic. The negativities of plastics can be eliminated with some precautions and applications. Because it has positive features such as low cost and recyclability. In terms of health, it does not need to be banned when factories are built far away."*

In addition to this situation about rebuttal, the students who got full points in this component presented rebuttal against the opposite claim by making warrants about the advantages of plastics over some of the items used in real world, and the possible harm of an alternative material instead of plastics that may cause. Moreover, their rebuttals include appropriate solutions for disadvantages of plastics. To make more concrete these results, the rebuttal of Student 14 take place in the argument can be given as an example:

> *"In order to support the use of plastics, people are required to be conscious. This means it is necessary to increase the production of healthy and reduced plastics*

types, and to increase the recycling rate. After all, there is no alternative to plastic. For example, it is not logical and not possible to make cars and computers from metal due to heaviness of metals and resulting these technological devices to be heavy."

It is seen that rebuttal consists of clear and understandable explanations of conscious use and possible negative effects of alternative materials.

6.2.1.2: Results of Group 2 for Argument Development. The Table 6.7. and Figure 6.3. show the scores of each participant in Group 2 according to argument development analysis, and average scores calculated for each component and for total score take place in both the table and graph.

Table 6.7. Argument development scores of group 2.

Students with Assigned Numbers	**Data**	**Warrant**	**Backing**	**Rebuttal**	**Total Score**
Student 13	3	3	2	2	10
Student 4	1	0	0	2	5
Student 17	3	3	1	3	9

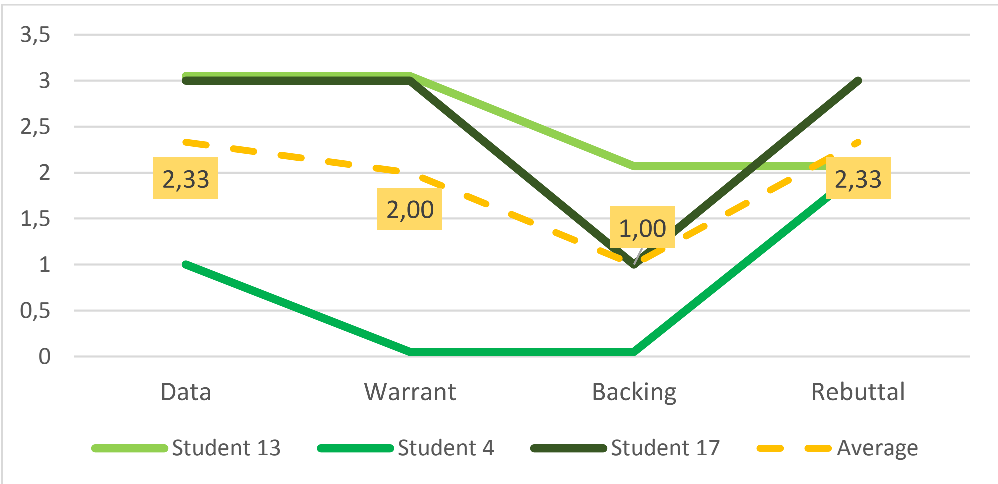

Figure 6.3. Argument development scores of group 2.

In the first place, it is necessary to point out that Student 13 and Student 17 in Group 2 chose their claims as “The use of plastics should be banned.” in the questionnaire, that is they rejected the plastics use. On the other hand, Student 4 “The use of plastics should not be banned.” In other words, s/he advocated use of plastics according to the scenario about plastics use.

Data: As shown in the table, the first result is that each student in Group 2 uses data in their argument. While Student 13 and 17 included multiple scientific data in their arguments, Student 4 utilized general data for supporting the claim.

According to analytical analysis of these table and graph, along with examination of the participants’ arguments, all the participants in Group 2 used text-based data in their arguments. That is, when the constructed arguments of the students are examined, it is not encountered that the arguments include data that not explained in the scenario. For example, Student 13 and 17 used the data about determination of plastics in fishes’ body and sea pollution due to throwing of plastics on the sea as evidence for supporting why plastics should be banned. On the other hand, Student 4 included general data like uses of plastics in constructions by considering the scenario.

When these data like sea pollution, uses of plastics in constructions are examined to determine whether the students added them to their arguments by citing from the scenario in implicit or explicit way, the result shows that did not tend to use data in implicit way, rather they explicitly added the data to their arguments as stated in the scenario.

Moreover, the students who use more than one scientific data in Group 2 tended to use data which are both related to the claim and to the counter claim. That is, these students presented evidence for rejecting plastics use by comparing data about both advantages and disadvantages about plastics. For example, data written in the argument of Student 13 is:

> “*Although plastics save energy, the plastics create waste in nature, and especially in sea.”*

It is seen from this statement there are two opposite data about plastics: saving energy and formation of waste due to plastics. When oral expressions and written arguments are analyzed, this can be interpreted as the student aimed at presenting the negative effects of plastics by comparing with its one of the advantages to show use of plastics are more harmful for environment. The same tendency also is observed in constructed arguments of Student 4 and Student 17.

Warrant: Secondly, as shown in the table, Student 13 and Student 17 used warrant component in their arguments and got the highest score according to the Rubric 1. That is, they included more than one scientific warrant that relate the data and claim. In that point, it is significant to emphasize that these students also included more than scientific data in the arguments as stated in previous paragraph.

When the warrants in the arguments of these students are examined in detailed way, the first result is related with inclusion of specific examples and cases. In other words, Student 13 and Student 17 provided link between the data and the claim which means present warrant through considering specific examples and situations explained in the text about plastics. For example, the warrants of Student 17 is:

> *"Plastics use should be banned. Because when plastics are used at high temperatures, a chemical called dioxin is released. For example, it has been determined that there is a very high amount of dioxins in the eggs and milk of animals fed around the plastic waste incineration plant. As a result, many diseases such as cancer may emerged."*

In addition, it is stated in the previous paragraph through the statement of Student 13, data were used in explicit way in the arguments of students in Group 2. Related with this result, it is seen that same student included warrants in explicitly. Specifically, the warrant of Student 13 written in the argument is:

> "*..... the sea is getting more and more polluted every day because of the plastic wastes."*

In this statement, the warrant to ban plastics use is sea pollution, and this result of plastics that the student use as warrant for his/her claim come from the scenario that puts emphasis on pollution observed in sea due to throwing of plastics on the nature.

When the constructed argument of Student 4 is analyzed, it is seen that s/he used warrant in his/her argument, but 0 point was assigned based on the rubric. The reason is that the warrant stated by Student 4 take place in the argument as follows:

> *"Plastics are used in the construction industry. Thus, it provides 70% better protection of our health."*

This statement includes inappropriate logical inference because the scenario state that thanks to use of plastics in construction industry, 70% savings are achieved in the energy consumed during heating and cooling buildings. However, Student 4 The student irrationally associated the 70% savings in energy with the 70% preservation of health.

Backing: It is seen from the table that backing component is the component with the lowest average score of the students in Group 2. Student 13 and Student 17 are the two students who get score from this component. While Student 13 was able to construct one clear and understandable backing component, certain part was true in backing of Student 17.

When the backings in the arguments of Students 13 and Student 17, the main concern lay behind the aim of the students for rejecting of plastics use is determined as death of living things. However, they received different scores even though they put emphasis on the same concept. To present differences in the backings of the students, statements of Student 13 and Student 17 are respectively given below as follows:

> *"The environment and sea are more and more polluted because of plastics. Health of fishes are negatively affected by the pollution of the sea since they unknowingly feed on them and die. Such harmful effects should not be taken into account because once living things begin to die, there is no going back."*

> *"Animals, human beings, and especially our Earth is dying because of the use of plastic. If we do not have a life to live, there is no meaning to make our life easier with plastics. Due to dying of living thing global warming also happens. And that means the glaciers melt, the sea overflows and the World gradually disappears."*

Student 13 stated backing as dying of living things are unsolvable solutions, and this kind of expression and relation are highly clear, meaningful and understandable. However, Student 17 related dying of living things with global warming, melting of glaciers etc., and the relation of these two results were not constructed by the student.

On the contrary, Student 4 was not able to add backing into his/her argument. This can be attributed to both results which are general use of data and inappropriate logical inference made for warrant. Therefore, it can be said that s/he is insufficient in explaining why plastics should be used, what possible supports should be done for advocating plastics use.

Rebuttal: As shown in the table, Student 13 and Student 4 got 2 points from this component, and Student 17 got full point which is 3 points.

When rebuttal components of the students are evaluated, the first result is stated as the students mentioned specific conditions for changing their claims. Thus, they created rebuttals proper with the definition and properties of this component stated in the literature as extraordinary situations that refute validity of the claims. For example, Student 4 presented the condition to reject plastics and use alternative material instead of plastics as follows:

> *"If there is a material that can be recycled and decomposes rapidly in nature, I use it instead of plastic."*

Similarly, Student 17 stated the specific condition that causes to refute his/her claim is increase in recycling.

In addition, all students in Group 2 formed the rebuttal against the opposite claim by comparing the possible warrants of one who supports opposite claim, positive and negative properties of plastics and concluded this comparison as the negative properties cause irreversible results. For example, the rebuttal takes place in argument of Student 13 as:

> *"There may be those who defend the use of plastics on the grounds that it works for us in our daily life. However, the use of plastics is untenable, as plastics have a major impact on the pollution of the seas and the lives of fish in the seas are endangered by plastics."*

<u>6.2.1.3. Results Regarding with Differences between the Group 1 and Group 2 for Argument Development.</u> In this part, the results of cross-case analysis made for developed arguments are presented and explained.

The first result is relating with differences between the groups in terms of their data sources. The students in Group 2 adhered to the given the scenario about plastics use while using data and warrant for their claims. On the contrary, the students in Group 1 were not depended on the text in terms of using data and warrant, rather they showed tendency in terms of using some scientific data that were not included in the text.

Secondly, Student 4 and Student 17 in Group 2 established an inappropriate logical relationship between the claim and the data among the participants in the groups. When inductive reasoning score of this student is checked from CCTTs, it is determined that score of Student 4 is 10 out of 23 and score of Student 17 is 5. These scores are the lowest scores compared with others. As stated in the Literature Review Chapter of this study, the inductive reasoning skill is about determining the cause-effect relationship and noticing the relationships. Therefore, it can be said that due to lack of inductive reasoning skills, Student 4 and 17 did not relate the claim to the data with appropriate logical inference.

Moreover, the students in Group 1 did not mention under which conditions they could change their claims from advocating plastics use to refuting plastics use. On the other hand, the students in Group 2 presented specific conditions under which they could change their claims. This difference may be related to the situation that the students in Group 1 students do not tend to change their claims, but the students in Group 2 tend to change their claims during explaining possible reasons of one who advocates opposite claim. This tendency can be associated with the sub-dimension of CCTDI namely as Maturity and Self-Confidence which refers to a disposition related with being able to realize complexity of the encountered issue, and from the table it is seen that Maturity and Self-Confidence scores of the students in Group 1 were higher than the scores of the students in Group 2

Finally, it is noteworthy that the students in Group 1 made an effort to present examples of alternative materials that can be used instead of plastics in the argument development process even though they advocated the use of plastics, and they tended to evaluate the advantages-disadvantages of a possible alternative material. However, this approach was not observed in arguments of students in Group 2. This may be due to one of the sub-dimensions of critical thinking disposition which is analyticity. It is calculated through CCTDI and refers to value the reasoning practice and evidence use for resolving problems, foreseeing possible difficulties in concepts and practices, and being continually ready for the potential need for intervention. The analyticity scores of the students in Group 1 are higher than the scores of the students in Group 2.

6.2.2. Counter Argument Development

According to the claim of the students in Group 1 and Group 2, they participated in the counter argument development process regarding plastics use. In this process, it is expected from the students to develop counter argument to the argument that advocates opposite claim. Written arguments and verbal expressions about their counter arguments are collected from the participants individually, and these developed counter arguments are analyzed based on the Rubric 2. Each participant's score that gets from each component and their total score are calculated. Two separate tables are formed with the scores: the first one is for Group 1 consists of the participants who have high level critical thinking skills and dispositions, and the second one is for Group 2 includes the participants with low level critical thinking skills and dispositions. In addition to the tables, line graphs are formed for both Group 1 and Group 2 by using the data in the tables. Also, the counter arguments and their components are examined qualitatively.

<u>6.2.2.1: Results of Group 1 for Counter Argument Development.</u> The Table 6.8. and graph 6.4. show the scores of each participant in Group 1 taken from each sub-dimension according to counter argument development process, and average scores calculated for each component and for total score take place in both the table and graph.

Table 6.8. Counter argument development scores of group 1.

Students with Assigned Numbers	Data	Warrant	Backing	Identifying Counter Argument	Total Score
Student 2	1	1	2	2	6
Student 14	2	2	2	2	9
Student 3	2	1	2	3	7

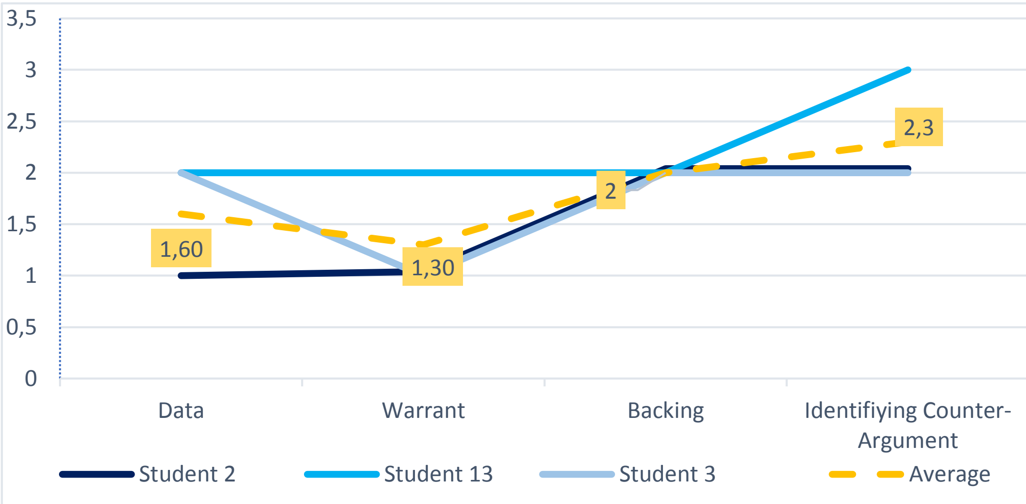

Figure 6.4. Counter argument development scores of group 1.

In the first place, it is required to point out that all the students in Group 1 continued supporting the claim about use of plastics. To the question as "Have you changed your mind after reading the argument of a person defending the opposite claim?" the participants stated that they did not change their decisions about plastics use.

Data: According to analytical analysis of these table and graph, each student in Group 1 utilizes data in their argument. While Student 3 and 14 use one scientific data, Student 2 includes general data in his/her argument.

According to examination of data in counter arguments developed by students in Group 1, it is indicated that they tended to use data related to their claims and related to counter claim. For example, Student 3 emphasized *"release of dioxin under high level of heat"* as the data. This data is appropriate data for counter claim which rejects plastics use. Student 3 used this data for making suggestions to eliminate negative effects on dioxin on health. The same student also used that data *"Plastics have high-quality."* to give evidence for his/her claim.

In addition, the data related to the claims of students in Group 1 were not text-based, and some of them were not cited from the scenario about plastics use. For example, Student 14 used data as *"harmless eco-friendly types of plastics"* which are not stated in the scenario.

Moreover, when the students in Group 1 used text-based data, it is seen that these data were added into arguments implicitly. For example, Student 2 used data for the counter argument development as follow:

"Plastics have variety of advantages for both health and environment."

In this sentence of the argument, the data was presented as variety of advantages of plastics for health and environment. In the scenario, advantages of plastics are defined as saving energy and water, using for packing etc., and results of these advantages explained through specific examples and cases. However, Student 2 considered the scientific data and positive effects of plastics, and did not state them in an explicit way. Rather, s/he made generalization and defined scientific data of plastics as variety of advantages without making in explicit way.

Warrant: As shown in the table, each student in Group 1 included warrants into their counter argument. Among the group, only one student defined as Student 14 included one scientific warrant that related data and claim as follows:

"*The effects of plastics vary depending on how we use it. There are points where the plastics cannot be replaced, for example in certain items and systems. We need to find an alternative; we cannot just switch to another existing material. For example, we cannot make CDs from metal, or from wood and glass, but t it can be made from plastic-based products."*

In the group, Student 2 and Student 3 formed warrant as a general explanation or description of the situation as follows respectively:

"If we stopped using plastic, what would we use instead of plastic? There is no clear answer to this. At least, we do not know what the harms and benefits of other substances are. Maybe it will reduce environmental pollution, but there will be other

bigger damages. It is dangerous and risky to recommend other substances and ban plastics without knowing and determining them."

"A dioxin insulation material is made for dioxin release, and factories are covered with it. Moreover, these factories may not be built in places close to living things, but in distant places. I am trying to develop solutions in order to use plastics efficiently and harmlessly."

When the warrants are examined and data components of these students explained above are taken into consideration, one significant relation between these components based on their structure and content can be stated as the result. That is, Student 2 and Student 3 used implicit data depend on the text, and with the effect of structure of data, they included warrants in their counter argument as general explanation.

Backing: According to the scores presented in the table and graph, it is seen that all the students in Group 1 included one clear and understandable backing in the counter argument development process.

The first result about backing components of the students is that they commonly tried to strength the reason why plastics should be used by concerning lack of alternative materials instead of plastics. For example, the backing of Student 2 situated in the counter argument as:

"The use of a different material instead of plastics for thermal insulation in buildings may cause more fuel consumption, water consumption and the release of toxic gases into the atmosphere, thereby disrupting the balance of the ecosystem."

Similar with this, Student 14 put emphasis on importance and necessity of plastic use by comparing with alternative materials in terms of technological progression as:

"If there is no plastic, we can lose the development in technology. For example, technological tools such as mobile phones and computers are light and insulating thanks to the use of plastic. Then we may have to rebuild all the technology."

When the content of students' backing components is examined from a broad perspective by considering to the whole counter arguments, it is seen that they included backings compatible with their warrants. As an example, Student 3 constructed the warrant component by mentioning solution of possible harmful effects of plastics on environment. Related with this evaluation, s/he stated the backing as follows:

> *"For example, the use of plastics does not have irresolvable damages such as nuclear power plant or gunpowder which can explode and harm everyone and everything in the nature."*

Identifying Counter Argument: As shown in the table, Student 2 and Student 3 in Group 1 were able to identify one scientific data and warrant of counter argument and got 2 points. On the other hand, Student 14 got the highest score determined for this component by identifying more than one data and warrants.

The first result about identifying counter argument is that the students in Group 1 detected different types of data and warrants in the counter argument. Identified data and warrants written in the arguments of the students are:

> Student 2:
>
> "*The justification one who advocates counter claim stated that is that environmental pollution and deterioration in the ecosystem endanger the survival of living things on earth."*

> Student 3:
>
> *"The one advocates counter claim mentioned that plastics produce dioxin at high temperatures."*

> Student 14:
>
> "*The explanation of one who advocates counter claim is the respiratory diseases caused by spread of plastics particles into the air and pollution caused by 350 thousand tons of plastics spilled into the sea every year."*

Different from counter argument identification of Student 2 and Student 3, Student 14 stated more than one data which are spread of plastic particles into the air, and 350 thousand tons of plastics spill; and also identified two warrants as respiratory disease and pollution.

<u>6.2.2.2: Results of Group 2 for Counter Argument Development.</u> The Table 6.9. and Graph 6.5. Show the scores of each participant in Group 2 taken from each sub-dimension according to counter argument development process, and average scores calculated for each component and for total score take place in both the table and graph.

Table 6.9. Counter argument development scores of group 2.

Students with Assigned Numbers	**Data**	**Warrant**	**Backing**	**Identifying Counter-Argument**	**Total Score**
Student 13	3	1	1	3	10
Student 4	3	2	0	3	8
Student 17	1	1	0	3	4

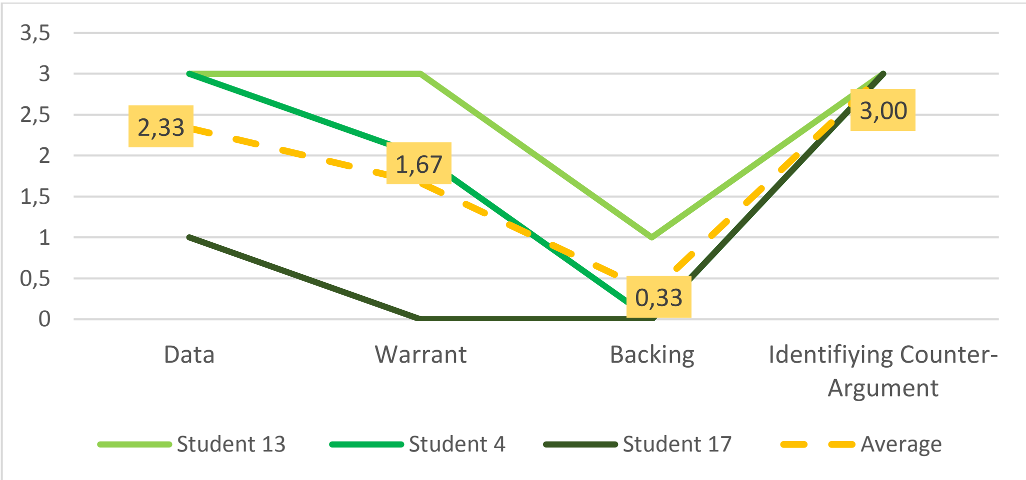

Figure 6.5. Counter argument development scores of group 2.

In the first place, it is required to point out that the Student 13 and 17 in Group 2 continued supporting the claim which is rejecting plastics use. However, to the question as "Have you changed your mind after reading the argument of a person defending the opposite claim?" the Student 4 stated that s/he changed his/her decision from advocating plastics use to rejecting plastics use.

Data: According to the scores in table and graph, each student in Group 2 used data in their argument. While Student 13 and 4 use more than one scientific data, Student 17 included general data in his/her argument.

When the data in the counter arguments of the students are analyzed, the common feature among the data is that it was developed through scientific data depend on the claim.

For example, data used by Student 13 in his/her counter argument take place in one of the parts of written argument as follow:

> *"Only 15% of plastics are recycled."*

According to this part of argument, it is seen that Student 13 used data which is 15% of recycling of plastics. Similar with Student 13, other students in Group 2 coded as Student 4 and Student 17 included text-based data which are directly related with their claim. These data are given respectively below as follows:

> *"Small plastic particles are found in body of fishes and the microscopic plastic particles are spread in the air."*

> *"Water is polluted by plastic and poultry is poisoned by plastics."*

The difference in terms of content of data between Student 4 and Student 17 is that while Student 4 used scientific data which is small particles in body of animals and in the air, Student 17 used general explanation about data as pollution of water and poisoned of poultry. Thus, the points are given to the students for this component differ from each other.

Warrant: As shown in the table and graph, Student 13 and Student 4 got points according to detailed evaluation of their warrants in the counter arguments, but zero point was determined for Student 17.

As seen in common, Student 13 and Student 4 constructed scientific warrants based on the data that were used as scientific and compatible with their claims. While Student 13 included more than one scientific warrant that relate their data and claim, counter argument of Student 4 involved one scientific warrant. The warrant detected in counter argument of Student 4 is presented below:

> *"The presence of small plastics take place in fishes and the spread of plastic in the air affect human health by causing diseases."*

From this statement, it is seen that Student 4 included the scientific warrant as danger in human health be derived from diseases due to small plastics occur in body of animals and the air. Along with this kind of justification, Student 13 also pointed out environmental pollution as follows:

> *"Only 15% of plastic is recycled. However, as the text mentions about environmental pollution, I understand that this is not an adequate recycling, therefore it causes environmental pollution. The environment and marine life are harmed."*

The warrant included by Student 13, environmental pollution and danger for marine life are explained in order to justify the claim which is rejecting of plastics use based on the data recycling of plastics in degree as 15%.

Student 17 did not get any point from this component of counter argument development even though s/he included warrant in the counter argument. It is noteworthy to explain the reason that the warrant consisted of inappropriate logical inference about plastics. In order to prove this warrant component in his/her counter argument is given below:

> *"Less plastic would be used in hospitals if patients were sick from plastic. The water is also polluted by plastic, if it was not polluted and becomes unusable, there would be no need for water savings. In addition, poultry is poisoned by plastics, and after we eat those poultry, it does not become so important that the food comes to us in a hygienic process by packing foods through plastics."*

When scores of the students that got from warrant component and content of these warrants are evaluated in a detail way, the result can be formed as the students who used more than one scientific data was able to include at least one scientific warrant for their counter claim. However, as seen in analysis of Student 17's counter argument when data were used as general explanation, the warrant component was not constructed as scientific.

Backing: According to the table constructed based on the analysis counter argument development, the backing component is the component that the students had the lowest average score when compared with the other components. Only one student defined as Student 13 used a backing even though certain parts of this backing is true because the component was situated in the written argument as:

> *"In the future, for example, there will be drought due to the use of plastic. How will we live if we cannot reach water? The use of plastics should not be supported in a place where life is in danger."*

This backing was evaluated as partially true because any scientific data or warrant advocate the inference about drought occur depend on plastics use.

Among other students, Student 4 who changed his/her claim based on the text about counter argument was not able to include backing to his/her counter argument.

Specifically, Student 17 used backing component through inappropriate logical inference and generalization as follows:

> *"Moreover, due to these damages of plastic, the world will die as the world will become more polluted, we will have to reduce the use of plastic even more in the future."*

According to this backing statement, Student 17 related plastics use with dying of the World, and this relation was not explained in logical sense. In that point, it can be said that the reason behind this inappropriateness in logical inference come from warrant component. As stated above, Student 17 also related the data and claim in an inappropriate logical way similarly, and this issue caused him/her to present same pattern in backing component.

Identifying Counter Argument: As shown in the table, all students in Group 2 were able to identify more than one scientific data and warrant of counter argument.

When identified scientific data and warrant of counter argument are analyzed in the arguments of students in Group 2, it is concluded on the result that the students mentioned data and warrants related with both health and environment. Example related to this finding written in the argument of Student 13 is;

> *"The reasons given by one who advocates counter claim are saving energy by making thermal insulation, using plastics in the equipment in the health field and in the packaging of foods in the food field."*

Difference from these data and warrants, Student 4 who changed his/her claim at the beginning of counter argument development process detected data and warrant from the counter argument as:

> *"Small pieces of plastics float in the air and adversely affect human health. Dioxin was found in the eggs and milk of chickens growing around the factories where plastics were burned, and it was determined that there was an increase in respiratory tract and liver diseases."*

6.2.2.3: Results Related with Differences between the Group 1 and Group 2 for Counter Argument Development. In this part of Results Chapter, findings determined after cross case analysis which is analysis between Group 1 and Group 2 for Counter Argument Development are listed and explained in a detailed way.

In the first place, the students in Group 2 tended to change their own claims about plastic use after reading the counter argument. Especially, these students stated that they have some dilemmas about plastics use and difficulties in comparing advantages and disadvantages of plastics in the interviews. On the other hand, the students in Group 1 did not tend to change their claims after reading the counter argument, and specifically they stated that it is necessary not to evaluate the data and warrants take place in counter argument as significant issues because these disadvantages are solved through some applications. This tendency can come from one of the sub-scale of critical thinking disposition which is Maturity and Self-Confidence. This sub-scale is defined as a disposition related with being able to realize complexity of the encountered issue, and one who has high level of this sub-dimension states multiple acceptable solutions for any issues. That is, s/he does not focus on only white and black points, but also take grey points into consideration. In this study, it is seen that the students who got low score from Maturity and Self-Confidence sub-dimension did not focus on grey points. In the first place, they made their decisions about plastics use, and then showed tendency to change their claims without taking possible solutions of disadvantages, advantages of counter claim or comparison of two opposite position about plastics. Therefore, when property of having Maturity and Self-Confidence is related with this result, it is seen that the students who the highest score from Maturity and Self-Confidence sub-dimension among the participants tried to consider grey points before taking a position from white or black point.

Secondly, the students in each group were able to identify at least one scientific data and warrant of counter claim. The difference between the groups is related with how to use data and warrant of counter argument. When the developed counter arguments of the students in Group 1 were examined, it is determined that they did not only use data to support their own claims and included scientific warrants, but also put emphasis on data and warrant of counter arguments to state possible and related solutions. In this case, they create their own arguments by refuting the counter argument. On the other side of the coin, the students in Group 2 tended to justify their claims by comparing the negative and positive effects of plastics use in terms of health and environment without stating solutions. In addition, they tried to refute the counter argument through comparison of opposite data and claims. Therefore, referring counter argument's data and warrants while developing counter argument by the students in each group can be drawn from the students' sufficient ability in identifying counter argument. Being able to identify scientific data and warrant of counter argument, and to develop counter argument revealed as independent from the critical thinking skills and dispositions of the students in this study. This sufficient ability achieved by all students can be based on the given structured and high-quality argument to the students. The structured arguments provide the students to comprehend argument of opposite claim, and to develop counter argument by considering the components in TAP model.

Moreover, Student 17 in Group 2 established an inappropriate logical relationship between the claim and the data among the participants in the groups. When inductive reasoning score of this student is checked from CCTTs, it is determined that score of Student Student 17 is 5 which is the lowest score compared with others' scores. As stated in the literature, the inductive reasoning skill is about determining the cause-effect relationship and noticing the relationships. Therefore, it can be said that due to lack of inductive reasoning skills, Student 17 did not relate the claim to the data with appropriate logical inference, and so constructing backing component.

7. CONCLUSION AND DISCUSSION

In this chapter, the results of this study are discussed in the light of the related literature. Firstly, the summary of the study is given to provide an insight into the whole study. In the following parts, the results of this study are discussed. Finally, in the last section of this chapter, the limitations and implications of the study are explained respectively.

7.1. Summary and Discussion

The purpose of the current study is to investigate how divergent critical thinking skills and dispositions of middle school students reflect themselves on argument development and counter argument development about the SSI which is determined as plastics use. For this purpose, the students in Group 1 whose critical thinking skills and dispositions are high, and the students in Group 2 whose critical thinking skills and dispositions are low according to the scores taken from The CCTT and the CCTD were engaged into argument development and counter argument development process about plastics use. The significant results are determined based on the analysis of arguments within the cases and across the cases, and it is significant to discuss these results based on the related studies in the literature. Before the discussion of the results, the summaries of them for argument development and counter argument development are given in the separate tables presented below as Table 7.1. and Table 7.2.

Table 7.1. Summary of the results for argument development

Argument Development	**Group 1**	• All students used data, and the sources of data were the scenario and prior knowledge of the students. Implicit data citation was observed. • The students who used scientific data included warrants with examples and specific situations, but the student who used implicit data also included warrants as implicit. • All students used similar backings as environment and ecosystem balance. The student who used implicit data constructed clear and understandable backing. • The students rebut counter claim by emphasizing appropriate solutions, but they did not mention possible conditions to change their claims.
	Group 2	• All students used data, and the sources of data were the scenario. Explicit data citation was observed. • The students who got points from warrant component included examples and specific situations. One student included warrant as inappropriate logical inference. • Two students used backings as dying of living things, but the student who included warrant with inappropriate logical inference did not construct any backing. The backing component is the component in which students get the lowest average score. • All students rebut counter claim by comparing positive and negative properties of plastics, and the students mentioned specific conditions for changing their claims.
	Comparison of Group 1 and Group 2	• The students in Group 1 were not depended on the text in terms of using data and warrant, but the students in Group 2 adhered to the scenario about while using data and warrant. • Two students in Group 2 established an inappropriate logical relationship between the claim and the data, and their inductive reasoning score are quietly low among the participants. • The students in Group 1 did not mention under which conditions they could change their claims, but the students in Group 2 presented specific conditions under which they could change their claims. This difference can come from Maturity and Self-Confidence which lead to tendency to change the claims. • The students in Group 1 made an effort to present examples of alternative materials, but the students in Group 2 did not show this effort. This may come from analyticity which refers to value the evidence use for resolving problems.

Table 7.2. Summary of the results for counter argument development.

Counter Argument Development	**Group 1**	• All the students in Group 1 continued supporting the claim about use of plastics. Both text-based data and prior knowledge-based data were used. Some data were added into arguments implicitly. • Each student included warrants into their counter argument. The students who used implicit data depend on the text, included warrants as general explanation. • All students included one clear and understandable backing related with the warrants. The backings were constructed to strength the reason why plastics should be used by concerning lack of alternative materials. • All students were able to identify at least one scientific data and warrant of counter argument. Each student detected different types of data and warrants in the counter argument.
	Group 2	• One student changed his/her claim in parallel with claim of counter argument. • Each student used data, and the common feature among the data is that they are scientific text-based data. • One student used warrant consisted of inappropriate logical inference about plastics. Other two students used at least one scientific warrant by focusing on dangers. • The backing component is the component in which students get the lowest average score. Only one student used a backing even though certain parts of this backing is true. One student included backing through an inappropriate logical way. • All students were able to identify more than one scientific data and warrant of counter argument.
	Comparison of Group 1 and Group 2	• The students in Group 2 tended to change their own claims about plastic use after reading the counter argument. The students in Group 1 did not tend to change their claims after reading the counter argument. This result is related with Maturity and Self-confidence disposition which provides one to see greys along with the white and black points, and so to state multiple solutions for any issue. • The students in Group 1 did not only use data to support their own claims and included scientific warrants, but also developed solutions against warrants of counter argument by referring to the data of it. The students in Group 2 tended to justify their claims by comparing the negative and positive effects of plastics.

The mean scores of Group1 and Group 2 are equal, and they are calculated as 7,33. Therefore, this result shows that there is not difference between the groups in terms of scoring. However, according to qualitative analysis of counter arguments indicates that Group 1 put emphasis on deficiencies in the argument of one who advocates the counter claim. That is, the students in Group 1 who supported the claim related with use of plastics explained the reason why not to change their claims as there are some significant deficiencies in the argument of counter claim in terms of pointing out possible solutions of harmful effects of plastics, possible and appropriate conditions to use plastics to eliminate negative effects on health and environment. Also, these students in Group 1 included data and warrant stated in text about argument of counter position to rebut the counter claim. On the other side of the coin, the students in Group 2 only focused on their claims without evaluating deficiencies in the argument of counter position, and tried to include only the related data and warrant with their claims even though some of the students in Group 2 changed their claims or showed tendency for changing the claim. This divergency between the groups confirms the idea stated by Facione (2011) and Kurnaz (2011) based on their studies. This idea explains that the students with high level of critical thinking skills focus on the deficiencies of one who advocates counter claim and try to rebut his/her claim by determining the deficiencies in the argument.

Along with inability to detect deficiencies in argument of counter claim for students who have low level of critical thinking skills, Vieira, Tenreiro-Vieira and Martins (2011) stated that these students also lack of diversified cognitive strategies as constructing and/or analysis of alternative situations towards one in the opposite position. Similarly, significant difference between the groups is determined in terms of constructing and analysis of alternatives in this study. The students in Group 1 assumed using of other materials like metals, or glass in some of the equipment in health care or technology. Based on this assumption, they tried to make inferences about the possible advantages and disadvantages of these materials on health and environment. Also, they tried to explain possible results of the equipment when they are constructed with alternative materials. This kind of tendency and endeavor is seen in both argument development and counter argument development process to justify their claims which is advocating plastics use. On the other side of the coin, the students in Group 2 tried to justify their claims by using related data, examples, and cases about plastics. Construction and/or analysis of alternative situations or materials instead of plastics, comparison of plastics and other materials in terms of their negative and positive effects on different areas are not seen in the argument development and counter argument development processes of the students in Group 2 even they advocate plastics use or not.

Schunk (2009) stated that a person with high level of self-confidence tries to convince people who advocate opposite claim of his/her claim rather than avoiding discussion. In parallel with this determination, the reflection of self-confidence on students' argument and counter argument developments are detected in this study. When counter arguments of the students in each group are analyzed, it is detected that Student 4 in Group 2 changed his/her claim from advocating of plastics use to rejecting them after reading the argument of counter claim. Also, in the same stage of data collection process, statements of Student 17 in Group 2 included dilemmas and difficulties in terms of decision making about plastics use even though s/he rejected plastics use while developing arguments. On the other side of the coin, the other students in both Group 1 and Group 2 did not show any tendency to change their claims, rather it is seen that they tried to stand behind their claims and arguments. Also, it can be deduced that since the students in Group 2 have some dilemmas and difficulties about making decisions, they tried to be more carefully about reading, evaluating and examining the counter argument. This inference can be supported by the fact that they get full points from the identifying counter argument component. In that point, the scores of the students in the Maturity and Self-Confidence, which is the sub-dimension of the CCTDI, were examined. As shown in Results Chapter, the scores of the Student 2, 3, 14 and 13 are 42 and 34 out of 42 points, while Student 4 and 17 got 29 and 19 points respectively. Therefore, it is seen that self-confidence and maturity disposition of the students who changed the claim and showed tendency to change got the lowest score among the students participated in argument and counter argument development process.

When the data used by the students in both two groups are examined qualitatively, it is indicated that the data used by students in Group 1 consisted of the data given in the scenario, scientific explanations, prior knowledge, and experiences in daily life. In addition, content analysis of the arguments and counter arguments of the students in Group 1 showed that they did not make specific data citation for their arguments, rather some of the data were evaluated and used in an implicit way. However, the students in Group 2 used data for supporting their own claim and for rebutting counter claim by depending on the scenario about plastics use prepared for this study. In that point, it is significant to state that even some of the students in Group 2 have prior knowledge and experiences about plastics, they did not integrate these data into their arguments and counter arguments. The difference about data use between the groups can be explained through the Sandoval and Millwood (2005)'s expression and research study conducted by Demiral (2014). According to the Sandoval and Millwood (2005), the coordination of claim and evidence is a difficult cognitive skill. Subject-matter knowledge is requirement for students to be able to understand the meaning of evidence, to determine which data can be used as evidence, and to construct the relationship between the claim and the evidence. Based on this, Demiral (2014) compared data use of two divergent groups: one of the groups consists of pre-service teachers who have high level of content knowledge and critical thinking skills, and the other group includes pre-service teachers with high level of content knowledge, but low level of critical thinking skills. The result showed that even the pre-service teachers have high content knowledge in each group, the participants with high level of critical thinking skills used data from different sources along with daily-life experiences, but the participants with low level of critical thinking only used data from lecture notes. This result stated by Demiral (2014) is compatible with the findings of this study in terms of data use. The students in Group 1 used data from both the scenario, their prior knowledge, and experiences. This can be interpreted as the students with high level of critical thinking skills have ability to use appropriate data to present the rightness of their claims.

By examining the ability to include backing component between the two groups, it is determined that the students in Group 1 included at least one clear and understandable backing for their claims even Student 3 used the warrants as general explanation in both argument development and counter argument development process. On the contrary, the backing component is the most salient component for students in Group 2 since the average scores of backing component in both argument development and counter argument development process are the least among the average scores of the other components. While the students in Group 1 asserted the backing components as protection of ecosystem, prevention of global warming and contagious disease in detailed way, Group 2 pointed out partially true backing components like dying of the World and living things. When these significant differences are taken into consideration between the Groups, it is seen that this difference and determined result are compatible with the results of the study of Voss and Dyke (2001). They stated that argumentation is depended on critical thinking, and defined argumentation as an effort in which both critical thinking and scientific reasoning are required. In addition, they emphasized that critical thinking is required to sustain a claim and to support this claim through backings in the argumentation process. Therefore, since the result of this study related with backing component showed reflection of high level of critical thinking skills and dispositions on using backing in the development of arguments and counter arguments, it is seen that these results are compatible with the result of the study conducted with Voss and Dyke (2001).

The result of this study for rebuttal component shows that the students in both Group 1 and Group 2 were able to rebut counter argument. Even the Student 4 in Group 2 who included the warrant as inappropriate logical inference was able to produces one rebuttal by justifying or supporting the claim it is defended. This can be originated from the guidance in written arguments. In the literature, it is stated that if students are guided in their written arguments, they included rebuttal in their arguments (Erduran et al., 2004). Similarly, Herrenkohl and Guerra (1998) mentioned that students are able to think critically for developing arguments when guidance and questions are provided to them (cited from Aslan, 2014). Also, the result about using rebuttal component in the arguments detected in both Group 1 and Group 2 is explained with the scaffolding of the arguments. Cho (2001) emphasized that the arguments that are developed and scaffolded as compatible with the issue have contributions for the production of argument components, increasing the quality of produced arguments and development of problem-solving skills in group or individual arguments (cited from Torun, 2017). Before the development of counter argument process, the structured arguments in opposite position are shared with the students, and it is expected from the students to develop counter arguments based on the structured arguments prepared for this study. Therefore, as stated by Cho (2001), the students were able to develop high-quality counter arguments based on the high level of structured arguments. Moreover, in the Kuhn's (1991) research, she put forward the necessity of establishing one's own argument clearly and strongly to be able to rebut counter argument. This correlation is detected in this result of the study. When the developed counter arguments of the students are examined depend on Kuhn's (1991) finding, it is seen that since the students constructed their counter arguments in sufficient level, they used rebuttal component.

7.2. Limitations

The study has some limitations when considering the data collection process, the number and high academic motivation of students participated in the study, and inability to generalize.

In the first place, the number of participants was limitation of this study. The reason is that there are 19 seventh grade students in the private school that was selected to conduct the study, and from these participants 6 students were determined according to their critical thinking skills and dispositions. However, the number of students is quiet low to generalize the findings of this study because the range between the scores are quietly close with each other. It is significant to gather the scores in wide range in order to show reflection of critical thinking skills and dispositions on developed arguments and counter arguments. Therefore, if the number of students is increased, it is possible to generalize the findings of the study.

In that point, it is required to state that the students at this private school were selected as the participants are highly motivated in terms of academic due to nature and missions of this private school and academic motivation. This property was significant for this study to apply critical thinking tests and argumentation processes. However, like number of the students, their high academic motivation also leads to limitation in this study since the range between the participants become quietly close. When developed arguments and counter arguments of the students in the groups are examined qualitatively and quantitively, the results show that there are not major differences between the groups. Detection of significant differences were constrained by high academic motivation of the students. Even the students who have low level of critical thinking skills and dispositions developed high quality arguments due to their high academic motivation. That is, even though the distinction between the groups was acquired through difference in critical thinking skills and disposition, high academic motivation provided the students in Group 2 to perform high level for argument and counter argument development.

Moreover, data collection process leads to a limitation in this study. As stated by Joiner and Jones (2003), when students are engaged in a face-to-face argumentation environment, quality of arguments become higher compared with the arguments gathered from online discussions. In this study, the participants developed arguments and counter arguments about plastics use as written forms and verbal expressions in semi structured interviews, and data was gathered through online meetings. The reason not to design argumentation environment as face-to-face is based on pandemic that has affected each part of the World and caused the schools to take lessons in online platforms in Turkey due to quarantine. Therefore, the only way to engage the participants in argumentation process was to connect them through online programs. If semi structured interviews were conducted as face-to-face rather than online, the students could develop the arguments in higher qualities.

7.3. Implications for Further Research

In this study, the students were engaged into argumentation process through the SSI scenario which is plastics use. According to the literature, since SSIs are defined as open-ended, complex, and controversial dilemmas that do not have specific answers (Zeidler, Walker, Ackett and Simmons, 2002), the students were expected to make decision process which is also one of the most important parts of science literacy (Driver, Newton, and Osborne, 2000). In that point, Lin (2014) stated that argumentation is the central component of the decision-making process, and for supporting critical thinking skills, argumentation is the significant approach. The reason was based on application of critical thinking skills for the construction of arguments. When the results of this study are examined in the light of this correlation between argumentation and critical thinking, they indicate that the students they developed arguments through the SSI, plastics use by adding scientific data, including warrants by relating data and claim, supporting their warrants, and also rebutting the counter claims. During this process, they used critical thinking skills and dispositions as able to examine and evaluate an argument for or against a claim. As a consequence, engaging students into argument development process provide them to enhance their critical thinking skills. In science lectures, it is allowed for students to develop arguments and counter arguments through SSIs. The study conducted by Gül and Akçay (2020) also put emphasis on this kind of opportunity for students, because results of their study showed that SSI based instruction in science education is a useful method to increase and improve students' critical thinking skills. Similarly, Tal and Kedmi (2006) revealed the relationship between high school students' argumentation and critical thinking skills in their study. The relation was found as argumentation skills of the students improved over time, and increased argumentation skills also provided students to enhance their critical thinking skills.

In addition, it is significant to state that the SSI scenario about plastics use was developed for this study by the researcher and her advisor (Can, Büçkün and Güven, 2021) can be used in the lectures for the aim stated in the previous paragraph. For the designing of these materials, five crucial criteria taken into consideration as familiarization of the topic for increasing interest, motivation and participation of the students (Jarvela and Reninger, 2014); the purpose of chosen SSI whether it focuses on the whole unit (Zeidler and Kahn, 2014) or focuses on only in a certain part of the unit to support learning process (Güven and Muğaloğlu, 2020); presentation of evidence in a balanced way in order to provide objectivity (Tsai, 2018); and being clear and compatible with the age of the participants to increase understandability (Güven and Muğaloğlu, 2020). Also, two opposite arguments related with the scenario were developed based on TAP argumentation model to motivate students to develop counter argument in accordance with the related opposite argument. These arguments were developed in the same structure and equal level in terms of inclusion of the component and order of these components. Therefore, these texts are contributed to the literature and may be applied to middle school students to integrate them into argumentation development process in science instructions since these materials have been practically tested with 19 seventh grade students studying in private middle school and found effective.

For implications in terms of research, the divergent cases were high level of critical thinking skills and dispositions, and low level of critical thinking skills and dispositions in this study. When developed arguments and counter arguments of two groups are examined qualitatively and compares as cross-case analysis, the study showed that the students present different tendency in terms of advocating their claims, choosing sources of data, including backings in their arguments, and the way of relating data and claim to include warrant. These are the differences between the divergent groups gathered through content analysis. In that point, it is required to obtain significant statistical differences between the groups in terms of the components in the developed arguments to present distinguishable reflection of divergent critical thinking skills and dispositions on arguments. Therefore, rather than designing the study based on qualitative research design and conducting with limited number of participants, in further research, Group 3 can be formed with the students who have middle level of critical thinking skills and dispositions as the third case. Also, the number of students in each group are increased to obtain more data. Thus, major and specific differences can be obtained for exploring reflection of critical thinking skills and dispositions on argument development processes.

Finally, some of the students in the groups stated that they have prior knowledges about plastics in addition to knowledges that are given in the 4^{th} unit of science lectures. Therefore, they tended to integrate these knowledges as data, warrant, backing or rebuttal into their arguments. Also, content analysis of the arguments showed that some of the students tended to use their prior knowledges in implicit way. In order to eliminate the differences between the students originated from their prior knowledge, a content knowledge test can be applied to the students, and while forming the groups, the students who have close content knowledges can be the member of the same group along with close critical thinking skills and dispositions. This key point should be taken into consideration for further research.

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APPENDIX A

Plastik Kullanımı

Plastikler petrol ve doğalgaz kaynaklı ürünlerdir. Plastikler kolay şekil alan, elektrik ve ısı yalıtkanlığı olan, kolay kırılmayan ve paslanmayan yapıya sahiptirler. Bu özelliklerinden dolayı günümüzde plastikler, her türlü eşyanın üretilmesinden, gıda ve sağlık malzemelerine kadar hayatın her alanında yer almaktadırlar.

Plastik maddeler sağladıkları hijyen açısından beslenme ve sağlık gibi sektörlerde kullanılmaktadır. Gıda ambalajlarında kullanılan plastik, ürünlerin temiz, sağlıklı ve güvenli koşullarda tüketiciye ulaşmasını sağlar. Tek kullanımlık plastik tabak ve bardaklar, iğne enjektörleri, serum, ilaç paketleri vb ürünler de plastik malzemelerden üretilmektedir.

Öte yandan, plastikler belirli şartlar altında kullanılmadığında hem insan hem de hayvan sağlığını tehdit eden bir maddeye dönüşebilmektedir. 70-90°C sıcaklık, plastik ürünlerde dioksinin açığa çıkmasına sebep olur. Dioksinin gıdalarla teması ve besin zinciri ile insan vücuduna girmesi başta kanser olmak üzere birçok sağlık problemlerine yol açmaktadır. Örneğin yapılan bir araştırmada, Kocaeli ilindeki atık yakma tesisi çevresinde beslenen hayvanların yumurta ve sütlerinde oldukça yüksek miktarlarda dioksin olduğu tespit edilmiştir.

Gözle görülemeyecek kadar küçük plastik parçalarının havada yayılmasıyla ve besin zinciriyle taşınması da sağlığa zarar verebilmektedir. Bu plastik parçacıklar solunum sonucu akciğerlerde ve besin yoluyla karaciğerde birikmeye sebep olup birçok sağlık problemlerini de beraberinde getirebilmektedir. Türkiye denizlerinde yapılan araştırmalar sonucunda balıklarda çok küçük plastik parçaları olduğu saptanmıştır. En çok Ege Denizi, sonra Marmara Denizi ve Akdeniz şeklinde azalmaktadır.

İnşaat sektöründe de plastiklerin yalıtkanlık özellikleri sayesinde binaların ısıtmak ve soğutmak için harcanan enerjide %70 tasarruf sağlanmaktadır. Ayrıca, plastik kullanımı su tasarrufu da sağlamaktadır. Örneğin, plastik torba üretimi sırasında harcanan su miktarı kâğıt torba üretimine göre 100 kat daha azdır. Tarımda kullanılan plastik sulama boruları, su ve bitki besin maddelerini kontrollü bir şekilde damla damla bitkilere vererek su kullanımını azaltır ve verimliliğini arttırır. Türkiye'de plastiklerin tarımda kullanım miktarının yıllık yaklaşık 600 bin ton olduğu belirtilmektedir.

Ancak plastiğin yoğun kullanımı, atık oranını da artırmaktadır. Türkiye'de bir kişinin günlük ortalama 210gram plastik atık oluşturduğu ve Türkiye' de yıllık 5 milyon ton plastik kullanımı olduğunu göstermektedir. Geri dönüşüm için yapılan harcamanın, yenisini üretmekten çok daha fazla olması sebebiyle Türkiye'de ömrünü tamamlamış plastiklerin yalnızca % 15'i geri dönüştürülmektedir. Plastik atıkların saklanması ve geri dönüştürülmesi sorunu yüzünden Türkiye'de günde 144 ton plastik denize bırakılmaktadır.

APPENDIX B

İsim:

Soyisim:

Plastik Kullanımı Hakkında Ne Düşünüyorsun?

Aşağıdaki soruları detaylı ve samimi bir şekilde cevaplayınız. Soruların doğru yada yanlış bir cevabı yoktur.

1. Aşağıdakilerden hangisi plastik kullanımı konusundaki görüşünü ifade eder? Sana **en uygun gelen** seçeneği işaretle.

A	**B**	**C**	**D**
Plastik kullanımı **kesinlikle yasaklanmalı.**	Plastik kullanımı **yasaklanmalı.**	Plastik kullanımı **yasaklanmamalı.**	Plastik kullanımı **kesinlikle yasaklanmamalı.**

2. Neden böyle düşündüğünü gerekçeleriyle açıklar mısın?

3. Seninle aynı görüşte olmayan bir kişinin gerekçeleri neler olabilir?

4. Senden farklı düşünen bu kişiye karşı cevabın neler olur?

APPENDIX C

Argument 1 (Advocating plastics use)

Plastik kullanımı yasaklanmamalıdır (**Claim**). Sağlık alanında yer alan araç gereçlerde ve gıda alanında besinlerin ambajlarlarında plastikler kullanılmaktadır. Plastiğin sağlık alanında kullanılmasıyla bu malzemelerin tek kullanımlık ve dolayısıyla hijyenik olması sağlanır. Gıda ambalajı olarak kullanılmasıyla da gıdaların temiz, güvenli ve hijyenik bir şekilde tüketicilere ulaşması sağlanır. Örneğin, Kocaeli'nde çıkarılan kaynak suları Türkiye'nin çeşitli bölgelerine plastik şişelerle taşınmaktadır (**Data**). Ancak, plastik yerine sağlık problemlerine yol açmayan, daha kolay üretilen ve daha ucuz maliyetli farklı malzemelerin kullanılması ile sağlık problemlerinin önüne geçilebilecek hijyen sağlanabilirse plastik kullanımının devam edilmesi savunulamaz (**Rebuttal)**. Dolayısıyla plastik kullanımı insan sağlığını sağlığını korumakta önemli rol oynamaktadır (**Warrant)**. Sağlığı korumanın en önemli yolu ise vücudumuzu hastalık yapıcı etkenlere karşı hijyen tedbirlerini alarak korumaktır (**Backing)**. Aynı zamanda plastiklerin bina yalıtımında kullanılması ile enerji kaynaklarından % 70 ve tarımda sulama sistemlerinde kullanılması ile su tüketiminden %75 oranında tasarruf edilmektedir. Örneğin, kağıt torba üretimine göre plastik torba üretimi sırasında 100 kat daha az su kullanılması plastikler sayesinde su tüketiminin daha az olduğunu göstermektedir (**Data)**. Öte yandan**,** daha kolay üretilen ve geri dönüştürülebilen ve çevreye negatif etkileri daha az olan farklı malzemeler kullanılabilirse, plastik kullanımına devam edilmesi savunulamaz (**Rebuttal)**. Dolayısıyla, plastik kullanımı enerji ve su tüketimini azaltarak, doğal kaynakları korumaktadır.(**Warrant)**. Doğal kaynakların korunması ise yeryüzünde varlığımızı sürdürebilmek için en önemli görevlerimizden biridir (**Backing)**.

Yukarıdaki sağlık ve çevre konusundaki gerekçelere göre plastik kullanımı yasaklanmamalıdır.

APPENDIX D

Argument 2 (Rejecting plastics use)

Plastik kullanımı yasaklanmalıdır (**Claim**). 70-90°C sıcaklık altında plastik ürünlerde zararlı madde açığa çıkmaktadır. Aynı zamanda küçük plastik parçalar havada yayılmaktadır. Örneğin, plastik yakımının yapıldığı fabrikaların etrafında büyüyen tavukların yumurta ve sütlerinde dioksine rastlanılmış ve solunum yolları ile karaciğer rahatsızlıklarında artış olduğu belirlenmiştir (**Data**). Ancak, plastik yerine daha zor üretilen ve maliyeti yüksek, sağlık alanında kullanılan araçlarda hijyeni önleyerek bulaşıcı hastalıkların yayılmasına sebep olacak farklı malzemeler kullanılırsa plastiğin yasaklanması savunulamaz (**Rebuttal**). Dolayısıyla, plastik kullanımının canlıların sağlığına zarar verdiğini göstermektedir (**Warrant**). Canlı sağlığının bozulmasına günlük hayatta sıkça kullanılan malzemelerin içerisinde yer alan kimyasal maddelerin sebep olması da bu durumun devam etmesine yol açar (**Backing**). Aynı zamanda plastiğin yoğun kullanımı ile bir kişinin yıllık oluşturduğu atık plastik miktarı yıllık 85 bin tondur. Geri dönüşüm oranının çok az olmasıyla tonlarca plastiğin denizlerde olması ve balıkların vücudunda plastik maddelere rastlanır (**Data**). Fakat, plastik yerine binaların ısı yalıtımında kullanılarak daha çok yakıt ve su tüketimine ve atmosfere zehirli gazların salınımına neden olarak ekosistemin dengesini bozacak bir malzeme kullanılırsa plastiğin yasaklanması savunulamaz (**Rebuttal**). Dolayısıyla plastik kullanımı çevre kirliliğine ve ekosistem dengesinin bozulmasına sebep olmaktadır **(Warrant).** Çevre kirliliği ve ekosistemde meydana gelen bozulmalar da yeryüzünde canlıların varlığını sürdürmelerini tehlikeye sokar **(Backing).**

Yukarıdaki sağlık ve çevre konusundaki gerekçelere göre plastik kullanımı yasaklanmalıdır.

APPENDIX E

İsim:
Soyisim:

Plastik Kullanımı Hakkında Senin Tam Tersin Savunulan Fikri Nasıl Değerlendirirsin?

Bu bölümde plastik kullanımıyla ilgili seninle aynı metni okuyan fakat senin tam tersin fikri savunan bir arkadaşının öne sürdüğü fikirleri değerlendirebileceğin sorular bulunmaktadır. Arkadaşının açıklamasından yola çıkarak bu soruları yanıtlarken AÇIK, DETAYLI ve ANLAŞILIR ifadeler kullanmaya dikkat etmelisin.

1. Arkadaşının plastik kullanımıyla ilgili sunduğu gerekçeleri nasıl değerlendirirsin? Açıklayınız.

2. Seninkinden farklı olarak arkadaşının açıklamasında sunduğu gerekçeler/durumlar nelerdir? Açıklayınız.

3. Arkadaşının bu açıklamalarına göre gelecekte kararını değiştirebileceğini düşünüyor musun? Nedenini açıklayınız.

4. Kararını değiştirdiysen, arkadaşına plastik kullanımıyla ilgili verdiğin kararı değiştirdiğini nasıl açıklarsın? Gerekçelerinizi yazınız. (Kararını değiştirmediysen bu soruya nokta koyup geçebilirsin.)

5. Kararını değiştirmediysen, arkadaşına plastik kullanımıyla ilgili senin kararının doğru olduğunu açıklamak için ne cevap verirsin? Gerekçelerinizi yazınız. (Kararını değiştirdiysen bu soruya nokta koyup geçebilirsin.)

6. Plastik kullanımı hakkında karar vermene ve hatta kararını değiştirmene yardımcı olabilmesi için bilmek isteyebileceğin başka bir şey var mı? Açıklayınız.

7. Senin ve arkadaşının plastik kullanımı hakkında aynı verilere bakmanıza rağmen farklı sonuçlara ulaşmanızı nasıl açıklayabilirsin?