REPUBLIC OF TURKEY

YILDIZ TECHNICAL UNIVERSITY

GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

INVESTIGATION OF THE MIDDLE SCHOOL STUDENTS' METAPHORIC PERCEPTIONS AND MENTAL MODELS ABOUT SOCIOSCIENTIFIC ISSUES

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MASTER OF SCIENCE THESIS

Department of Mathematics and Science Education

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A thesis submitted by Ebru ERTUĞRUL in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE is approved by the committee on 07.07.2021 in Department of Mathematics and Science Education, Science Education Program.

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Ebru ERTUĞRUL

Dedicated to my family

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Ebru ERTUĞRUL

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LIST OF ABBREVIATIONS

AAAS	The American Association for the Advancement of Science
GMO	Genetically Modified Food
MONE	Ministry of National Education
NRC	The National Research Council
SSI	Socioscientific Issue
STS	Science - Technology - Society
STSE	Science - Technology – Society - Environment

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ABSTRACT

Investigation of the Middle School Students' Metaphoric Perceptions and Mental Models about Socioscientific Issues

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Department of Mathematics and Science Education
Master of Science Thesis

Advisor: Prof. Dr. Mustafa Sami TOPÇU

In this study, it was aimed to determine the metaphoric perceptions and mental models of middle school students (6th, 7th, and 8th grades) on various socioscientific issues (GMO, Nuclear Energy, Organ Donation). In the research, phenomenology design was used within the scope of qualitative research method. The study group of the research consists of 180 middle school students (6th, 7th, and 8th grades) studying in a public school in the Şehitkamil district of Gaziantep in the 2019-2020 academic year. In the research, a form consisting of 4 open-ended questions prepared separately for each socioscientific issue (SSI) was used as a data collection tool. According to the data obtained, metaphors and mental models were examined, calculated as frequency (f) and percentage (%), and classified into conceptual categories. While metaphors are classified as structural, ontological and directional according to their characteristics, mental models are classified as structural, synthesis and primitive. It was determined that while most of the students had negative perceptions about GMO and Nuclear Energy, they had positive perceptions about Organ Donation and the students had some insufficient information and misconceptions about these issues. In addition, it has been observed that the media, school, and social environment are very effective

in obtaining information about SSI. It was observed that the mental models and metaphors that students formed on GMO and Nuclear Energy were more diverse than Organ Donation. In order to increase the awareness of students about SSI and to eliminate existing misconceptions, it has been suggested to include more SSI in the curriculum, to focus on the teaching of SSI in the education of pre-service teachers, and to apply different methods and techniques in the lessons in order to arouse students' curiosity about SSI.

Keywords: Genetically modified organisms (GMO), mental model, metaphor, nuclear energy, organ donation

ÖZET

Ortaokul Öğrencilerinin Sosyobilimsel Konularla İlgili Metaforik Algılarının ve Zihinsel Modellerinin İncelenmesi

Ebru ERTUĞRUL

Matematik ve Fen Bilimleri Eğitimi Anabilim Dalı

Yüksek Lisans Tezi

Danışman: Prof. Dr. Mustafa Sami TOPÇU

Bu araştırmada, ortaokul öğrencilerinin (6.,7., ve 8. sınıf) çeşitli sosyobilimsel konulara (GDO, Nükleer Enerji, Organ Bağışı) ilişkin var olan metaforik algılarının ve zihinsel modellerinin belirlenmesi amaçlanmıştır. Araştırmada nitel araştırma yöntemi kapsamında fenomenoloji deseni kullanılmıştır. Araştırmanın çalışma grubu 2019-2020 eğitim-öğretim yılında Gaziantep ili Şehitkamil ilçesindeki bir devlet okulunda öğrenim gören 180 ortaokul (6.,7., ve 8.sınıf) öğrencisinden oluşmaktadır. Araştırmada her sosyobilimsel konuya (SBK) yönelik ayrı olarak hazırlanan ve 4 tane açık uçlu sorudan oluşan form veri toplama aracı olarak kullanılmıştır. Elde edilen metaforlar ve zihinsel modeller incelenerek veriler frekans (f) ve yüzdelik (%) olarak hesaplanmış, kavramsal kategorilere ve özelliklerine göre sınıflandırılarak tablo haline getirilmiştir. Metaforlar özelliklerine göre yapısal, ontolojik ve yönsel metaforlar olarak sınıflandırılırken, zihinsel modeller ise yapısal, sentez ve ilkel modeller olarak sınıflandırılmıştır. Araştırmanın sonuçlarına göre; ortaokul öğrencilerinin büyük bir kısmının GDO uygulamalarına ve Nükleer Enerjinin kullanımına ilişkin olumsuz algılara

sahipken Organ Bağışına ilişkin olumlu algılara sahip oldukları ve öğrencilerin sosyobilimsel konularla ilgili yetersiz bilgilere ve bazı kavram yanılgılarına sahip oldukları elde edilmiştir. Medya, okul ve sosyal çevrenin öğrencilerin sosyobilimsel konularla ilgili bilgi edinmeleri ve etkilenmeleri konusunda oldukça etkili olduğu belirlenmiştir. Öğrencilerin GDO ve Nükleer Enerji konusunda oluşturdukları zihinsel modelleri ve metaforları daha çeşitli iken Organ Bağışı konusunda geliştirdikleri zihinsel modellerin ve metaforların çeşitliliğinin daha az olduğu tespit edilmiştir. Öğrencilerin sosyobilimsel konularla ilgili bilgi seviyelerini arttırmak ve var olan kavram yanılgılarını gidermek için müfredatta sosyobilimsel konulara daha fazla yer verilmesi, öğretmen adaylarının eğitiminde eğitim fakültelerinin sosyobilimsel konuların öğretimine ilişkin ağırlık verilmesi ve öğretmenlerin öğrencilerde sosyobilimsel konulara merak uyandırmak ve araştırma yapmalarını sağlamak için derslerde farklı yöntem ve teknikler uygulanması önerilmiştir.

Anahtar Kelimeler: Genetiği değiştirilmiş organizmalar (GDO), metafor, nükleer enerji, organ bağışı, zihinsel model

1
INTRODUCTION

1.1 Literature Review

1.1.1 Socioscientific Issues

The rapid change taking place in the scientific and technological fields has revealed many effects in the social life (Topçu, 2015). In the process from the past to the present, there has always been a mutual relationship between the fields of science and the societies affected by science. While scientific developments are shaped according to the needs of societies, and societies are rapidly affected by scientific developments (Sadler & Zeidler, 2004). In other words, it can be said that science is inseparable from the society from which it comes out in all aspects, and therefore science and society cannot be unrelated. These developments have caused some dilemmas and discussions in society. As a result of this complex interaction and relationship, a new field has emerged under the name of socioscientific issues (SSI) which is concerning science and society (Sadler, 2004; Topçu, 2015).

1.1.1.1 Characteristics of Socioscientific Issues

SSI are defined as being generally controversial, having no clear answer, requiring individuals to make decisions while concerning both science and society, and including moral and ethical concerns (Sadler, 2004). SSI requires discussion, but the decision-making process is not easy since it necessitates thinking from different perspectives such as ethical, moral, scientific, social, political, economic, and environmental (Sadler, 2011). It can be said that SSIs are multi-faceted and should be evaluated from different perspectives. There is complexity and some inevitable ethical issues inherent in SSI. Therefore, there are opinions about SSI rather than the truths and scientific opinions accepted by everyone. Individuals form their opinion on the subject by adding their own moral views along with scientific evidence. Some individuals prioritize scientific evidence; others prioritize ethical values. Therefore, individual ideas can be quite diverse and different from each other.

Nuclear energy, global warming, genetically modified organisms (GMO), genetic testing, gene therapy, stem cell, cloning, vaccine, genetic engineering practices, and industrial activities are some of the SSIs that create controversy in the national and international arena.

Evren and Kaptan (2014) explain that in order to deal with socioscientific issues in the science teaching process, it is necessary to evaluate whether the selected topics meet certain criteria. A researcher, teacher, or pre-service teacher should decide whether the content of the subject contains an SSI context. When they are deciding, they should ask the following questions to themselves.

- ✓ Does the subject have scientific content?
- ✓ Does it have a dilemma?
- ✓ Does it include Science-Society-Technology interaction?
- ✓ Is it open-ended and not the only correct answer?
- ✓ Can the answer change be depending on the ethical, moral, and emotional values of the people? (Evren & Kaptan, 2014)

Figure 1.1 shows the holistic SEE-SEP model covering six subject fields of SSIs: sociology / culture (S), environment (E), economics (E), science (S), ethics / morality (E) and politics (P) is linked to three aspects of value, personal experiences and knowledge. The purpose of using the acronym SEE-SEP is to make people aware of the multidimensional characteristics of SSIs and to develop a more holistic perspective on SSIs.

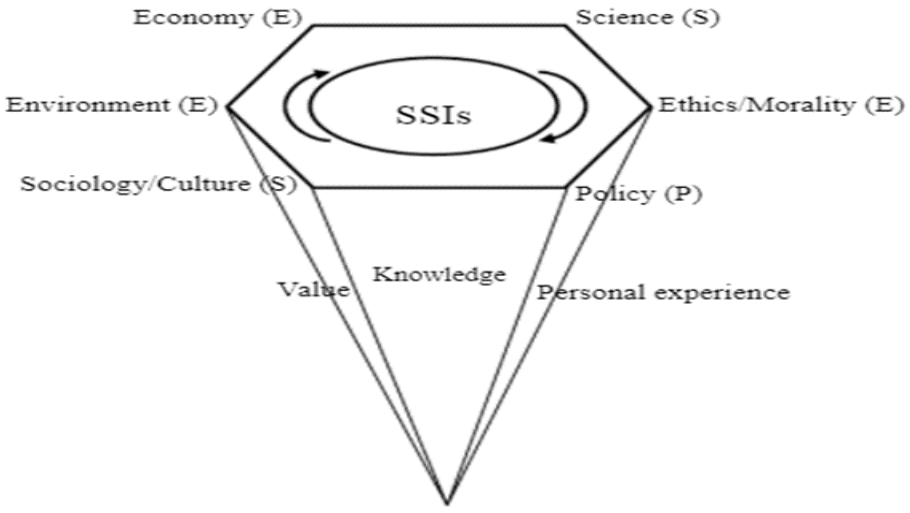

Figure 1.1 SEE- SEP Model of SSI (Chang-Rundgren & Rundgren, 2010, p.10)

SSI may change according to the values of the society in which they are located, but there are also SSI that concern the whole world. In addition to SSI that is of international nature and concerning all people, there are also SSI that concern only the communities of a country or a region. From a general perspective, SSI can be classified nationally, globally, and locally according to its content and effects.

1.1.1.2 Importance of Socioscientific Issues

Researchers focus on two basic approaches to the use of SSI. The first one is the approach in which SSI is accepted as the purpose for the development of individuals' knowledge, self-efficacy, perceptions, and opinions. Another approach is the use of SSI as a tool for the development of scientific argument and reasoning skills of individuals (Zeidler & Sadler, 2008; Klosterman & Sadler, 2010). Sadler and Zeidler (2004) advocated the view of recognizing all aspects of the subject on SSI, the stages of producing solutions, and the evaluation skills are among the complementary components of science literacy. Therefore, they emphasized the importance of including SSI in the curriculum for education levels and many levels of science education (middle school, high school, and university). As a result of this education, it is aimed for individuals to use these skills in order to get to know themselves and their environment, and to tend to be more sensitive to the events and problems occurring in their environment by gaining different perspectives (Sadler & Zeidler, 2004). SSI increases students' ability to learn scientific concepts and daily life problems (Klosterman & Sadler, 2010). These ideas have enabled SSI to be included in the science course in our country as well as all over the world. Controversial topics such as GMO, stem cell studies, genetic studies, cloning, and global warming are included in science education programs in many countries in order to increase students' awareness of SSI (Oulton, Dillon, and Grace, 2004). This intended awareness will also serve to make students a citizen who can fulfill the requirements of the global community (Dawson, 2011).

It is seen that countries generally continue their efforts to improve their education programs and sometimes apply radical changes in science curricula, to train individuals who will meet the development and needs of the 21st century (Ünal,

Coştu & Karataş, 2004). SSI is the social aspect of science courses therefore they are among the important issues to be addressed in science education in order to raise a conscious and responsible individual (Kolsto, 2001). The effective use of socioscientific issues in science education can enable the training of individuals who will help bring society to a modern and democratic level. Integrating SSI into science education and programs contributes to the achievement of these goals.

1.1.1.3 History of Socioscientific Issues

The first involvement of SSI in the science curriculum took place in the United States and England. The American Association for the Advancement of Science (AAAS) and the National Research Council (NRC), known for their worldwide importance, emphasized the significance of SSI in science education and suggested that SSI should be included in the science education curriculum. It has been stated that it is important for students to participate voluntarily in the decision-making process in scientific and social events in daily life, and that teaching SSI is an important goal for science literacy (AAAS, 1990; NRC, 1996).

Having looked at the historical development of SSI reveals that science education researchers focused on the Science-Technology-Society (STS) approach in the 1970s and 1980s. Aikenhead (1992) defined STS teaching as a student-centered, socially structured approach that focuses on traditional knowledge, skills, and concepts but integrates field knowledge into social and technological contexts. STS education aims to develop social responsibility awareness among students through the effects of science on technological developments and social structure (Yang & Anderson, 2003). The STS approach has revealed that learning science in the context of technology and society will make more sense for students. While the STS approach focuses on the effects of decisions in science and technology on society, some problems have arisen regarding the STS approach not drawing attention to ethical issues, daily life, students' moral and character development (Sadler, 2004b; Zeidler, Sadler, Simmons & Howes, 2005).

The criticisms made to STS led to the emergence of a more comprehensive approach called science-technology-society-environment (STSE) and in the 1990s, the STSE approach was adopted. This approach is a more advanced version of the

STS approach, the environmental dimension has been added and it deals with science in a more social, cultural, and more political context. In this approach, developments in science and technology are in a deep relationship with society and the environment (Zeidler & Keefer, 2003). Although the STSE approach is a more developed approach than the STS approach while drawing attention to ethical dilemmas and debates, it was still thought to be insufficient to explain the pedagogical aspect of the students' ethical and moral developments, debates, arguments, and the nature of science (Zeidler et al., 2005).

The shortcomings resulting from both approaches (STS and STSE) have led to the emergence of SSI with pedagogically strong foundations that make the relationship between science-technology-society more meaningful in students' daily lives. Although the emergence of the concept of SSI in the literature in the 1980s, its use as an education concept started in the 2000s (Zeidler et al., 2005). In the 2000s, the scope of the science literacy concept was expanded by determining the gains required to make decisions on controversial issues with the education of SSI, which was formed by adding ethical issues and the nature of science to the STSE approach. (Topçu, Yılmaz-Tüzün & Sadler, 2010). Solomon (1993) explained the characteristics of the education of SSI as follows:

- Understanding the effects of environmental threats at local and global level on quality of life
- Being aware of the economic and industrial dimensions of technology
- To be aware that scientific knowledge is changeable
- Knowing that discussing personal ideas and value judgments is a democratic action
- Knowing that it has a multicultural dimension

1.1.1.4 Socioscientific Issues in Turkey's Science Education

Increased interest in the SSI in Turkey and to carry out work in this area has been realized in subsequent years compared to other countries. SSI in our country was indirectly included in the STSE item in the curriculum published in 2006 for the first time, as scientific subjects with social content (MONE, 2006). After that, it is

seen that the Primary Science Education Program, which was developed in 2013, was directly included in the form of the expression of SSI. SSI was included in the "Science-Technology-Society-Environment" dimension, and their aims and importance were mentioned. It is also stated that the environment, social structure, and technological developments affect the decision-making processes of students on SSI. In the 2013 science course curriculum, SSI was directly included among the 12-item main objectives, and they were stated as "improves thinking habits by using SSI" (MONE, 2013, p. 11). In the Science Curriculum published in 2018, the expression of SSI is included in the 9th item of the curriculum as "to develop reasoning ability, scientific thinking habits and decision-making skills using SSI" (MONE, 2018, p. 9). In the renewed science curriculum, in the context of 21st-century skills, scientific process and life skills, as well as innovative and entrepreneurial thinking skills were also highlighted. In general, Turkey's renewed science education programs examined, it is seen that the program was revised according to social needs in line with raising conscious and science-literate individuals. The main purpose of science education since 2005, according to constructivist learning theory being applied in Turkey, is to help students gain more skills instead of giving scientific knowledge (MONE, 2018). Therefore, decision-making in SSI is listed as a life skill. With the ability to make decisions on socioscientific issues, students are expected to be educated as conscious citizens who combine newly acquired knowledge with past knowledge, investigate whether the information is true or false, able to reason and question, and have a critical point of view.

1.1.2 Models

The concept of the model refers to the product created as a result of certain processes; however, modeling is a scientific study that includes all steps used in these procedures (Gilbert & Justi, 2002). In other words, modeling is all the processes to express a phenomenon, event, situation, object clearly; the model is a product that has been revealed by modeling processes (Güneş, Gülçiçek & Bağcı, 2004b). Models are a phenomenon that we encounter in every aspect of our lives. Models have become a part of our lives in defining an object, solving problems,

making sense, and explaining events, making analogies, embodying abstract assets, and in many areas. They are a simplified representation, picture, scheme, or representation of complex objects or a process (Harrison, 2001).

The most important feature of the models is that they form the core of scientific thinking and are an important element of scientific studies (Kılıçoğlu, 2019; Özcan, 2005). In other words, models play an important role in the process of revealing scientific information. Scientists use models and the modeling process to understand and predict how an event occurs, how a system behaves, or how a process is developing (Günbatar & Sarı, 2005). Scientists use models in formulating assumptions to be measured and explaining scientific events, concepts, and processes when doing scientific research (Cerit-Berber & Güzel, 2009). Model building allows students to build scientific arguments by providing justified data to explain claims about a situation and the location of situations (Maia & Justi, 2009). Models have an important place in the advancement of science, in the development of information existing in individuals and in revealing new information (Günbatar & Sarı, 2005).

The model develops in a certain process as a result of modeling knowledge that is already present in individuals' minds. The model-building process takes place in three stages. These stages are:

• Determining the properties between the model and the objective,

• Determining the relationships and development between the components in a system,

• An idea is to be guessed by simplified representations (Gilbert & Justi, 2002).

The model is a very broad concept; therefore, it contains many features. Models can be considered as an important communication tool that enables and facilitates understanding of each other better. Models can change or the existing model can be developed with some new additions and subtractions. The models used in teaching help the students to acquire the information they do not learn and know (Taber, 2001). In other words, individuals with learning difficulties can be taught an abstract concept with model and modeling studies.

In science teaching, abstract concepts can be difficult to make accessible and understandable for students. The use of models in science education for such problems is a different solution method for difficult concepts to learn. In recent years, models and modeling have become a basic need in daily life, technology, and science education applications (Kaiser, 2010). It is inevitable to realize the importance of models and modeling in science teaching and learning.

When model definitions in the literature are examined, it is observed that the classification of the models is done in different ways by researchers who have different perspectives. Classifying models allows us to highlight the differences between models. The most frequently encountered and adopted classification in the literature was made by Harrison and Treagust (2000). In this classification, models are scrutinized in different groups as scaling models, pedagogical analogical models, symbolic models, mathematical models, theoretical models, map-diagrams tables, concept process models, simulations, and mental models.

In science education, there are diverse classifications made about the models. Örnek (2008) classified models into two groups as mental (internal) and conceptual (external). Conceptual models are defined as an external representation that makes it easier to teach situations in the world or the relationships of systems (Greca & Moreira, 2000). Mental models are internal representations of real and imaginary situations and express students' personal knowledge, yet the conceptual models refer to scientifically accepted knowledge (Norman, 1983).

1.1.2.1 Mental Models

Mental models are internal presentations formed as a result of perceptions in the minds of individuals and these presentations are special products that individuals create during their cognitive development (Harrison & Treagust, 1996). Mental models are individuals' thoughts, personal ideas, or internal representations about situations and concepts (Gilbert, Boulter & Rutherford 1988). According to Vosniadou (1994), mental models are cognitive structures created as an example of reality to explain the reason for an event and to make suggestions on this event. That is, the main role of a mental model is to enable the person who created it to

explain and predict the physical system it represents. Students create mental models to describe the world around them and the events taking place in the world (Sözcü, 2015). Mental models make real-world complex events more understandable with the simplified image created in students' minds (Barnett, Barab & Hay, 2001).

Scientists (e.g., Harrison & Tregust, 2000; Norman, 1983; Ritchie, Tobin & Hook, 1997) argue that models are expressions of the human mind and mental representations. Mental models are structures that guide individuals in using their thoughts. Mental models are personal, internal, effective, and incomplete information of facts. Mental models are processes that develop and grow as new information is added, therefore experiences provide a variety of mental models (Gilbert, Boulter & Rutherford, 1988). To put it another way, mental models are constantly changing with individuals' daily lives, experiences, and new knowledge.

Mental models may not always be compatible with scientific knowledge and real situations because of the constantly renewable and changeable features of mental models. Mental models may be missing or different from the real structure or even the structure described during the lesson. Individuals' unique experiences and differences provide a diversity of mental models (Coll & Treagust, 2001).

Coll and Treagust (2003) studied mental models in two groups as physical mental models and conceptual mental models. Physical mental models, events related to physical properties; conceptual mental models are the formation of abstract concepts and models in our minds.

Mental models are specific to the observer, and it is a very difficult process to discover and reveal the mental models of individuals (Coll & Treagust, 2003). Many factors such as textbooks, teachers, classmates, experiences, daily life, and individual beliefs can be found in the formation of mental models that students have. Considering mental models as the reflection of the reality in students' minds, any visual data that students make about any subject or concept can be used as a good measurement tool. (Moseley, Desjean-Perrotta & Utley, 2010). Studies to determine mental models are generally focused on written explanation and

drawing, and qualitative analysis is used in studies. Drawings are used frequently to determine mental model (Ültay, Dönmez-Usta & Durmuş, 2017).

Coll & Treagust (2003) and Kurnaz (2011), based on their analysis of the relevant literature, stated that researchers highlight the following features of mental models:

- Mental models have no clearly defined boundaries and are variable structure.
- Mental models are often incomplete, which can include contradictory, incorrect and unnecessary concepts. For this reason, they are generally unscientific.
- Mental models are functional to guide the process of explanation or hypothesis, therefore it allows to predict the behaviour of the system.
- Mental models cannot be easily depicted because they are specific to individuals.
- Even if the mental model building process is specific to the individual, there is a consensus in subjective structuring processes due to social interaction.

1.1.2.2 Mental Models in Education

Revealing the mental models that exist in students helps the teaching activities to progress in a quality way and to process the information correctly. Mental models become permanent with new knowledge gained through experience. This continuity is limited by the individual's needs, interaction with the living environment, and perspective. This interaction also gives clues about the content, quality, and adequacy of the information acquired by the individual. In other words, mental models reveal at what level and how the individual learns information (Ünal & Ergin, 2006). If the mental models are examined in detail, it can be observed at what level of knowledge individuals have on a subject or how they construct and process the information (Kurnaz & Sağlam-Arslan, 2008; Kurnaz, 2011). Although mental models are so effective at the meaningful learning stage, if they are used in unfavorable situations and in ways that are not beneficial for people, they can cause differences of opinion and perception between the learner and the teacher. Individuals' deficiencies on the learned

subject or the information they have incorrectly acquired may stem from the environment in which the learning takes place (Kurnaz & Sağlam Arslan, 2009, 2010). According to Vosniadou and Brewer (1992), teachers can reveal how and how much the student learned the subject by using the mental models that students have on a subject they learned. Based on this situation, it is very important to evaluate mental models to examine to what extent the individual has learned the information, to check whether the information has reached the desired level and whether the information given is received in the desired way (İyibil & Saglam-Arslan, 2010).

1.1.2.3 Studies on Mental Models

This section includes studies that have been conducted through different approaches to examine mental models related to various socioscientific issues.

With a similar purpose to the present thesis study, Gerçek (2020) aimed to determine the cognitive structures and views of high school students about GMOs in their research. A qualitative research method was used in the research and the study group consisted of 205 students from different high schools selected by the purposeful sampling technique. The data were evaluated by content analysis. It was observed that the conceptual framework of GMOs was not fully formed for the participant students. When the drawings were examined, it was determined that most of the drawings were related to the health hazards of GMOs. Another study about GMOs, which is among the subjects of this study, was conducted by Ertaş-Karaaslan in 2017. Ertaş-Karaaslan (2017) examined the visual images of pre-service science teachers about GMOs in her thesis study and according to the results of the research, it was pointed out that most of the pre-service teachers had negative perceptions and some misconceptions about the concept of GMO.

One of the most recent studies on this subject in Turkey is a study by Öztürk and Yenilmez-Türkoğlu (2019) on examining the mental models of pre-service science teachers on various socioscientific issues. The study group of the research consists of 40 pre-service teachers who are 4th-grade students in a science teaching program at a state university. Various socio-scientific issues were presented to the

teacher candidates, they were asked how they envision these issues in their minds, and they were asked to draw the images in their minds on paper. The obtained data were evaluated through content analysis and this analysis was carried out by coding the repeated figures in the drawings and obtaining themes from the codes. Findings have shown that teacher candidates generally have alternative concepts and limited understanding of socio-scientific issues. In addition, while teacher candidates exhibited more detailed mental models in some socio-scientific subjects such as nuclear power plants, they did not exhibit clear mental models in other subjects such as sugar loading. This study is a good example for this study in terms of analyzing and categorizing mental models.

Using content analysis, which is the method used in this thesis, Kıvrak (2018) conducted a thesis examining the mental models of fourth-grade students about environmental pollution. The study group of the research consists of 110 fourth-grade students, representing different sociocultural environments and studying in two different primary schools. The results of the research show that the socio-cultural environment in which students are located can be an effective factor in shaping children's mental models related to environmental pollution. Since the study was conducted with students while examining the factors that shape students' mental models, it is an effective study for the field with a different perspective.

As an example of mental models that form a different socioscientific issue, Arık (2014) conducted a study to determine the mental models of 109 seventh-grade students studying in three different eco-schools in Istanbul related to the greenhouse effect. As a result of the research data, it was found that the students had five different mental models: the reasons and results of the greenhouse effect, the misconception - the ozone layer and the greenhouse effect, the misconception - the daily temperature difference, the scientific explanation of the greenhouse effect, the conceptual error - the greenhouse used for agricultural purposes. Another study on the greenhouse effect was conducted by Shepardson, Choi, Niyogi and Charusombat (2011), to determine the mental models of 225 seventh-grade students in 3 different schools in the USA. As a result of the research, 5 different mental models were obtained as a result of the inductive analysis of

students' drawings and explanations. Model 1) greenhouse effect for plants, Model 2) the effect of the ozone layer, which becomes thinner and thicker as a result of the effect of greenhouse gases, on the Earth's temperature, Model 3) greenhouse gases in the atmosphere, Model 4) the effect of greenhouse gases on solar rays in the warming the Earth's surface and Model 5) the effect of sunray being reflected back and forth between the Earth and greenhouse gases resulting in global warming.

Emli (2014) studied the subject of global warming, being a different socioscientific issue that has been on the agenda recently. They conducted the research to examine the mental models of 85 seventh-grade students regarding global warming. The data of the research were collected using the "Global Warming Questionnaire", which includes open-ended questions about global warming. As a result of the research findings, it was determined that the perceptions of students about global warming were associated with the concepts of drought and melting glaciers. Moreover, their knowledge level about global warming was insufficient and their mental models displayed a mixed appearance. The researcher determined that there is a perception in the minds of the students that global warming may cause an environmental disaster, and that the students perceive global warming as a life-threatening risk.

Considering the studies on mental models from a general point of view; Ültay, Dönmez-Usta and Durmuş (2017) conducted a study aiming to examine the national studies published on mental models in the field of education according to some criteria. As a research tool, content analysis was utilized in the study which includes 33 studies on mental models. The data were analyzed according to the purpose, subject, method, findings, and result variables of the study. It has been observed that the subjects mostly studied in "atom, universe, and chemistry". It was seen that they mostly used drawings as a data collection tool and a case study was carried out as a working pattern. With the inference from this study, it can be said that studies on mental models related to socioscientific issues have not been very common yet.

1.1.3 Metaphors

The word metaphor is a Greek word and is composed of the words "meta: beyond" and "pherin: carry". It is used to mean “telling one thing with another thing” (Lakoff & Johnson, 2015). While perceiving new concepts, the common aspects of the new concepts with the concepts that already exist in mind are often brought up. Another newly learned feature of a concept is often paired with features of other well-known situations or simulations are created in minds. That being the case; metaphors, as the explanation of abstruse concepts with the use of known concepts through analogy, are encountered in learning (Geçit & Gencer, 2011). Metaphors are some of the powerful mental and linguistic tools that organize and guide our ideas and thoughts. Metaphor is an understanding and way of thinking therefore it reflects our subconscious's view of events and facts. The large number of metaphor types is the biggest proof of how diverse personal perceptions are (Botha, 2009). Metaphors are also an important subject in which the creativity, experience, knowledge, and cultural values of individuals are utilized.

Metaphor is the process of understanding and perceiving a subject from the perspective of another subject and establishing a link between the complex concept and the previously existing knowledge in the mind (Uyan-Dur, 2016). According to Lakoff & Johnson (2005); through metaphors, the abstract concepts we experience in our lives are reconstructed with more meaningful, easy-to-understand, and concrete concepts that we will use in our lives. Metaphors are a tool that individuals use to express how they see objects, environment, life, and events using various analogies (Cerit,2008).

Metaphors are technically a tool consisting of several elements:

1. An abstract phenomenon (situation, case) that you want to explain or make sense of.

2. A (more) concrete fact that we will use in explaining this phenomenon and its verbal expression.

3. Special equivalences established between these two phenomena (Sezer, 2003).

Metaphors are not only metaphors but also fundamental mechanisms of thought (Cerit, 2006). Metaphor is the transfer of a situation or phenomenon that we want to explain as another story by using visual, auditory, and sensory representation systems in a different way. While people create metaphors, they also give clues about their own life and thinking processes. For this reason, metaphors are also used as data collection tools of scientific research (Büyükbayram, 2004).

1.1.3.1 The Functions of Metaphors

Metaphor facilitates learning and contributes to the rapid analysis of knowledge structures encountered for the first time as a powerful mental structuring and modeling system for individuals to understand and construct their own worlds (Arslan & Bayrakçı, 2006). Metaphor is formed by the attachment of one thing or opinion to something else that is impossible to happen, so that the two ways of thinking can be shifted. Metaphors enable the synthesis of ideas in the right brain by using sequential thinking possibilities ignored by the linear functions of the left brain (Heidorn, 2001). According to Elliot (1984), the most important rhetorical function of metaphor is to stimulate the imagination, awaken emotions and take action. The information presented through metaphors offers a deeper perspective and can tell us the view, perception, experience, and knowledge about the concept with a single concept (Şentürk, 2015).

Parable and figurative narratives are methods that people often use in explaining a situation in their daily lives, and this situation adds power to the narration. The subject is better understood when the event, situation, and entity are told by analogy with another concept that has a relationship and emphasizing certain features (Şişman, 2002). The functions of metaphor can be thought of as roles that transfer from one meaning system formed between concepts to another concept, which serve to see and understand the concepts, connect two unconnected phenomena, and lead from the well-known expression to the lesser-known expression (Alpaslan, 2007). According to Bourgeois and Pinder (1983), scientific knowledge cannot be considered separate from interpretation, attitudes, and evaluations. Approaches to knowledge and understanding in the mind of the human being have integrity. Therefore, metaphors do not only function in

revealing scientific knowledge about a concept but also do great things in revealing the perceptions left by these concepts in the mind. (Lakoff & Johnson, 1980a).

Metaphoric perception can be defined as individuals' expressing their affective thoughts about a concept, event, and phenomenon through metaphors. The concept of metaphoric perceptions is the verbal reflection of individuals' perceptions of their external worlds. Metaphoric perception helps people express some simulations they use in their daily lives and some events they cannot understand. Metaphorical perception is important in terms of clearly deducing the structures in the minds of students (Tamimi, 2005).

1.1.3.2 The Use of Metaphors in Education

Metaphor can be defined as a tool that makes learning easier, enables concretization of abstract concepts, allows to say what is meant to be expressed with fewer words, and helps to depict the picture formed in the mind (Yücel-Cengiz, 2016). Metaphors are a linguistic phenomenon and cognitive method used to express students' thoughts, to remember the learned facts, and to create a basis for new facts. In other saying, metaphors are part of our conceptual system, they affect our view of the world on events and facts (Lakoff & Johnson, 1980). Metaphors have been used as an educational tool from ancient times until today. When metaphor is handled in terms of education and training, it is defined as the process of deciding about the unknown characteristics of the other, based on the known characteristics of one, by comparing two phenomena (Ocak & Gündüz, 2006).

Instructional metaphors play an active role in linking a situation with a different situation as well as in solving many problems (Sanchez, Barreiro & Maojo, 2000). Metaphors simplify the teaching process by embodying abstract concepts and linking the known and unknown in the events (Derman, 2014). In addition to these, it can be said that metaphors are used for various purposes such as determining personal perceptions and concretizing abstract concepts (Ceylan, 2016). At the same time, it is seen that metaphors have a unifying role in thoughts

and feelings. In this way, metaphors can connect students' cognitive and affective domains during their teaching. Concretizing the concepts and establishing a relationship with the concepts that students know are deemed necessary and important to make learning more permanent (Akgün, Duruk & Tokur, 2017). Metaphors are structures used to explain a concept existing in the mind of the learner with another concept, to deepen and enrich its meaning. In other words, it is the students' explanation of the concepts of the subject using other concepts. Semerci (2007) expressed the metaphor as "the transfer of meaning from one object with perceptual similarity to another". Metaphors are auxiliary structures that enable the student to construct information and learn the subject or concept in a more concrete and simpler way. Metaphors are widely used in both science and social sciences. Metaphors in education are effective tools used to reveal correct information and to eliminate the confusion of concepts (Pratte, 1981). Metaphors can be used as a powerful "pedagogical tool" in revealing, understanding, and changing the mental images that students have about some phenomena during their education (Saban, 2008). Metaphors are important tools that can help develop and change what happens in the classroom, make sense of teachers' responsibilities and roles, and improve their teaching (Çelikten, 2006).

1.1.3.3 Studies on Metaphors

This section includes studies that have been made with different approaches to examine metaphors related to various socioscientific issues and utilized while conducting this research.

Gürbüzoğlu-Yalmancı (2016), in which high school students' perceptions of the concept of Genetically Modified Organisms (GMO) are examined, is included as a study suitable for the purpose of this thesis because the study group consists of students and the study includes the subject of GMOs. Phenomenology and art-based research methods were used in the research. The study group of the research consists of 203 high school students. The data of the research were obtained by qualitative data collection tools (drawing and metaphor). Content analysis technique was used for data analysis. As a result of the drawings and metaphors produced, the common perceptions of the students towards the

concept of GMO, the change of GMO, its effect on human health, and its harmful effect by appearing to be beneficial are discussed in conceptual categories. When these conceptual categories and other specified categories are examined, it can be said that the students have a negative opinion about GMOs. In addition, at the end of the study, it was determined that the students had some misconceptions about GMOs.

In a similar study, Kışoğlu and Keleş (2018) conducted a study aiming to determine the perceptions of pre-service science teachers about Genetically Modified Organisms (GMOs) through metaphors. The qualitative research method was used in the study, which consisted of 150 science teacher candidates as the study group of the research. It was seen that the reasons for the metaphors produced by the participants were grouped into four different categories. The findings showed that the higher the grade level, the less negative opinions about using GMO products. In addition, it has been determined that female students participating in the study have a more negative opinion about GMO products than male students. Another study on GMOs, Yapıcı and Ertaş-Karaaslan (2018), was conducted with the aim of evaluating pre-service science teachers' use of metaphors related to GMOs. In the research, the phenomenology method was used within the scope of the qualitative research model. According to the data obtained, it was determined that 150 valid metaphors were produced from 189 teacher candidates, and 39 of them were invalid. Most metaphors were found in the category of 'causing changes in appearance or structure', while the least number of metaphors were found in the 'beneficial effects' category. As a result of this research, it was determined that many pre-service teachers had some misconceptions as well as negative perceptions about the GMO concept.

In an overview of biotechnology applications, Akçay (2016) conducted a study aiming to determine the metaphorical perceptions of pre-service teachers in different branches towards the concept of biotechnology. In the study in which the phenomenology research design was used, a sample was created with 135 pre-service teachers from three different branches in accordance with the typical case sampling method. The data in the study were obtained by the questionnaire method. As a result of analyzing the data obtained from the questionnaire, which

consists of two parts, with content analysis, pre-service teachers produced 77 different metaphors and categories such as innovation, necessity, advantage, tool, and threat were created by editing the metaphors. As a result of the study, it was stated that almost all of the teacher candidates had positive perceptions about biotechnology. In addition, it is among the other results obtained in the study that the perceptions of the candidates for biotechnology do not show a significant difference according to the gender variable.

Related to Nuclear Energy, another socioscientific topic, which is included in this thesis, Turan (2017) conducted a study examining the metaphorical perceptions of pre-service teachers about Nuclear Power Plants. The research was evaluated according to the metaphor analysis method. The classroom teacher candidates produced 70 metaphors in total. Students who were supportive, against, or indecisive about the nuclear power plant explained their reasons metaphorically. It was observed that the students produced quite consistent thoughts while explaining their opinions. In addition, it was observed that male teacher candidates supported more nuclear energy than female teacher candidates. Another study on the concept of nuclear was conducted by Seyhan (2016) to determine the views of 6th, 7th, and 8th-grade students on the concept of nuclear through metaphors. For this purpose, there were 528 students in the study, which was conducted face-to-face at nine schools in Sinop, Mersin, and Ankara. The provinces where the study was conducted were determined randomly by using criterion sampling, which is one of the purposeful sampling methods. The data of the study conducted with the scanning method were analyzed with the content analysis approach. During the analysis, the answers were examined in three steps in order to examine the relationship between the subject and source of the metaphor, and the subject and source of the metaphor. According to the results of this study, it is seen that the perceptions of the participants included in the study about the nuclear concept are based on explosion, death, disaster, disaster, accident.

A sample study on organ donation, which is the last topic of this thesis, was conducted by Harman and Çökelez (2017) in the form of examining the perceptions of pre-service science teachers about organ donation through

metaphors. It was observed that pre-service science teachers developed different metaphors about organ donation. As a result of the research, it was seen that the science teacher candidates did not create a negative metaphor for organ donation. It was determined that all of the science teacher candidates had positive perceptions about organ donation. Another study on Organ Donation was conducted by Baker and Boland (2010) to determine the organ donation perceptions of university students. A questionnaire was prepared by 389 students to measure their knowledge about organ donations in general, their attitudes towards receiving and giving donations, and their intended behavior. The results showed that the students had mixed feelings about organ donation and their knowledge about the process was minimal.

In terms of examining the relationship between metaphors and mental models, Christidou and Koulaidis (1997) examined the relationship between the use of students' metaphors and mental models regarding the ozone layer and ozone depletion. The study is based on semi-structured, individual interviews with primary school Greek students. Analysis of the data pointed to the construction of a limited number of models regarding the role of the ozone layer and the depletion process. The expressions used by the students are divided into categories such as persons, substances, and objects (containers, partition surfaces, absorbent or reflective surfaces, or holes). The results of the two dimensions of the analysis were correlated. It has been found that there are correlations between the ontological basis of the metaphors and the particular models children use to understand and explain the role and consumption of the ozone layer. Therefore, metaphors can be used as educational tools to improve understanding in case of depletion of the ozone layer and layer.

1.2 Objective of the Thesis

The aim of this study is to examine the mental models and metaphorical perceptions of middle school students towards various SSI (Nuclear Energy, Genetically Modified Organisms (GMO), and Organ Donation). In addition, this study aims to determine the attitudes of students on socioscientific issues and the sources of information that they are influenced by when obtaining information.

For this purpose, the study questions that the researcher aims to put forward are presented below by the researcher.

1. What are the metaphoric perceptions of 6th, 7th and 8th grade students related to SSI?
    a. What are the metaphoric perceptions of 6th, 7th, and 8th grade students about GMO?
    b. What are the metaphoric perceptions of 6th, 7th, and 8th grade students about Nuclear Energy?
    c. What are the metaphoric perceptions of 6th, 7th, and 8th grade students about Organ Donation?
2. What are the mental models of 6th, 7th and 8th grade students related to SSI?
    a. What are the mental models of 6th, 7th, and 8th grade students about GMO?
    b. What are the mental models of 6th, 7th, and 8th grade students about Nuclear Energy?
    c. What are the mental models of 6th, 7th, and 8th grade students about Organ Donation?
3. What are the attitudes of the 6th, 7th, and 8th grade students towards socioscientific issues?
4. What are the sources of information that 6th, 7th and 8th grade students are affected by on socioscientific issues?

1.3 Hypothesis

In this thesis, a qualitative research approach has been applied, so no hypothesis has been established regarding the research questions. The significance of the study is explained in detail in the next step.

1.3.1 Importance of the Thesis

SSI are among the subjects that individuals in society generally encounter and are interested in as a component of the values that concern society, as well as having a major role in studies related to science education (Evren & Kaptan, 2014). The

importance of SSI has increased with the inclusion of SSI in the science program; therefore, it is necessary to examine research on SSI and evaluate the results. Although socioscientific issues are included in the curriculum, it is thought that the teaching of socioscientific issues has not yet reached the desired level. One of the first reasons for this situation is the lack of literature on teachers' design and practice of teaching socioscientific issues (Sadler, Friedrichsen, Graham, Foulk, Tang & Menon, 2015; Topçu, 2015). Given these shortcomings, more research on socioscientific issues is required for learning environments to be focused on socioscientific issues.

In the period after the development of the program, how much and how SSI issues are taught in schools is an issue that needs to be discussed and studied. When the literature is examined, it has been observed that the most studied subjects are determining the knowledge level of prospective teachers on socio-scientific issues while surveys are the most used data collection tool in studies (Özdemir & Çobanoğlu, 2008; Sönmez, 2011; Turan 2012, Baltacı, 2013; Cebesoy & Dönmez Şahin, 2013; Genç, 2016). Studies on the investigation of mental models and metaphorical perceptions on SSI are very rare (Uzunkol, 2012; Gürbüzoğlu Yalmancı, 2015; Seyhan, 2016; Harman & Çökelez, 2017; Turan, 2017; Akçay, 2017; Ertaş Karaaslan, 2017; Kışoğlu & Keleş, 2018; Yenilmez-Türkoğlu, 2019; Karakaş ,2019). This study differs from the other studies in that it is carried out with students and simultaneously examines metaphorical perceptions and mental models related to different socioscientific issues as a whole. During the learning and teaching process, students' awareness of their own mental models and metaphorical perceptions, editing, and modification of these models contributes to the construction and learning of new knowledge. In this context, the study is important in terms of revealing the results such as how SSI is perceived by students and how it is mentally animated. Determining how students express socioscientific issues, make sense of them, and describe them as imaginary constitutes the basis of the research. This study is considered important in terms of revealing the perceptions of students about various socioscientific issues and providing the opportunity to show the phenomena that they cannot express with words with drawings. In addition, students' prior knowledge and stereotypes

about SSI, as in the teaching of other subjects, can greatly affect effective learning (Hewson & Hewson, 1993). Students make sense of events and concepts according to themselves, and sometimes this may contradict scientific knowledge. In science lessons, instead of transferring stereotyped information to the student, the teacher is to structure the students' impressions about the events around them and ensure that they overlap with scientific information (Yağbasan & Gülçiçek, 2003). Therefore, it is thought that teachers who know students' mental models and perceptions on SSI that concern many disciplines will contribute to meaningful learning by organizing learning activities accordingly. In general, it is believed that the results obtained in this study will be useful in future research on socioscientific issues and in determining the methods and techniques to be applied in the teaching of socioscientific issues.

1.3.2 Limitations

-The study is limited to 6th, 7th, and 8th grade students studying at a public school located in the Şehitkamil district of Gaziantep in the 2019-2020 academic year.

-The information and answers given by the students are limited to the data collection tool.

- The study is limited to GMO, Nuclear Energy, and Organ Donation in terms of the inclusiveness of socioscientific issues.

1.3.3 Assumptions

It was assumed that the students participating in the research were volunteers, expressed their opinions sincerely and the results of the study were transferable.

2
FRAMEWORK

2.1 The Framework of the Research

The framework is the plan that guides the researcher for a research (Grant & Osanloo, 2014). The framework relates to concepts and refers to empirical research and important theories used to promote and systematize the knowledge adopted by the researcher (Peshkin, 1993). Moreover, the theoretical framework is linked to the research problem being studied as the focus of the research. Therefore, it guides a researcher's research design and data analysis plan selection (Lester, 2005).

2.1.1 Characteristic Features of Socioscientific Issues

It has been suggested that socioscientific teaching and learning is an effective approach to support meaningful learning in schools. The main purpose of this study is to examine the mental models and metaphorical perceptions of 6th, 7th, and 8th grade students towards various SSI for effective SSI teaching and learning. At this point, Ratcliffe & Grace's (2003) definition and explanation of SSI guided this study in selecting the topics to be presented to the students and examining the suitability of the subjects in a socioscientific context.

Ratcliffe & Grace (2003), by conducting a study on SSI, emphasized the multidimensional structure of SSI and explained the distinctive features of SSI as follows:

- are usually one of the issues we face in the media.
- are current issues in our daily life.
- have scientific foundations and limitations.
- considering sustainable development
- include the process of generating new ideas, analyzing and decision making individually and socially.

- dealing with the cause of contradictory scientific evidence and unfinished knowledge.
- can also have global, local, and national dimensions with their social and political dimensions.
- require ethical and moral reasoning (Ratcliffe & Grace, 2003; Topçu, 2015).

Considering the characteristics of the socioscientific issues given above, Nuclear Energy, Genetically Modified Organisms and Organ Donation topics were selected in this study, and a study about mental model and metaphorical perceptions was formed on these topics.

2.1.2 Classification of Mental Models

Mental models are formed by the interpretation of the individual's prior knowledge about a subject and the scientific information learned during the teaching process (Harrison & Treagust, 2000). From this perspective, mental models are the synthesis of prior knowledge and the teaching process (Franco & Colinvaux, 2000). Mental models found in students can be examined under three categories. Vosniadou and Brewer (1992) grouped mental models in 3 categories in their study on mental models. These are primitive models, synthesis models, and scientific models.

-Primitive models are non-scientific, social life models based on assumptions and experiences of students. Primitive model is the situation where student knowledge does not overlap with scientific knowledge.

-Synthesis models are formed as a result of students' assimilation of the information they learned at school with experiential experiences and cultural values. Synthesis model is the situation in which student information partially overlaps with scientific knowledge and partially does not overlap.

-Scientific models are mental representations of the individual that overlap with scientific knowledge (school knowledge).

In this study, while analyzing the mental models of students using the classification developed by Vosniadou and Brewer (1992), they were classified as primitive, synthesis and scientific.

2.1.3 Conceptual Metaphor Theory (Contemporary Metaphor Theory) by Lakoff & Johnson (1980)

The most widely accepted definition of metaphor is the definition introduced by Lakoff & Johnson (1980), who developed the Contemporary Metaphor Theory. For Lakoff & Johnson (1980), metaphor is primarily the way one thing is envisioned through another. Lakoff & Johnson (1980) stated that metaphor is a tool for understanding the targeting experience based on a familiar person in the source field and that it is widely used not only in language but also in thought and action in daily life. In this study, the determination, analysis, and classification of metaphors were made according to this theory.

The most used contemporary theory in the definition of metaphor in recent years is the conceptual metaphor theory developed by Lakoff and Johnson. This theory was introduced by George Lakoff & Mark Johnson in the book "Metaphors we live by" (1980). The theory goes back a long way and is based on centuries of scientific work that took metaphor not only as an ornamental tool in language, but also as a conceptual tool for structuring, reconstructing, and creating reality. Lakoff & Johnson (2005) list the key ideas of Metaphor Theory as follows.

- Metaphors are basically conceptual; metaphorical language is secondary.
- Concept metaphors are based on daily experience.
- Abstract thinking is largely metaphorical, if not entirely.
- Metaphoric thinking is inevitable, always present, and often unconscious.
- Our concept system is not entirely consistent because the metaphors used to reason about concepts can be inconsistent.
- We live our lives on the basis of inferences provided through metaphor

Lakoff & Johnson (1980) basically divided the metaphors into three parts: conceptual, direction, and ontological metaphors.

Conceptual Metaphors

Conceptual metaphors are expressed by Lakoff & Johnson (1980) as the highest number of groups. The purpose of such metaphors is to put the concept to be explained in a certain structure by using another concept. In this respect, these metaphors are broader and more complex than other types of metaphors. In this type of conceptual metaphor, complex and abstract experiences are conceptualized based on their simple and specific experiences. Conceptual metaphors are used in situations where one concept is structured metaphorically relative to another.

Direction Metaphors

In the concept of direction metaphor, there is a whole system in which one concept does not construct another concept but is complemented by each other. Most of these are referred to as direction metaphors as they relate to spatial orientations such as up-down, in-out, fore-back, open-closed, deep-shallow, mid-periphery. Direction metaphors give a concept spatial orientation and are not random. It has its foundations in our physical and cultural experience. Although polar opposites are physical in nature, such as up-down, inside-out, direction metaphors based on them can vary from culture to culture. In summary, direction metaphors are the figurative expression of knowledge or situations in language, depending on the dominant beliefs of a culture. Depending on the different cultures from each other, the metaphors produced also differ.

Ontological Metaphors

Ontological metaphors are metaphors of existence or matter. In this type of metaphor, something that is in the abstract state that is intended to be described in such metaphors is seen as an entity or matter. A figurative comparison is made with an abstract object. Ontological metaphors are quite natural and persuasive and are often regarded as direct descriptions of mental events. Ontological metaphors are among the most basic devices for understanding experiences. The experiences people have with physical objects form the basis of an enormous variety of ontological metaphors, ways of looking at events, activities, and emotions. The experiences people have with physical objects form the basis of an

enormous variety of ontological metaphors, ways of looking at events, activities, and emotions. Ontological metaphors serve a variety of purposes. For example, the increasing in prices metaphorically causes the concept of "inflation" to be seen as an asset. In such cases, ontological metaphors can make us see inflation as an entity, refer to it, quantify it, define a particular aspect, see it as a cause, act on it, and perhaps even believe that we understand it.

3
METHODOLOGY

3.1 Method of the Research

Taking the aims of the research, research questions, and theoretical frameworks into account, the qualitative research method was preferred in the study. Qualitative research is defined as the study in which a process is followed to reveal perceptions and events in a realistic and holistic way in a natural environment (Yıldırım & Şimşek, 2011). In the research, the subject was approached with a holistic perspective by determining, classifying, and comparing students' mental models and metaphorical perceptions about socioscientific issues.

The phenomenology model, which is a qualitative research method, was used in this study. To elaborate on this particular model, it can be said that facts can emerge in different ways in the world we live in; such as events, experiences, perceptions, orientations, concepts, and situations. Phenomenology constitutes a suitable research ground for studies that aim to investigate phenomena that are not completely alien to us as an idea, but also that we do not fully understand (Yıldırım & Şimşek, 2008). In studies carried out with phenomenological design, the cognitive structures existing in their minds are tried to be conceived by examining the comments of the research participants about the facts they have personally experienced. The purpose of phenomenological studies is to examine personal ideas, experiences, and perceptions about concepts and phenomena at common points (Creswell, 2014). Phenomenology aims to reveal perceptions on a specific phenomenon and to classify these perceptions according to conceptual categories (Marton, 1986). The phenomenology model focuses on concepts that we are aware of but do not have a detailed and in-depth perception of. The phenomenological method was preferred because the study allowed the students to evaluate their current approaches to various socioscientific issues, examine their mental models and their metaphoric perceptions, and describe the meaning given to the concepts. In this study, according to the answers given by the

students, the situations affecting students' learning about socioscientific issues and their approaches to these issues were examined, and some common results were tried to be determined and compared.

3.2. Research Group

The study was carried out with a total of 180 6,7 and 8th-grade students studying at a middle school affiliated to the Ministry of National Education in the district of Şehitkamil in Gaziantep province. Purposeful sampling technique, one of the sampling techniques, was used in this study. In purposeful sampling, the researcher determines the sample group in accordance with the purpose of the research and by considering the criteria he/she has determined (Marshall & Rossman, 2014). In purposeful sampling, in addition to saving time, the sampling has a high degree of universal representation, as they include the relevant participants in the research (Creswell, 2014). There was an elaboration on the notion that the numbers of students taken from grade levels are equal. While choosing the participants, it was taken into account that the students had taken the Science Applications course together with the Science course in order to have ideas about the subjects. Therefore, 6th, 7th, and 8th-grade students were included in the study because they took Science and Science Applications course and had ideas about socioscientific issues. For this purpose, the annual plans of the courses that the students take were also taken into consideration. 5th-grade students were not included in the study because they did not have full knowledge of the subjects in the study. Besides, it would affect the research results. Within the framework of the research ethics, it was made sure that the names of the students would be kept hidden in terms of providing confidentiality, moreover, student codes were created by giving numbers to each student. Information on the grade levels and numbers of the participants can be seen in Table 3.1.

Table 3.1 Grade levels and numbers of participants

Grade Level	Number of Students Applied	Student Codes
6th Grade	60	A1,A2,……..A59,A60
7th Grade	60	B1,B2……B59,B60
8th Grade	60	C1,C2……C59,C60
Total	**180**	**180**

3.3 Data Collection Tool

In order to determine students' mental models and metaphorical perceptions on Nuclear Energy, Genetically Modified Organisms (GMO), and Organ Donation issues, a total of three data collection tools consisting of the same type of questions for each subject were prepared. Draft questions to be included in the data collection tool were prepared by the researcher and the elicitation of expert opinion was provided. The questions in the draft form were sent to two instructors working in the field of science education for expert opinion. Furthermore, the data collection tool was finalized by making the necessary arrangements in the draft form in line with the expert opinions. With the thought of not limiting the students' mental models and metaphorical perceptions, it was decided not to provide information about the subjects and not include examples from daily life in the data collection form. The data collection form consists of four questions:

1. Question: *What are your thoughts on Genetically Modified Organisms (GMO) / Nuclear Energy / Organ Donation? Write all your ideas below.*

This question was asked to determine the students' approach to the given subjects.

2. Question: *When the word Genetically Modified Organism (GMO)/Nuclear Energy/Organ Donation is mentioned, you are asked to fill in the blank by making an analogy with anything that comes to mind, and to write the reason for making this analogy with the word of "because". Complete the following sentence.*

- Genetically Modified Organisms (GMO) / Nuclear Energy / Organ Donation as ……. Because ……..

This question was asked to determine the students' metaphorical perceptions and it was provided to establish a connection between the subject and the source of the metaphor with the phrase "…..... similar." while this situation was being asked to be justified with the conjunction "because".

3.Question: *If you were to describe Genetically Modified Organisms (GMO)/ Nuclear Energy / Organ Donation with a drawing, what kind of picture would you draw? (You can use explanatory words and sentences in your drawings.)*

This question was asked to determine students' mental models. Interviews will be held with students whose drawings are incomprehensible.

4. Question: *Where or from what sources did you get the information you have about Genetically Modified Organisms (GMO)/ Nuclear Energy/ Organ Donation?*

This question was asked to give clues about how students' prior knowledge, approaches, mental models, and metaphorical perceptions were formed.

3.4 Data Collection Process

The data subject to the study were collected in a middle school affiliated with the Ministry of National Education in the district of Şehitkamil in Gaziantep province in the 2019-2020 academic year. The implementations were carried out by the researcher after the necessary legal permissions were obtained from the relevant provincial national education directorates of the Ministry of National Education. Before the applications were carried out, the students were informed about the purpose of the research, how to answer the data collection tool, volunteering, and confidentiality. All students participated in the research voluntarily. The students were asked to sincerely answer the questions in the data collection form in one lesson hour (40 minutes). Since there are three data collection forms and with the application of one data collection form every week, the data collection process took 3 weeks. No intervention was made to the students during the application.

3.5 Data Analysis

In this study, a content analysis technique was used for data analysis. Cohen, Manion, and Morrison (2002) defined content analysis as organizing scientific data according to a certain criterion, classifying them according to their characteristics, comparing their differences, and drawing theoretical conclusions. The main purpose of content analysis is to perform a systematic analysis of the collected data. Text, images, and sounds can be included in content analysis (Flick, Kardorff, & Steinke, 2004). In this study, students' sentences and drawings were analyzed. The idea behind the content analysis is to gather data around themes and concepts that can be explained, and to interpret by organizing them in a way that the reader can understand (Yıldırım & Şimşek 2005). Themes or categories must represent the data collected, be objective and distinctive.

In this study, while analyzing the content, the 5-stage evaluation process used by Sezgin, Koşar, Koşar and Er (2016), which is cascaded by Creswell (2014) as a method in his book, was taken into consideration. These are respectively;

1. Naming and Elimination Stage,

2. Classification Stage,

3. Category Development Stage,

4. Validity and Reliability Step,

5. Data Editing Phase for Quantitative Data Analysis

Within the framework of these steps, the data were subjected to content analysis and the analysis processes performed are presented below.

Stage 1: Naming and elimination

At this stage, the forms of each student were coded and numbered according to their grade levels (A1, B1, C1 ……), the data collection forms filled in by the students were read one by one and entered on a Microsoft Office Excel worksheet. In addition to the metaphors and mental models created by the students regarding the concepts, the students' information along with their frequency values were also entered on a Microsoft Office Excel worksheet. Firstly, the metaphors created

by the participants were examined, followed by their mental models. The two sections were evaluated independently of each other, that is, if the participant filled in the section on metaphor and yet did not fill in the section on the mental model, the metaphorical perception was considered valid, and the mental model was deemed invalid. In this sense, the forms that are not corresponding to the purpose, such as the ones inconsistent with the subject and/or the description part, or the ones left blank were deemed invalid and eliminated. According to these criteria, 37 participants related to GMOs were deemed invalid because they could not create a purposeful metaphor, and as a result, 144 valid metaphors emerged. 39 participants' entries related to Nuclear Energy were deemed invalid because they could not create a purposeful metaphor, and as a result, 141 valid metaphors emerged. 43 participants' entries related to Organ Donation were deemed invalid because they could not create a purposeful metaphor, and as a result, 137 valid metaphors emerged. Drawings that were left blank in mental models or that could not fully explain the perception about the subject were deemed invalid. In this sense, 41 participants' entries related to GMO were deemed invalid because they could not create a purposeful mental model, and as a result, 139 valid mental models emerged. As 42 participants' entries could not create a purposeful mental model related to Nuclear Energy, it was deemed invalid, resulting in 138 valid mental models. 48 participants' entries about Organ Donation were deemed invalid because they could not create a purposeful mental model, and as a result, 132 valid mental models emerged.

Stage 2: Classification Stage

In the classification stage of the research, the connections were tried to be determined when the metaphor and mentality produced by the students were examined and interpreted in detail. These links are explained by similarity or difference. Metaphors and mental models are also grouped according to their similarities and differences. In addition, at this stage, metaphorical perceptions are classified as "conceptual", "direction", and "ontological". Mental models are classified as "scientific", "synthesis" and "primitive" models.

Stage 3: Category Development Stage

At this stage, metaphors and mental models were brought together in terms of their common features and gathered under different categories by using the connections determined after the classification stage. Considering the similar characteristics of the determined metaphors, 6 different categories related to GMO were obtained. These categories where metaphors are collected are as follows; "Effects on Health", "Change of Appearance", "Structural Changes", "Advantages", "Contain Both Beneficial and Harmful Properties", and "Uncertainty". On the other hand, 6 different categories related to Nuclear Energy were obtained. These categories where metaphors are collected are as follows; "Effects on Health", "Effects on the Environment", "Importance", "Take Measures", "Generation of Nuclear Energy", and "Nuclear Power Plant Descriptions". When it comes to Organ Donation, 8 different categories were obtained. These categories where metaphors are collected are as follows; "Opportunity to Start Over", "Life Saving", "Social Dimension", "Human Values", "Uneasiness", "Vital Importance", "Religious Dimensions", and "Emotions".

Considering the similar characteristics of the determined mental models, 4 different categories related to GMO were obtained. The categories where mental models are collected are as follows; "Change in Appearance", "Effects on the Quality", "Negative Effects on Health", and "The Effect on the Production Process". 5 different categories related to Nuclear Energy were obtained. These categories where mental models are collected are as follows; "Effects on Living Things", "Effects on The Environment", "Advantages", "Nuclear Power Plant", and "Nuclear Energy Generation". 4 different categories related to Organ Donation were obtained. These categories where mental models are collected are as follows; "Effects on People", "Organs", "Social Dimension", and "Hesitation".

Stage 4: Validity and Reliability Step

Ensuring the validity and reliability of any research is extremely important in terms of the suitability and accuracy of the collected data. Reporting the collected data in detail and explaining how the researcher reached the results are among the important criteria of validity in qualitative research (Yıldırım & Şimşek, 2008).

In order to increase reliability in qualitative research, each stage and the path followed in the study should be explained in detail (Karadeniz & Demirel, 2008). Firstly, a literature review on the subject was carried out and a form suitable for the purpose was created in order to substantiate the validity of this study. Validity and reliability were tried to be validated by asking for verbal explanations, having different types of questions, and drawing in the data collection tools. The cases investigated in the study were tried to be analyzed in a transparent and impartial way, thus increasing the validity. The data were reported in detail, and the results were evaluated profoundly. In the study, the validity of the research was ensured by giving place to direct quotations about the answers and drawings of the students. The results and conclusions have been repeatedly audited and reviewed to increase consistency in the explanations.

The intercoder reliability technique, which is another method to guarantee the reliability, was also used in the research. For this purpose, the metaphors and drawings of the participants were analyzed by two independent researchers to ensure inter-rater consistency. According to Miles and Huberman (1994), more reliable themes emerge when two or more expert researchers code the dataset separately. This formula is as follows:

Reliability = (Consensus * 100) / (Consensus + Disagreement)

For this reason, to verify the validity of the study, expert opinion was sought to confirm whether the metaphors and mental models specified under the conceptual categories obtained in the study represent the conceptual category in question. In the next process, the categories created by the researcher and the matches made by the expert were compared. In this comparison, the frequencies of consensus and disagreement were determined, and the reliability of the research was established. Reliability calculations were made for both metaphors and mental models related to GMO, Nuclear Energy, and Organ Donation in the study. In the analyzes made, the encoder reliability percentage was found to be above 90% for all cases. In qualitative studies, the desired level of reliability is provided when the agreement between expert and researcher evaluations is 90% or more (Saban, 2008). Two researchers extensively discussed both the coding and the codes

assigned to the participants on the unreconciled codes, and a consensus was reached.

Stage 5: Data Editing Phase for Quantitative Data Analysis

The categorization of metaphors and mental models, the validity and reliability of the analysis, the frequencies (f), and percentages (%) of the data obtained from metaphors and mental models were calculated.

4
FINDINGS

In this section, the results of each main and sub-research question of the study are presented in detail.

4.1 Findings on Metaphorical Perceptions about SSI

The first main research question of this study is: *"What are the metaphoric perceptions of 6th, 7th and 8th grade students related to SSI?".* In this section, the results obtained from the sentences made by the students regarding this research question and related sub-questions are presented. Metaphors and justifications of students on socioscientific issues were analyzed and their metaphorical perceptions on socioscientific issues were determined.

4.1.1 Findings on Metaphorical Perceptions about GMO

At this stage, the conceptual categories, frequencies, and percentages obtained from sentences reflecting students' metaphorical perceptions of GMO concept are given in Table 4.1. It is seen that a total of 93 types and 143 valid metaphors related to the concept of GMO have been developed by middle school students under six conceptual categories.

Table 4.1 Findings on metaphors about GMO

Conceptual category	Metaphors	The number of types of metaphors	f	%
Effects on Health	unhealthy (6), hormone (3), carcinogen (3), virus (3), chemical drug (2), illness (2), poison (2), smoke (2), cancer risk, microbe, unhealthy fruit, junk food, toxic substance, harmful, psychological problem, bacteria, threatening, bomb, bioaccumulation, toxin, global warming, insecticide, chemical product, medicated, sugar	24	41	28,67
Change of Appearance	hormone (5), food coloring (3), make up (3), fake (2), person having plastic surgery (2), change of state, trick, hormone fruit, converter, air pump, different shapes, hormonal food, dough, jigsaw puzzle, collage, metamorphosis, balloon, photocopy, overgrowth, inflated, new image	21	31	21,68
Structural Changes	gene transfer (7), mutation (4), artificial food (3), cheat (2), tasteless (2), Turkish (2), hormone, greenhouse, instant juice, toy, admixture, gene change, artificial, damaged product, genetic disorder	15	29	20,28
Advantages	rich nutrient content (2), efficient product, scientific purpose, impressive, vitamin, effective agriculture, beneficial, undamaged product, duplicate production, diversity, delicious, increasing nutritional value, biotechnology, technology, product range, regeneration, long lasting, useful food	18	19	13,29
Contain Both Beneficial and Harmful Properties	technology (4), human (3), drug (2), internet (2), both negative and positive, both useful and useless	6	13	9,09
Uncertainty	antibiotic (2), time bomb, question mark, gift pack, processed product, obscurity, dilemma, vaccine, unknown error	9	10	6,99
Total		**93**	**143**	**100**

-Metaphors in the 'Effects on Health' Category

Middle school students produced metaphors about the health effects of GMOs in this category. Students developed 24 types of metaphors for the "Effects on Health" category. The frequency of using metaphors in this category is 41. In other words, 41 (28,67%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Unhealthy (6)". Sample sentences of the students regarding this category are given below.

C11: GMO is like unhealthy because the drugs and hormones given to the food impair human health.

B52: GMO is like a chemical substance because it has negative effects on human health.

A45: GMO is like a virus because it makes people sick.

-Metaphors in the 'Change of Appearance' Category

Middle school students produced metaphors about the apparent changes of the GMO concept in this category. Students developed 31 types of metaphors for the "Change of Appearance" category. The frequency of using metaphors in this category is 31. In other words, 31 (21,68%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Hormone (5)". Sample sentences of the students regarding this category are given below.

A3: GMO is like hormone because it makes fruits and vegetables very large.

C33: GMO is like a person who has had plastic surgery because there is a lot of difference between food before GMO and after GMO.

B10: GMO is like food coloring because it changes the color of food.

-Metaphors in the 'Structural Changes' Category

Middle school students produced metaphors about the structural changes caused by GMOs in this category. Students developed 15 types of metaphors for the "Structural Changes" category. The frequency of using metaphors in this category is 29. In other words, 29 (20,28%) of the students produced metaphors in this

category. It is seen that the metaphor with the highest frequency value in this category is "Gene Transfer (6)". Sample sentences of the students regarding this category are given below.

C21: GMOs are like mutations because they play with the genetic structures of foods and a new genetic structure emerges.

C15: GMO is like gene transfer because desired traits are passed on to fruits and vegetables through gene transfer.

B23: GMO is like artificial because the natural structure of foods is destroyed by the processes.

-Metaphors in the 'Advantages' Category

Middle school students produced metaphors about the advantages of GMOs in this category. Students developed 18 types of metaphors for the "Advantages" category. The frequency of using metaphors in this category is 19. In other words, 19 (13,29%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Rich Nutrient Content (2) ". Sample sentences of the students regarding this category are given below.

C3: GMO is like a product with rich nutritional content, because it can transfer the properties and nutritional values we want to the food.

B50: GMO is like product variety because with GMO, many different types of the same product can be made.

-Metaphors in the 'Contain both Beneficial and Harmful Properties' Category

Middle school students produced metaphors about GMOs having both beneficial and harmful properties in this category. Students developed 6 types of metaphors for the "Contain Both Beneficial and Harmful Properties" category. The frequency of using metaphors in this category is 13. In other words, 13 (9,09%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Technology (4)". Sample sentences of the students regarding this category are given below.

A6: GMO is like technology because it has both beneficial and harmful properties.

B24: GMO is like human, it has both good and bad features.

-Metaphors in the 'Uncertainty' Category

Middle school students produced metaphors about the uncertainty and ambiguity of the effects of GMOs in this category. Students developed 9 types of metaphors for the "Uncertainty" category. The frequency of using metaphors in this category is 10. In other words, 10 (6,99%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Antibiotic(2) ". Sample sentences of the students regarding this category are given below.

C13: GMO is like an antibiotic because its effects are not fully known.

B36: GMO is like a time bomb because it can cause a big problem at any moment.

4.1.2 Findings on the Classification of Metaphors about GMO

In this section, metaphors developed by middle school students about GMO are classified as conceptual, ontological and direction according to their characteristics. Information about the classification, frequency and percentages of metaphors is given in Table 4.2.

Table 4.2 Findings on the classification of metaphors about GMO

Metaphor Category	f	%
Conceptual	133	93,01
Ontological	10	6,99
Direction	0	0
Total	**143**	**100**

When the metaphors created by middle school students about GMO were examined, 133 of the students (93,01%) produced conceptual metaphors and 10 of them (6,99%) produced ontological metaphors. No direction metaphor was found in the findings. Sample sentences of the students are given below.

A24: GMO is like a change of state because food is changed to another state with GMO. (Conceptual Metaphor)

C35: GMO is like human because food has lost its essence. (Ontological Metaphor)

4.1.3 Findings on Metaphorical Perceptions about Nuclear Energy

At this stage, the conceptual categories, frequencies, and percentages obtained from sentences reflecting students' metaphorical perceptions of Nuclear Energy concept are given in Table 4.3. It is seen that a total of 95 types and 141 valid metaphors related to the concept of Nuclear Energy have been developed by middle school students under six conceptual categories.

Table 4.3 Findings on metaphors about nuclear energy

Conceptual category	Metaphors	Number of Different Metaphors	f	%
Effects on Health	atomic bomb (5), dangerous (4), war (2), virus (2), detrimental (2), radiation, bomb, thief, cigarette, chemical matter, disaster, death, poison, cancer, chemical weapon, suicide, explosive, weapon, dangerous, earthquake , warfare, chemical.	23	33	23,40
Effects on the Environment	factory (5), smoke (3), chemical waste (2), CO2 (2), garbage (2), thermal power plants (2), natural disaster (2), fossil fuel (2), problem, murderer, dirty gas, stove, chemical matter, environmental pollution, gasoline, coal, environmentally harmful, smoke from factory chimney, nature destruction, exhaust	20	32	22,70
Importance	energy source (5), power (2), electric energy (2), money, highly efficient energy, saving, economic freedom, food, oxygen, basic need, source, producer, valuable, sun, beneficial, energy factory, requirement, water, energy drink, necessary, power source	22	27	19,15
Take Measures	mobile phone (3), medicine (3), knife (3), internet (2), non-renewable energy, slippery road, technology, enemy, risky, battery, experiment, fire, life, two-faced, ready to explode bomb	15	22	15,60
Generation of Nuclear Energy	atom (6), nuclear power plant (5), atomic fission (3), geothermal energy, atomic nucleus	5	16	11,35
Nuclear Power Plant Descriptions	cylinder (2), thermal power plant, tea glass , flue, saucepan, a big boiler, penny bank, vase, smoke boiler, bubbling cauldron	10	11	7,80
Total		**95**	**141**	**100**

-Metaphors in the 'Effects on Health' Category

Middle school students produced metaphors about the health effects of Nuclear Energy in this category. Students developed 23 types of metaphors for the "Effects on Health" category. The frequency of using metaphors in this category is 33. In other words, 33 (23,40%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Atomic Bomb (5), ". Sample sentences of the students regarding this category are given below.

C8: Nuclear Energy is like an atomic bomb because it is created by the splitting of the atom and harms people.

A57: Nuclear energy is like radiation because it poses a cancer risk to humans.

B39: Nuclear energy is a bomb ready to explode because you do not know when the bomb will explode and people are in danger.

-Metaphors in the 'Effects on The Environment Category'

Middle school students produced metaphors about the effects of Nuclear Energy on the environment in this category. Students developed 20 types of metaphors for the "Effects on the Environment" category. The frequency of using metaphors in this category is 32. In other words, 32 (22,70%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is " Factory (5) ". Sample sentences of the students regarding this category are given below.

A14: Nuclear energy is like a fossil fuel it causes air and environmental pollution.

B51: Nuclear Energy is like a factory, both pollute nature.

-Metaphors in the 'Importance' Category

Middle school students produced metaphors about the importance of Nuclear Energy in this category. Students developed 22 types of metaphors for the "Importance" category. The frequency of using metaphors in this category is 27. In other words, 27 (19,15%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is

"Energy Source (5)". Sample sentences of the students regarding this category are given below.

B9: Nuclear energy is like a source of energy because we get our energy from nuclear power plants.

C37: Nuclear energy is like power because nuclear energy makes us stronger economically.

-Metaphors in the 'Take Measures' Category

Middle school students produced metaphors about taking measures in the use of Nuclear Energy in this category. Students developed 15 types of metaphors for the "Take Measures" category. The frequency of using metaphors in this category is 22. In other words, 22 (15,60%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Mobile Phone (3)". Sample sentences of the students regarding this category are given below.

C29: Nuclear Energy is like cell phones, it was invented for good, but it is often used for bad things.

A39: Nuclear energy is like the internet and you need to be careful when using it.

-Metaphors in the 'Generation of Nuclear Energy' Category

Middle school students produced metaphors about Nuclear Energy Generation in this category. Students developed 5 types of metaphors for the "Generation of Nuclear Energy" category. The frequency of using metaphors in this category is 16. In other words, 16 (11,35%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Atom (6)". Sample sentences of the students regarding this category are given below.

C44: Nuclear Energy is like an atom because it is derived from the nucleus of the atom.

A1: Nuclear Energy is like a nuclear power plant because nuclear energy is produced there.

-Metaphors in the 'Nuclear Power Plant Descriptions' Category

Middle school students produced metaphors about Nuclear Power Plant in this category. Students developed 10 types of metaphors for the " Nuclear Power Plant Descriptions" category. The frequency of using metaphors in this category is 9. In other words, 11 (7,80%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "*Cylinder (2)* ". Sample sentences of the students regarding this category are given below.

B43: Nuclear energy is like a bubbling cauldron because steam also comes out of the nuclear power plant.

A35: Nuclear energy is like a vase because nuclear power plants are wide at the top and bottom and thin in the middle.

4.1.4 Findings on the Classification of Metaphors about Nuclear Energy

In this section, metaphors developed by middle school students about Nuclear Energy are classified as conceptual, intentional and ontological according to their characteristics. Information about the classification, frequency and percentages of metaphors is given in Table 4.4.

Table 4.4 Findings on the classification of metaphors about Nuclear Energy

Metaphor Category	f	%
Conceptual	134	95,04
Ontological	7	4,96
Direction	0	0
Total	**141**	**100**

When the metaphors created by middle school students about Nuclear Energy were examined, 134 of the students (95,04%) produced conceptual metaphors and 7 of them (4,96%) produced ontological metaphors. No direction metaphor was found in the findings. Sample sentences of the students are given below.

C54: Nuclear energy is like an earthquake because it causes deadly damage (Conceptual Metaphor).

B35: Nuclear energy is like a thief, it takes away people's health (Ontological Metaphor).

4.1.5 Findings on Metaphorical Perceptions about Organ Donation

At this stage, the conceptual categories, frequencies, and percentages obtained from sentences reflecting students' metaphoric perceptions of Organ Donation concept are given in Table 4.5. It is seen that a total of 79 types and 137 valid metaphors related to the concept of Organ Donation have been developed by middle school students under eight conceptual categories.

Table 4.5 Findings on metaphors about organ donation

Conceptual category	Metaphors	Number of Different Metaphors	f	%
Opportunity to Start Over	reborn (5), new life (4), luck (3), new beginning (2), second chance (2), source of hope (2), ray of hope (2), new year, light, regeneration, magic, battery, painter, compass, spring, change	16	29	21,17
Life Saving	medicine (3), forgiveness of life (3), life (2), treatment (2), important (2), give gifts (2), give life to a person (2), come back to life, present, recycling, miracle, gain, hold on to life, survive	14	23	16,79
Social Dimension	sharing life (3), helping out (2), social solidarity, civic duty, helpful, humanitarian mission, bridge, task, grant, solidarity, awareness, family, exemplary behavior, trust	14	17	12,40
Human Values	sacrifice (3), helpfulness (3), share (2), empathizing (2), to be conscientious, favor, do a kindness, volunteering, humanity, be merciful	10	16	11,68
Uneasiness	risky (7), harmful (2), excogitative, worrying, a hard decision, complex, hard	7	14	10,22
Vital Importance	oxygen (3), health (2), heart (2), spirit, water, breath, necessity, vital need, sun	9	13	9,49
Religious Dimensions	acquire merit (5), sin (3), disobeying God (2), disrupting order (2), objectionable	5	13	9,49
Emotions	hope (7), happiness (3), joy, compassion	4	12	8,76
Total		**79**	**137**	**100**

-Metaphors in the 'Opportunity to Start Over' Category

Middle school produced metaphors about organ donation giving people opportunity to start over. Students developed 16 types of metaphors for the

"Opportunity to Start Over" category. The frequency of using metaphors in this category is 29. In other words, 29 (21,17%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is " Reborn (5) ". Sample sentences of the students regarding this category are given below.

B4: Organ Donation is like being born again because people who donate organs start a new life.

A48: Organ donation is like luck because people are given a chance to live healthy.

-Metaphors in the 'Life Saving' Category

Middle school students produced metaphors about life saving in this category. Students developed 14 types of metaphors for the "Opportunity to Start Over" category. The frequency of using metaphors in this category is 23. In other words, 23 (16,79%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is " Medicine (3) " and "Forgiveness of Life (3)". Sample sentences of the students regarding this category are given below.

C55: Organ donation is like giving a gift because people are given a new life.

B19: Organ donation is like medicine because sick people recover and regain their health.

-Metaphors in the 'Social Dimension' Category

Students produced metaphors about the social dimension of organ donation. Students developed 14 types of metaphors for the "Social Dimension" category. The frequency of using metaphors in this category is 17. In other words, 17 (12,40%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Sharing Life (3)". Sample sentences of the students regarding this category are given below.

B11: Organ donation is like sharing life because sharing our organs means sharing our life.

C3: Organ donation is like social solidarity because it strengthens the bonds and relationships between people in society.

-Metaphors in the 'Human Values' Category

Middle school students produced metaphors about life human values in this category. Students developed 10 types of metaphors for the "Human Values" category. The frequency of using metaphors in this category is 16. In other words, 23 (11,68%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Sacrifice (3)" and "Helpfulness (3)". Sample sentences of the students regarding this category are given below.

C5: Organ donation is like sacrifice because organ donors give up their own organs for the lives of other people.

C44: Organ donation is like empathy because we have to put ourselves in the place of people who need organs and donate organs.

-Metaphors in the 'Uneasiness' Category

Students produced metaphors about organ donation involving uneasiness in this category. Students developed 7 types of metaphors for the "Uneasiness" category. The frequency of using metaphors in this category is 14. In other words, 14 (10,22%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Risky (7)". Sample sentences of the students regarding this category are given below.

B7: Organ donation is like risky because health problems may occur in the person donating the organ.

C11: Organ donation is like a hard decision because health and religious aspects should also be considered when making a decision.

-Metaphors in the 'Vital Importance' Category

Students produced metaphors about the vital importance of organ donation. Students developed 9 types of metaphors for the "Vital Importance" category. The frequency of using metaphors in this category is 13. In other words, 13 (9,49%)

of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Oxygen (3)". Sample sentences of the students regarding this category are given below.

A47: Organ Donation is like oxygen because it is necessary for people to live.

C53: Organ Donation is like health because it allows people to regain their health, which is the most important thing in this life.

-Metaphors in the 'Religious Dimensions' Category

Students produced metaphors about the religious dimensions of organ donation. Students developed 5 types of metaphors for the "Religious Dimensions" category. The frequency of using metaphors in this category is 13. In other words, 13 (9,49%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Acquire Merit (5)". Sample sentences of the students regarding this category are given below.

B53: Organ Donation is like doing good deeds because it is helping other people to make them happy.

C50: Organ donation is like disobedience to God because we disrupt the existing order.

-Metaphors in the 'Emotions' Category

Students produced metaphors about the emotions of organ donation. Students developed 4 types of metaphors for the "Emotions" category. The frequency of using metaphors in this category is 12. In other words, 12 (8,76%) of the students produced metaphors in this category. It is seen that the metaphor with the highest frequency value in this category is "Hope (7)". Sample sentences of the students regarding this category are given below.

C47: Organ donation is like hope because it expresses to the donor that nothing is over and everything has just begun.

B31: Organ donation is like happiness because it saves people from pain and bad conditions.

4.1.6 Findings on the Classification of Metaphors about Organ Donation

In this section, metaphors developed by middle school students about Organ Donation are classified as conceptual, ontological and direction according to their characteristics. Information about the classification, frequency and percentages of metaphors is given in Table 4.6.

Table 4.6 Findings on the classification of metaphors about organ donation

Metaphor Category	f	%
Conceptual	123	89,78
Ontological	12	8,76
Direction	2	1,46
Total	**137**	**100**

When the metaphors created by middle school students about Nuclear Energy were examined, 123 of the students (89,78%) produced conceptual metaphors and 12 of them (8.76%) produced ontological metaphors and 2 of them (1,46%) produced direction metaphors. Sample sentences of the students are given below.

B8: Organ donation is like a second chance because sick people regain their health and start a healthier life (Conceptual Metaphor).

C43: Organ donation is like a painter because people's lives are redrawn with organ donation (Ontological Metaphor).

B23: Organ donation is like a compass because it gives direction to people's lives (Direction Metaphor).

4.2 Findings on Mental Models about SSI

The second main research question of this study is: *What are the mental models of 6th, 7th, and 8th grade students regarding SSI?* In this part, results regarding this research question and related sub-questions are presented. Drawings and explanations in the data collection tool were used to determine students' mental models related to socioscientific issues.

4.2.1 Findings on Mental Models about GMO

At this stage, the conceptual categories obtained from the drawings that reflect the students' mental models for the GMO concept, their frequency and percentages are given in Table 4.7. It is seen that a total of 16 types and 139 valid mental models related to the GMO concept have been developed by middle school students under four conceptual categories.

Table 4.7 Findings on mental models about GMO

Conceptual category	Mental Models	The number of types of mental models	f	%
Change in Appearance	Larger fruit / vegetable / animal / Person (48) Different colored fruit / vegetable(9) Different shapes fruit / vegetable (7) Perfect looking fruit / vegetable (7) Rotten fruit / vegetable (4) Fruits / vegetables that are different inside and outside (4) Gene Transfer (2)	7	81	58,27
Effects on the Quality	Delicious fruit / vegetable (8) Vitamin Injected fruit / vegetable (6) Quality fruit / vegetable (5) Durable fruit / vegetable (3)	4	22	15,83
Negative Effects on Health	Disease (14) Allergy (4)	2	18	12,95
The Effect on the Production Process	High fruit / vegetable yield (10) Short growing fruit / vegetable (7) Cheap product (1)	3	18	12,95
Total		**16**	**139**	**100**

-Mental Models in the 'Change in Appearance' Category

Middle school students developed 7 types of mental models for the "Change in Appearance" category. The frequency of using mental models in this category is 81. In other words, 81 (58,27%) of the students produced mental models in this

category. In this category, the mental model with the highest frequency value is "Larger fruit / vegetable / animal (48)", while the mental model with the lowest frequency value is "Rotten fruit / vegetable (4)". Sample drawings of these findings are presented in Figure 4.1, 4.2, 4.3 and 4.4.

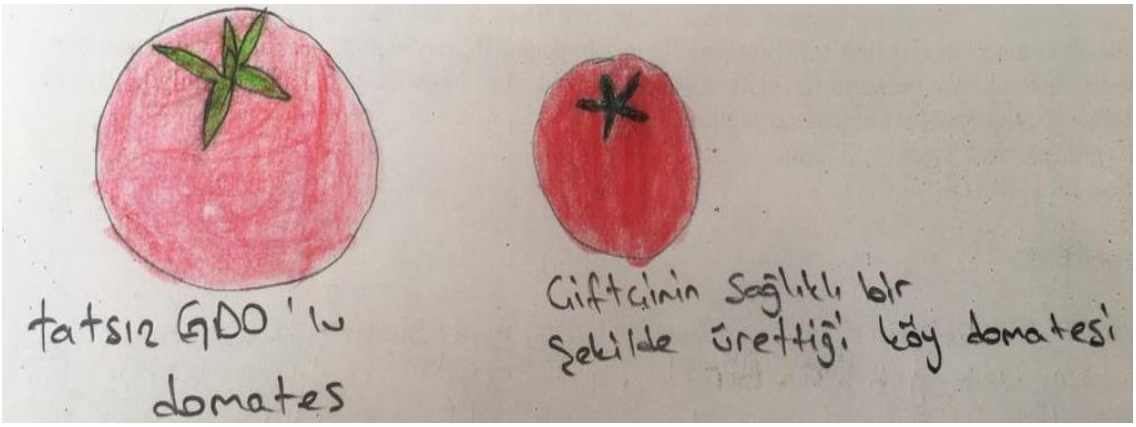

Figure 4. 1 Drawing of B13 coded student

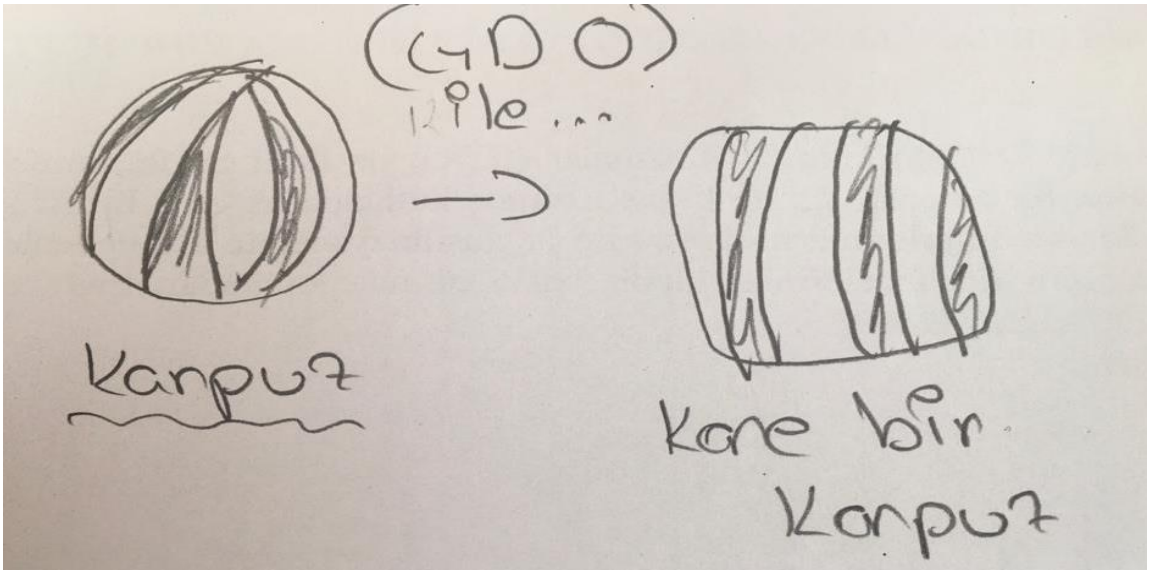

Figure 4. 2 Drawing A21 coded student

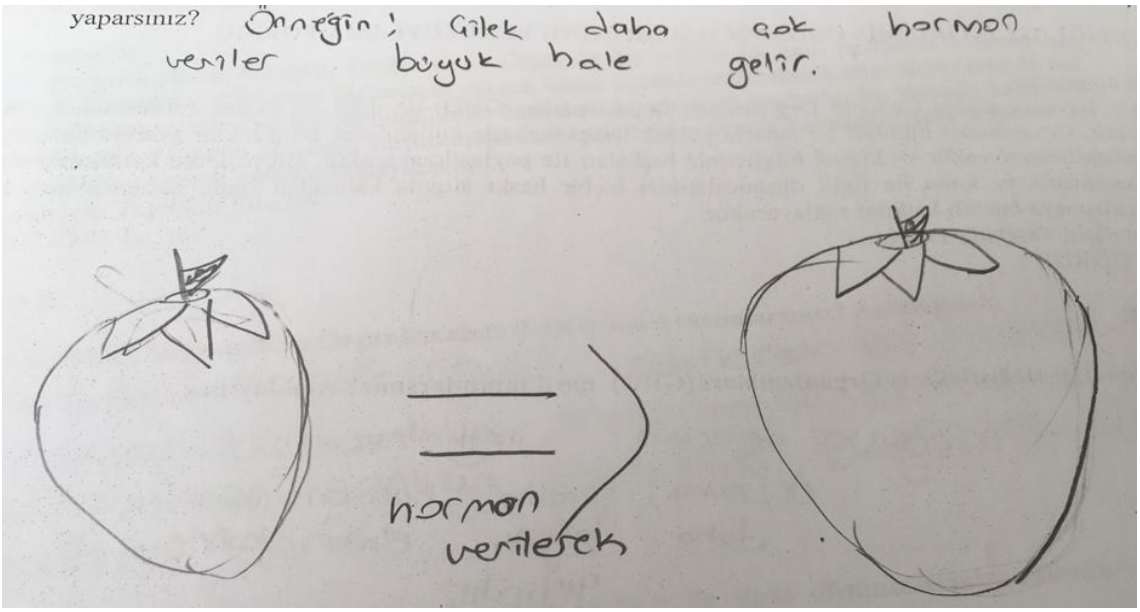

Figure 4.3 Drawing of C8 coded student

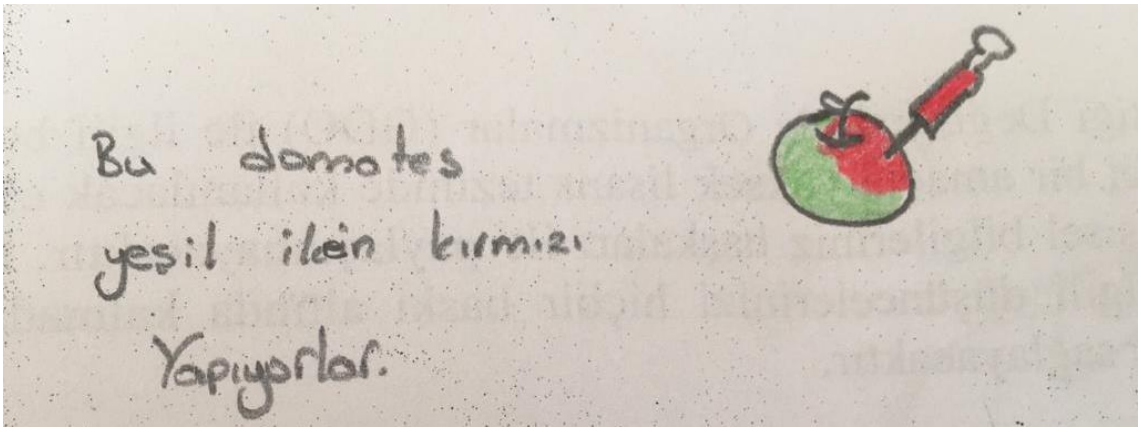

Figure 4.4 Drawing of A32 coded student

-Mental Models in the 'Effects on the Quality' Category

Middle school students developed 4 types of mental models for the "Effects on the Quality" category. The frequency of using mental models in this category is 22. In other words, 22 (15,83%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is " Delicious fruit / vegetable (8)", while the mental model with the lowest frequency value is " Durable fruit / vegetable (4)". Sample drawings of these findings are presented in Figure 4.5, 4.6, and 4.7

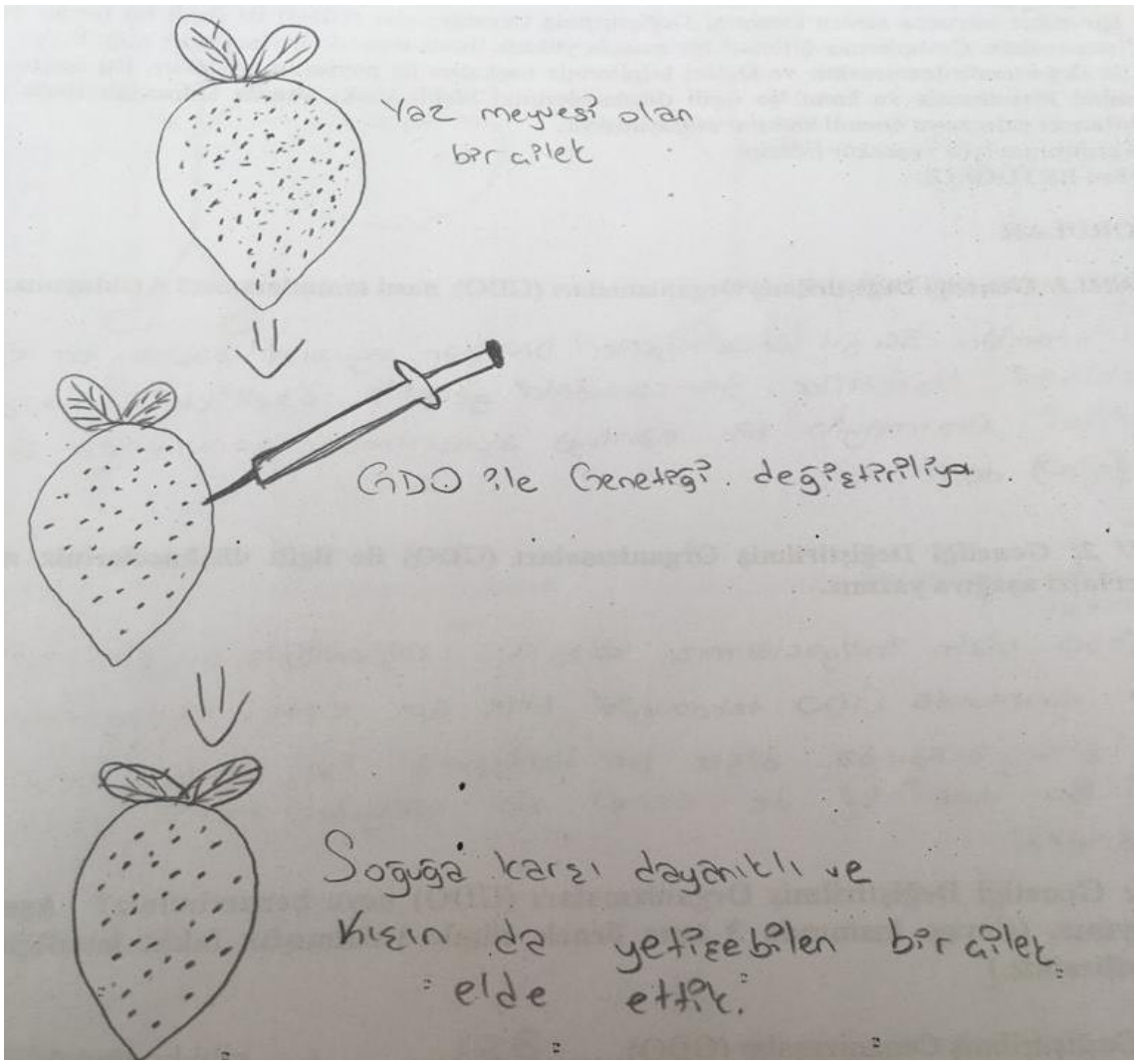

Figure 4.5 Drawing of C45 coded student

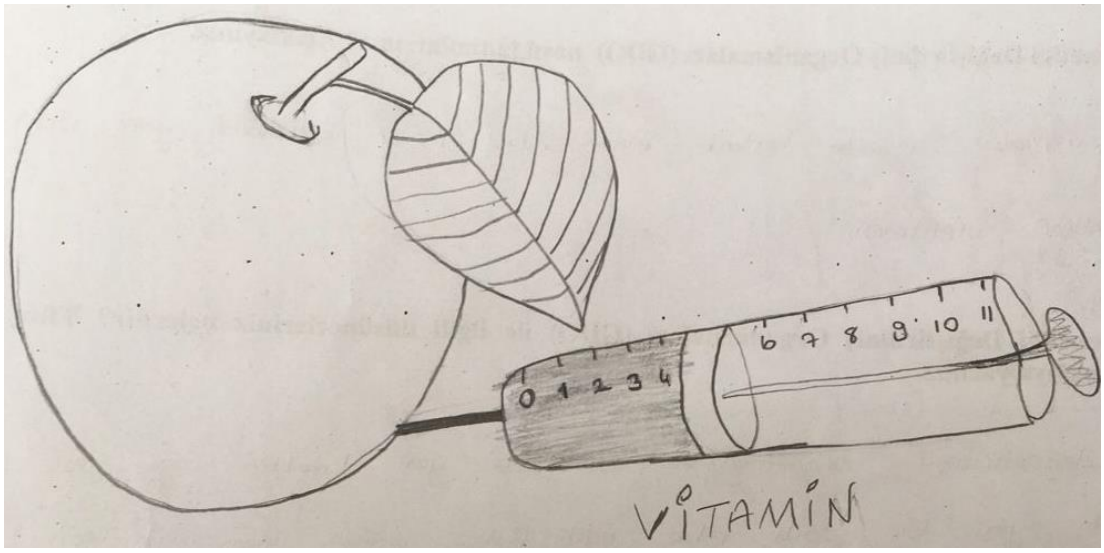

Figure 4.6 Drawing of B22 coded student

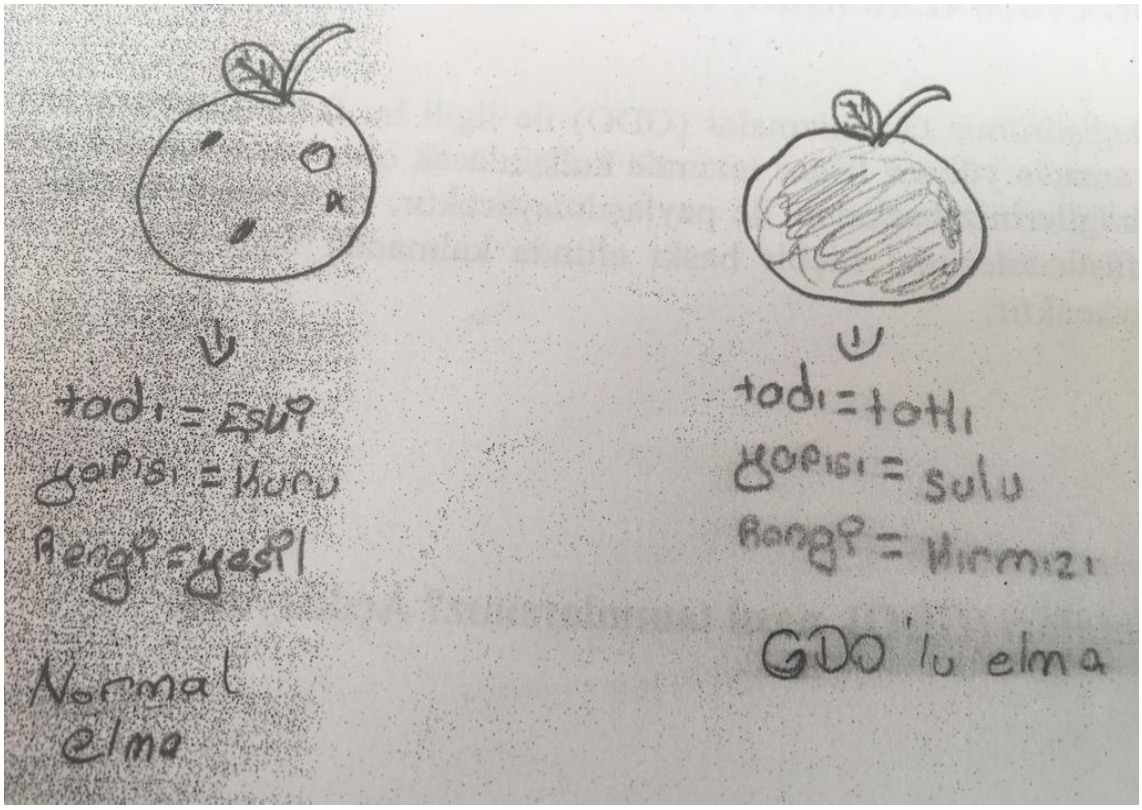

Figure 4.7 Drawing of A52 coded student

-Mental Models in the 'Negative Effects on Health' Category

Middle school students developed 2 types of mental models for the "Negative Effects on Health" category. The frequency of using mental models in this category is 18. In other words, 18 (12.95%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is " Disease (14) ", while the mental model with the lowest frequency value is " Allergy (4)". Sample drawings of these findings are presented in Figure 4.8 and Figure 4.9.

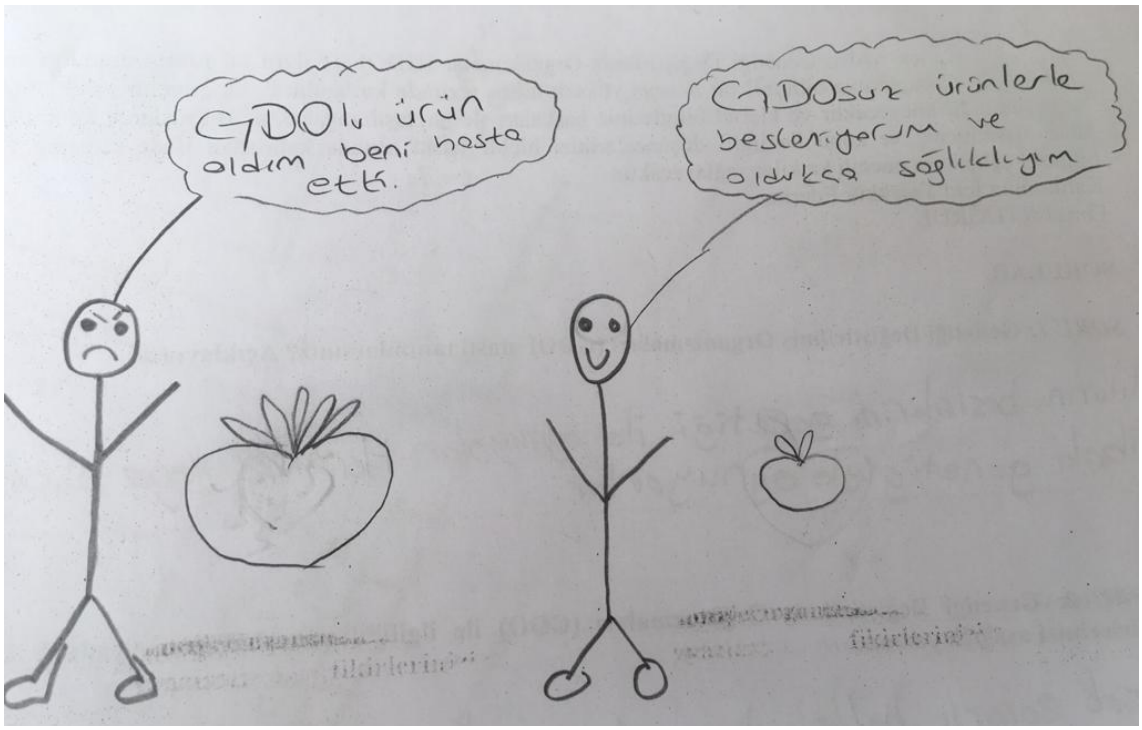

Figure 4.8 Drawing of B2 coded student

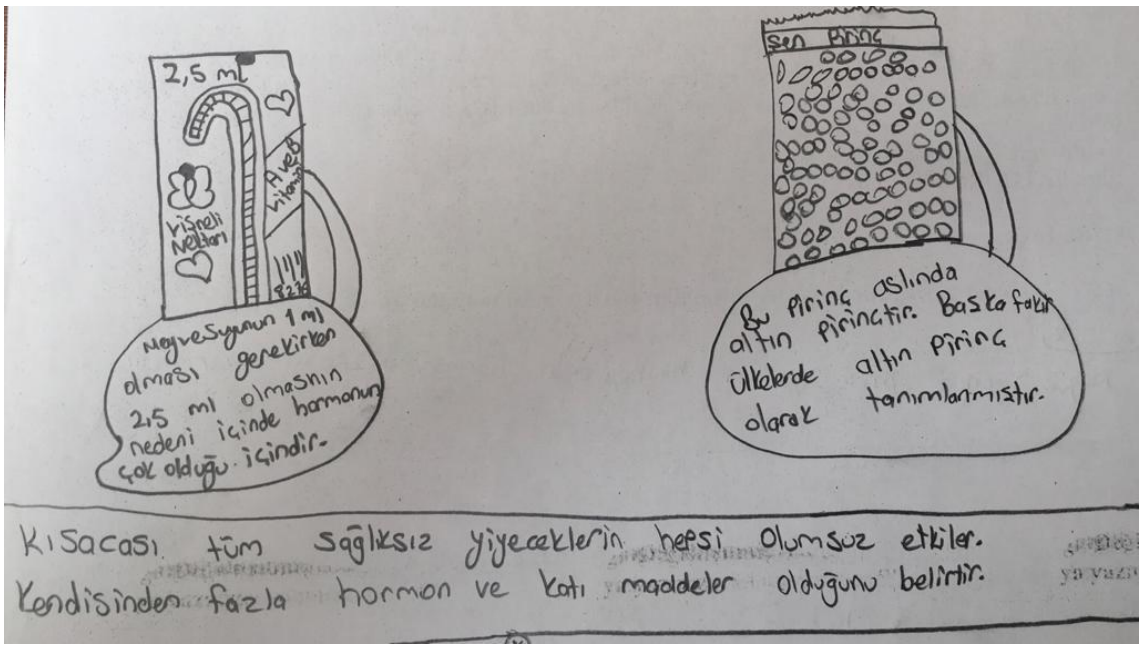

Figure 4.9 Drawing of A14 coded student

-Mental Models in the 'The effects on the production process' Category

Middle school students developed 3 types of mental models for the " The effects on the production process" category. The frequency of using mental models in this category is 18. In other words, 18 (12,95%) of the students produced mental models in this category. In this category, the mental model with the highest

frequency value is "High fruit / vegetable yield (10)", while the mental model with the lowest frequency value is " Cheap product (1)". Sample drawings of these findings are presented in Figure 4.10 and Figure 4.11.

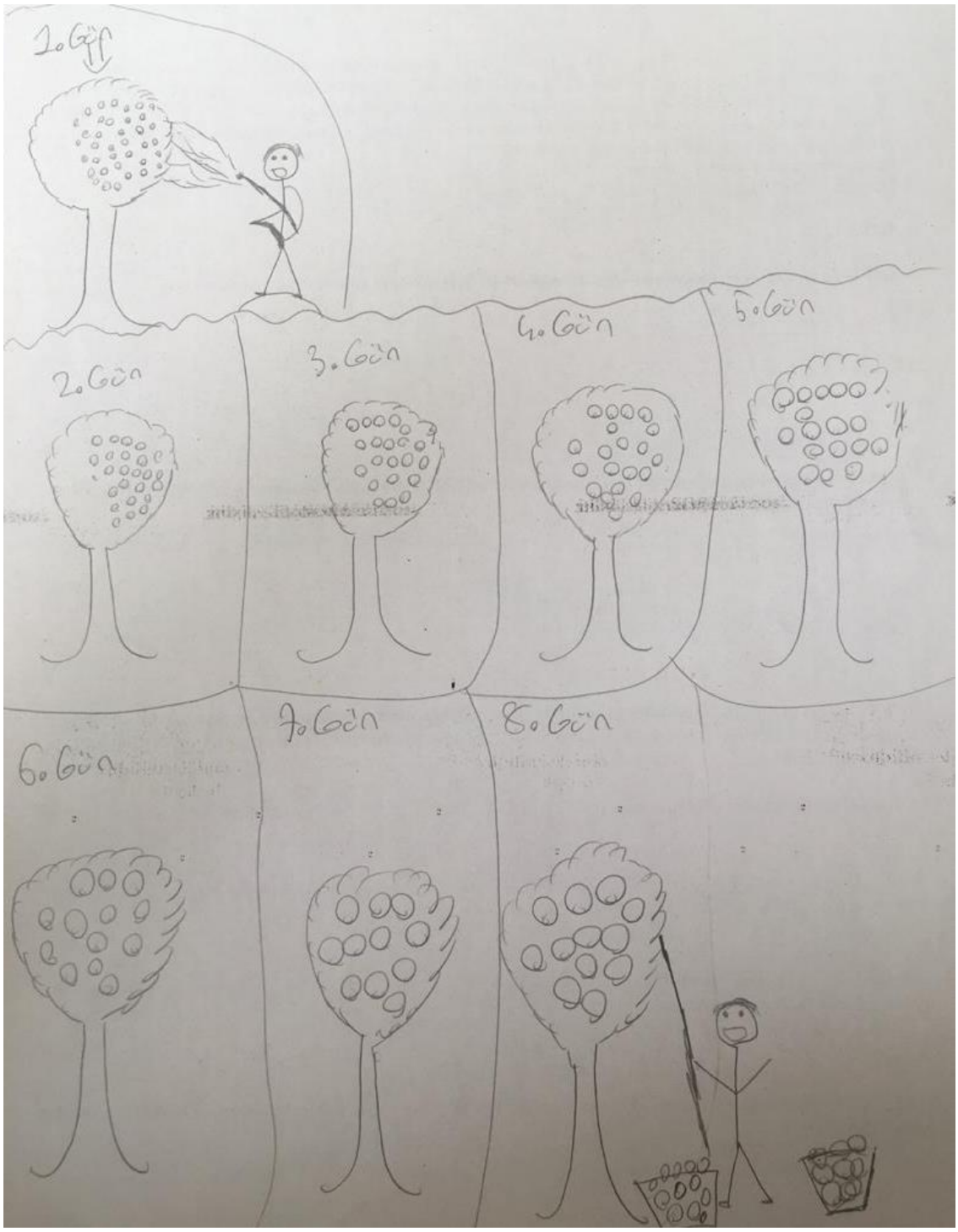

Figure 4.10 Drawing of A43 coded student

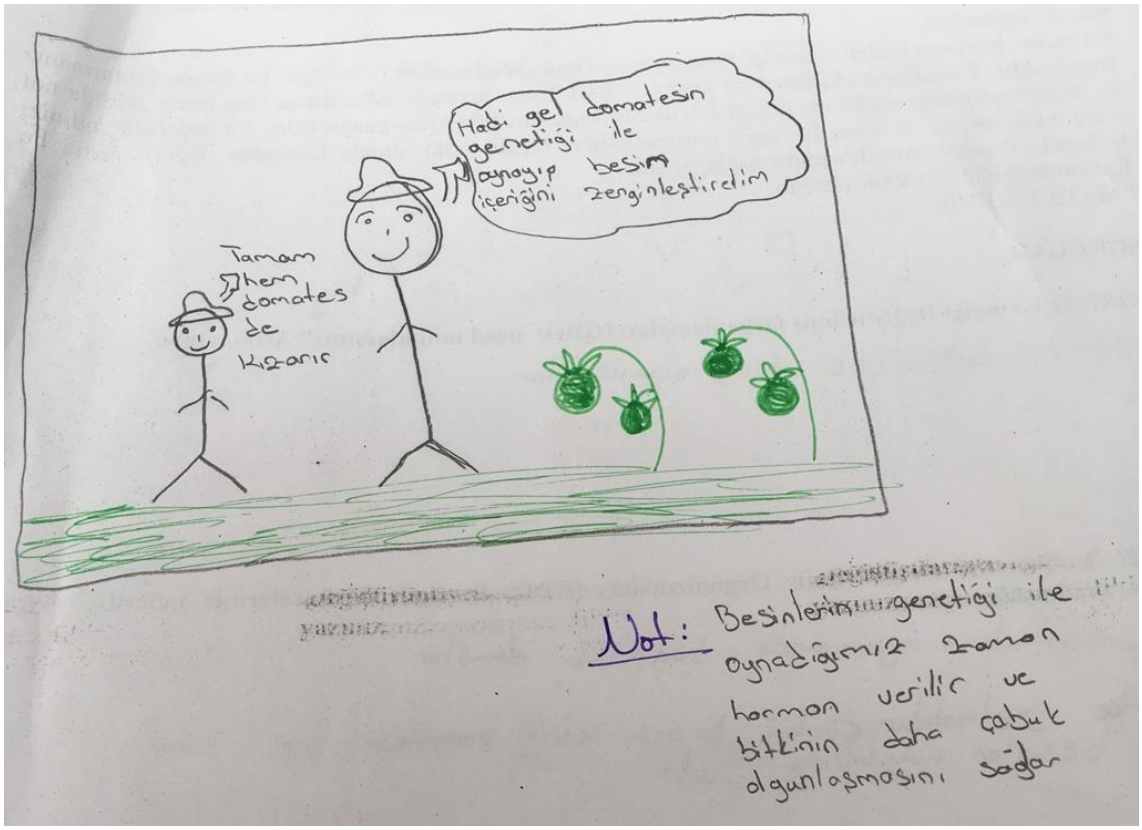

Figure 4.11 Drawing of B10 coded student

4.2.2 Findings on the Classification of Mental Models about GMO

In this section, students' mental models related to GMO are classified in accordance with the primitive, scientific and synthesis model definitions of Vosniadou and Brewer (1992). Information on the classification, frequency and percentages of mental models is given in Table 4.8.

Table 4.8 Findings on the classification of mental models about GMO

Mental Model Category	f	%
Synthesis	58	41,73
Scientific	43	30,93
Primitive	38	27,34
Total	**139**	**100**

When the mental models drawn by the students about GMO are examined 58 of the students (41,73%) produced synthesis model, 43 of the students (30,93%)

produced scientific model and 38 of the students (27,34%) produced primitive model. Sample drawings of these findings are presented in Figure 4.12, 4.13 and 4.14.

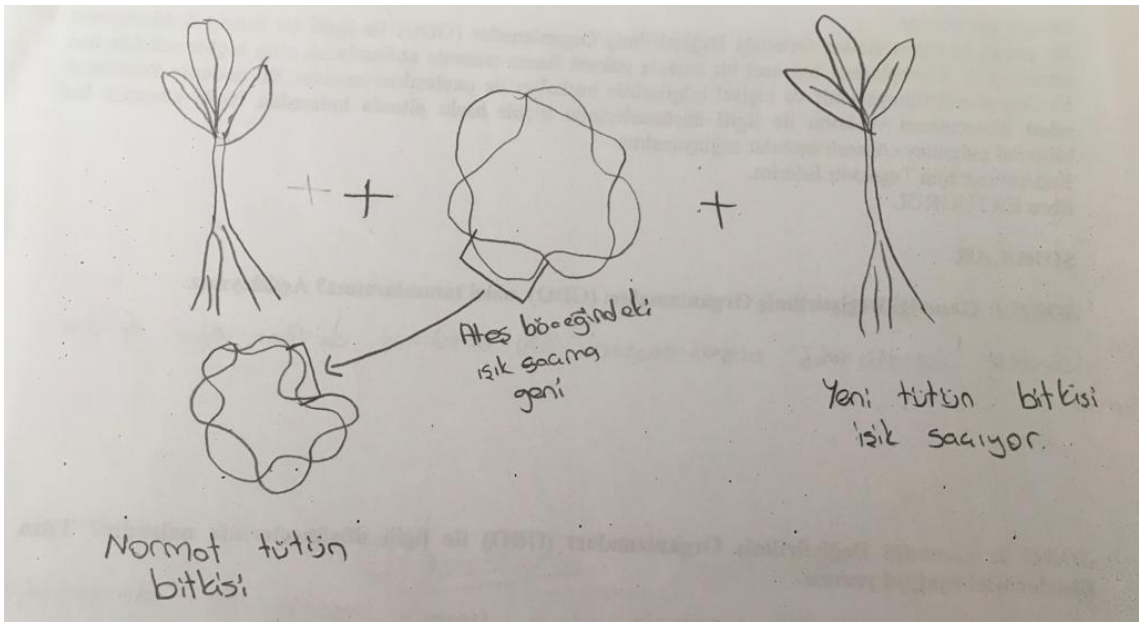

Figure 4.12 Drawing of C26 coded student (Scientific Model)

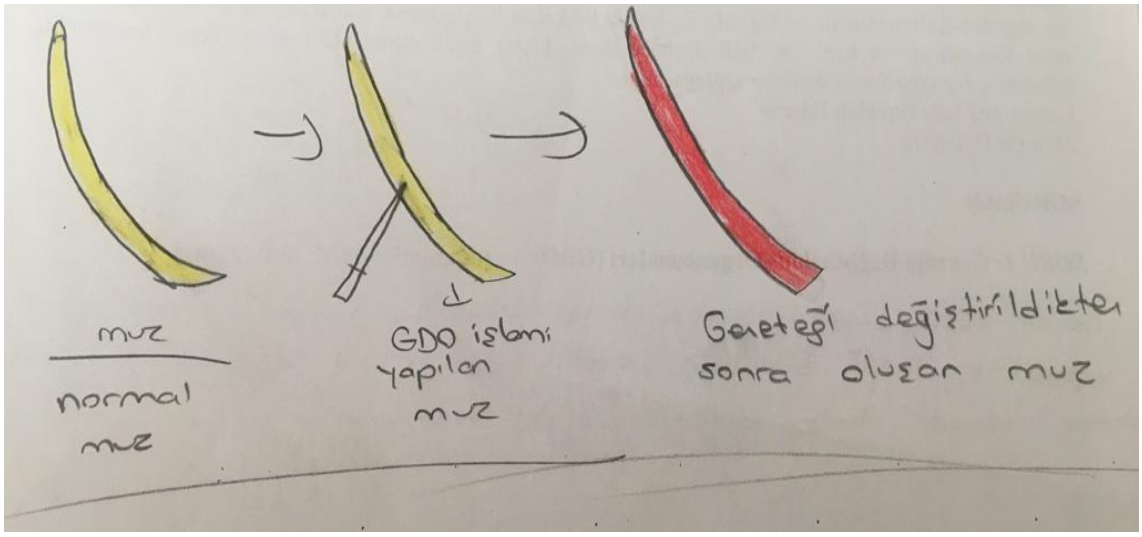

Figure 4.13 Drawing of B34 coded student (Synthesis Model)

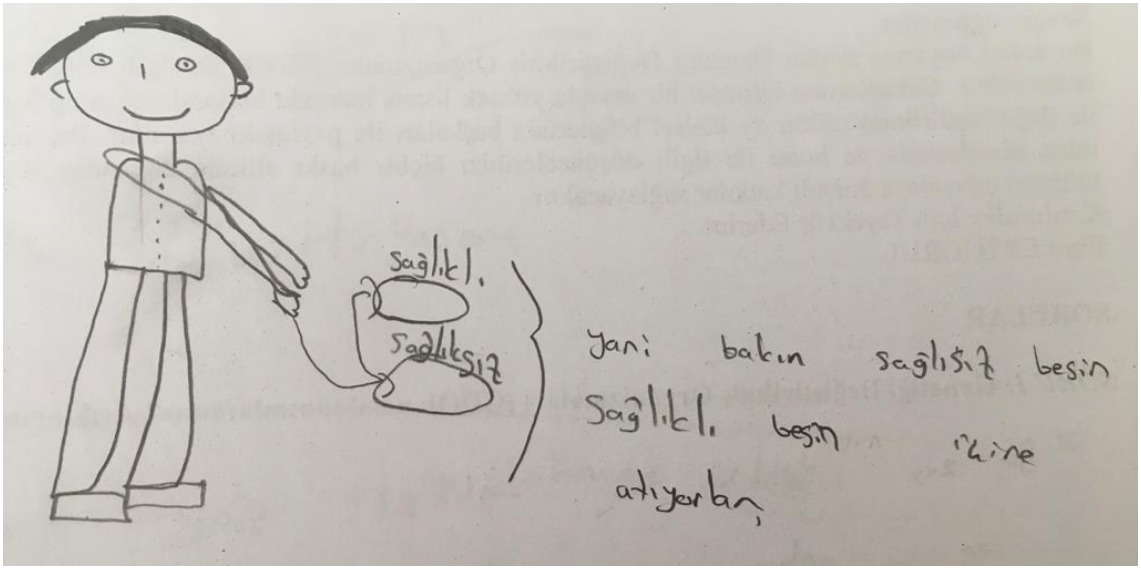

Figure 4.14 Drawing of A7 coded student (Primitive Model)

4.2.3 Findings on Mental Models about Nuclear Energy

The conceptual categories obtained from the drawings that reflect the students' mental models for the Nuclear Energy, their frequency and percentages are given in Table 4.9. It is seen that a total of 22 types and 138 valid mental models related to the Nuclear Energy concept have been developed by middle school students under five conceptual categories.

Table 4.9 Findings on mental models about nuclear energy

Conceptual category	Mental Models	The number of types of mental models	f	%
Effects on Living Things	Dead Animals (16) Sick People (11) Drying Trees (10) Anxious People (8) Disabled People (3) The Transmission of Radiation to The Human Body (2)	6	50	36,23
Effects on The Environment	Smoky Factory Chimney (9) Polluted Air (6) CO2 Emission (4) Impact on Settlements (4) Dirty Water Resources (4) Radiation Scattering (2) Nuclear Waste (1)	7	30	21,74
Advantages	Energy production (9) Power generation (8) Energy efficiency (3) Economic gain (3)	4	23	16,67
Nuclear Power Plant	Nuclear Power Plant drawings (13) Nuclear power plant explosion (8)	2	21	15,22
Nuclear Energy Generation	Atom (7) Atomic Nuclei Fragmented (6) Uranium (1)	3	14	10,14
Total		**22**	**138**	**100**

-Mental Models in the 'Effects on Living Things' Category

Middle school students developed 6 types of mental models for the "*Effects on Living Things*" category. The frequency of using mental models in this category is 50. In other words, 50 (36,23%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is "Dead Animals (16)", while the mental model with the lowest frequency value is "The Transmission of Radiation to the Human Body (2)". Sample drawings of these findings are presented in Figure 4.15 and Figure 4.16.

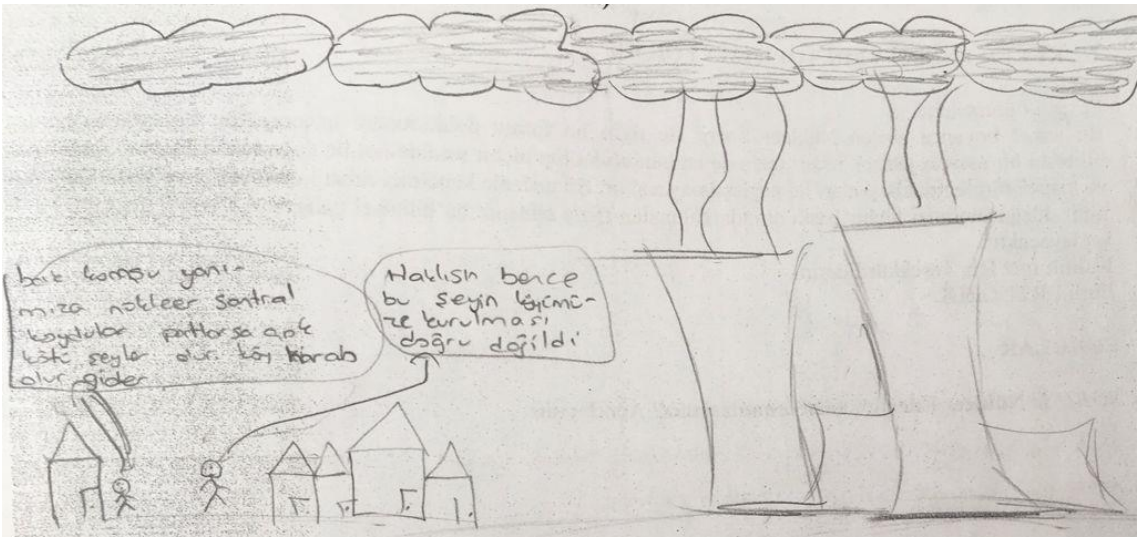

Figure 4.15 Drawing of A50 coded student

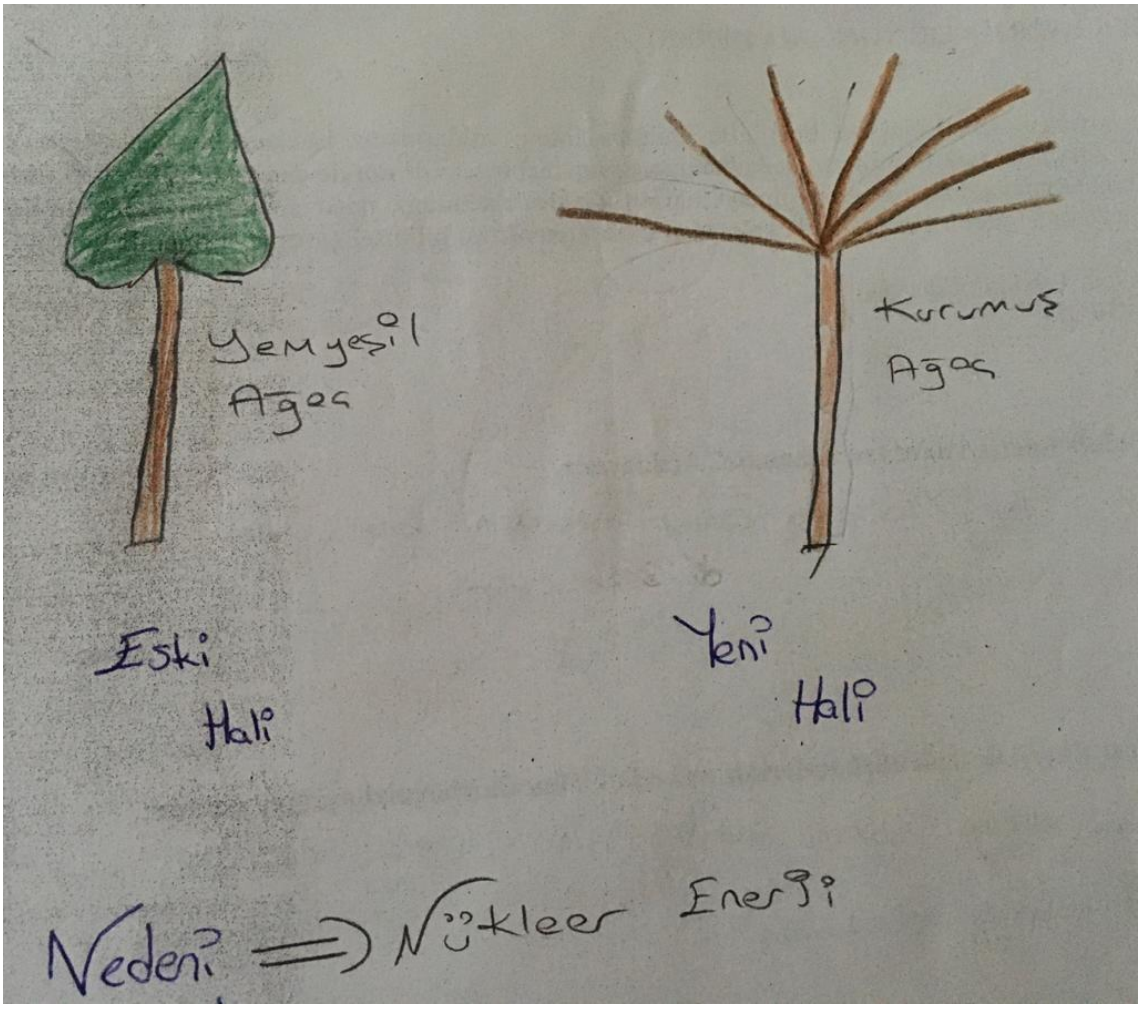

Figure 4.16 Drawing of C2 coded student

-Mental Models in the 'Effects on the Environment' Category

Middle school students developed 7 types of mental models for the "*Effects on the Environment* " category. The frequency of using mental models in this category is 30. In other words, 30 (21,74%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is " Smoky Factory Chimney (9)", while the mental model with the lowest frequency value is " Nuclear Waste (1)". Sample drawings of these findings are presented in Figure 4.17 and Figure 4.18.

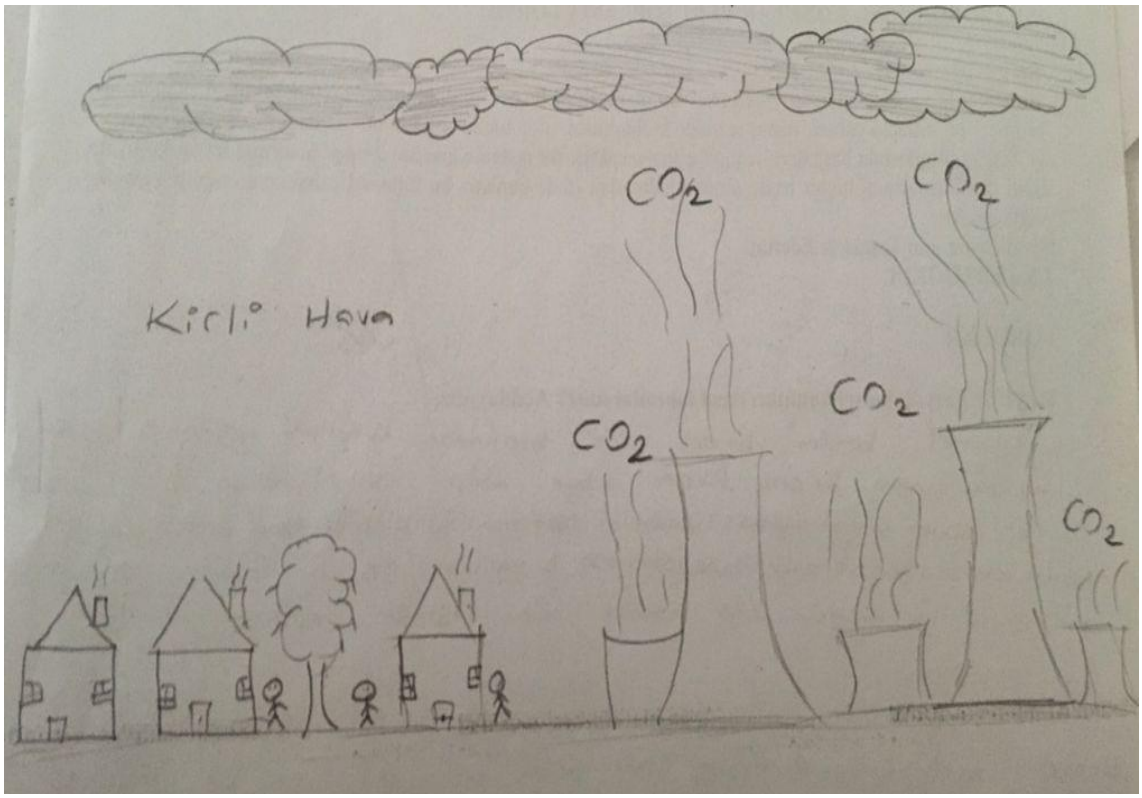

Figure 4.17 Drawing of B41 coded student

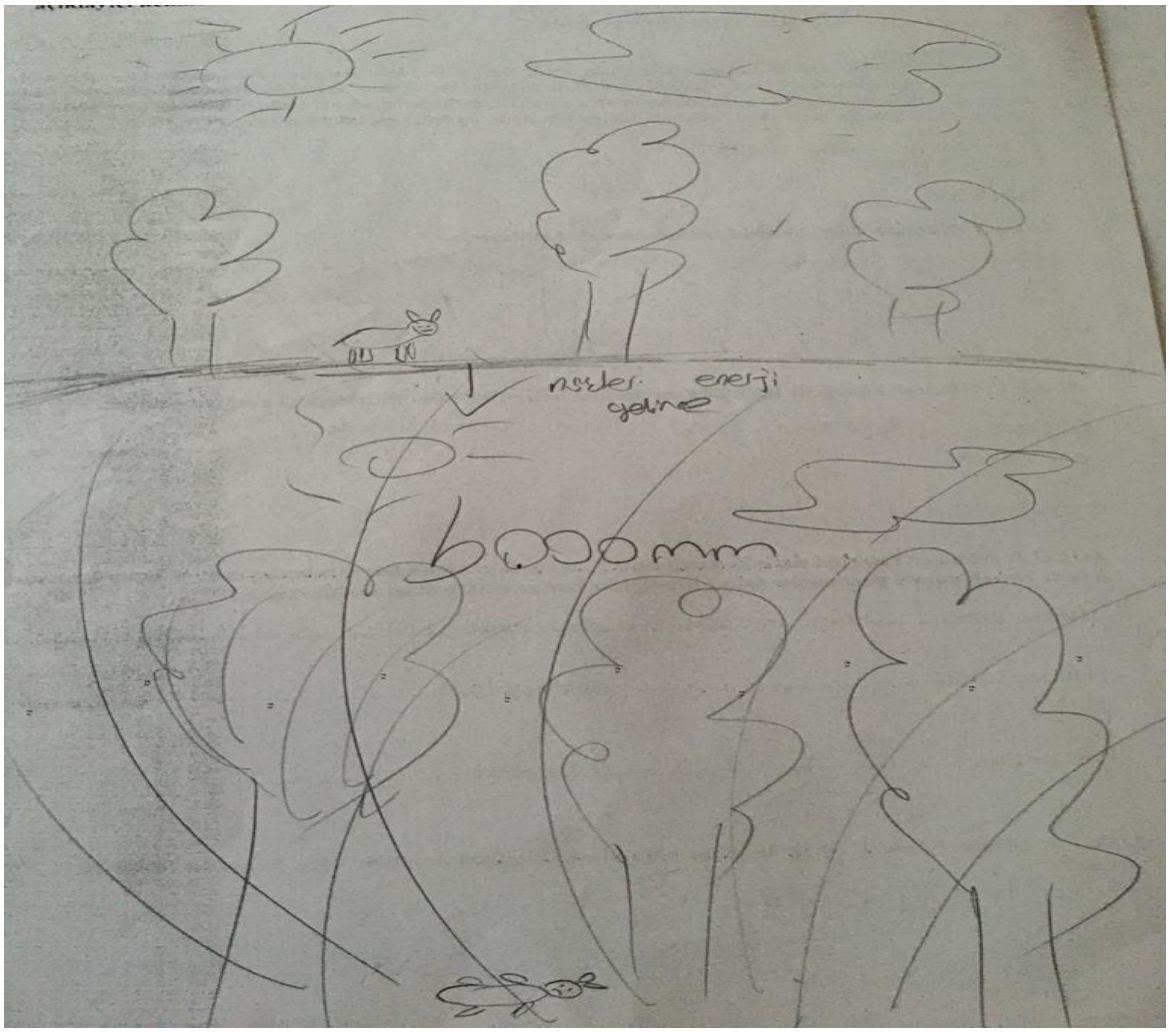

Figure 4.18 Drawing of A3 coded student

-Mental Models in the 'Advantages' Category

Middle school students developed 4 types of mental models for the "*Advantages*" category. The frequency of using mental models in this category is 23. In other words, 23 (16,67%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is " Energy production (9)", while the mental model with the lowest frequency value is "Energy efficiency (3)" and "Economic gain (3) ". Sample drawings of these findings are presented in Figure 4.19 and Figure 4.20.

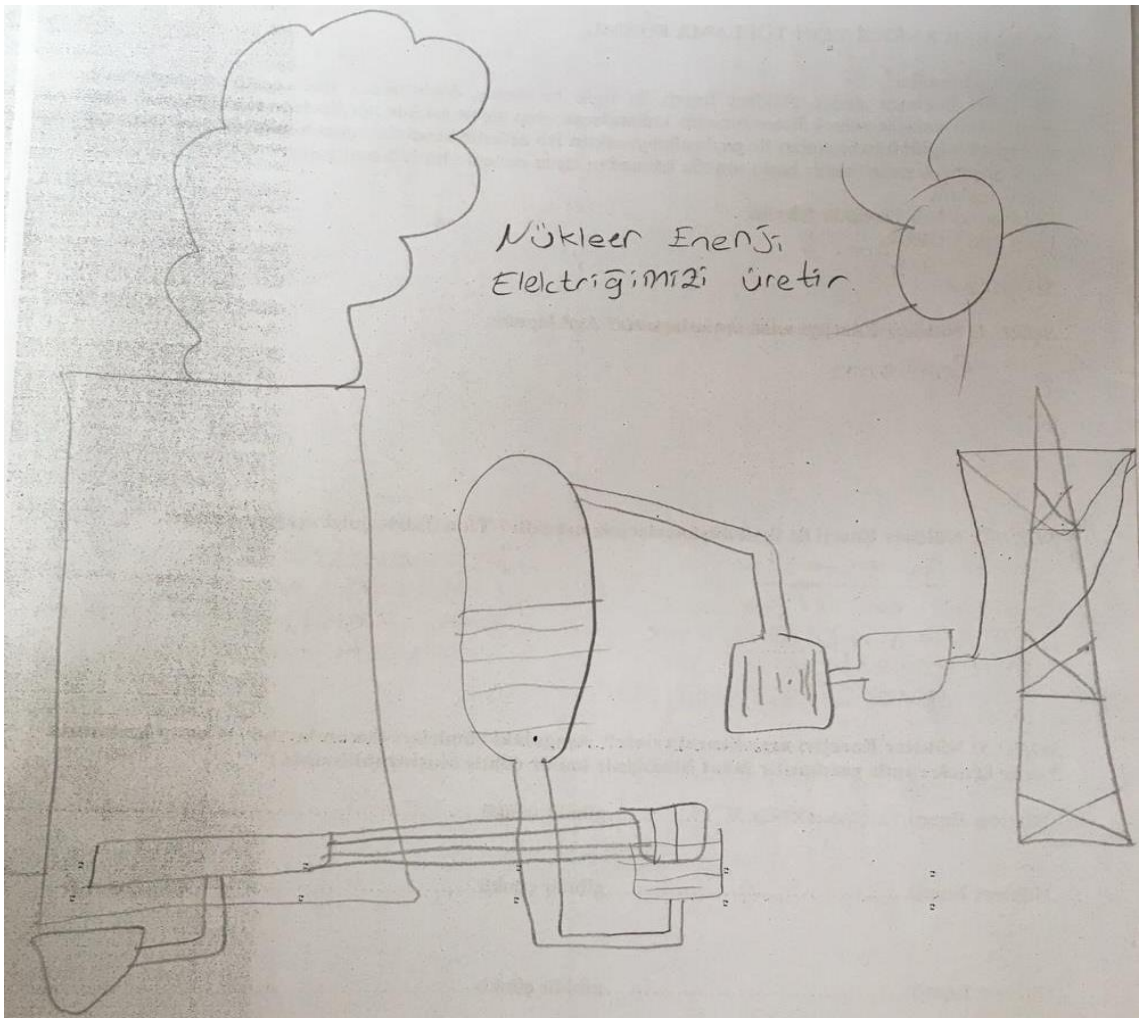

Figure 4.19 Drawing of C36 coded student

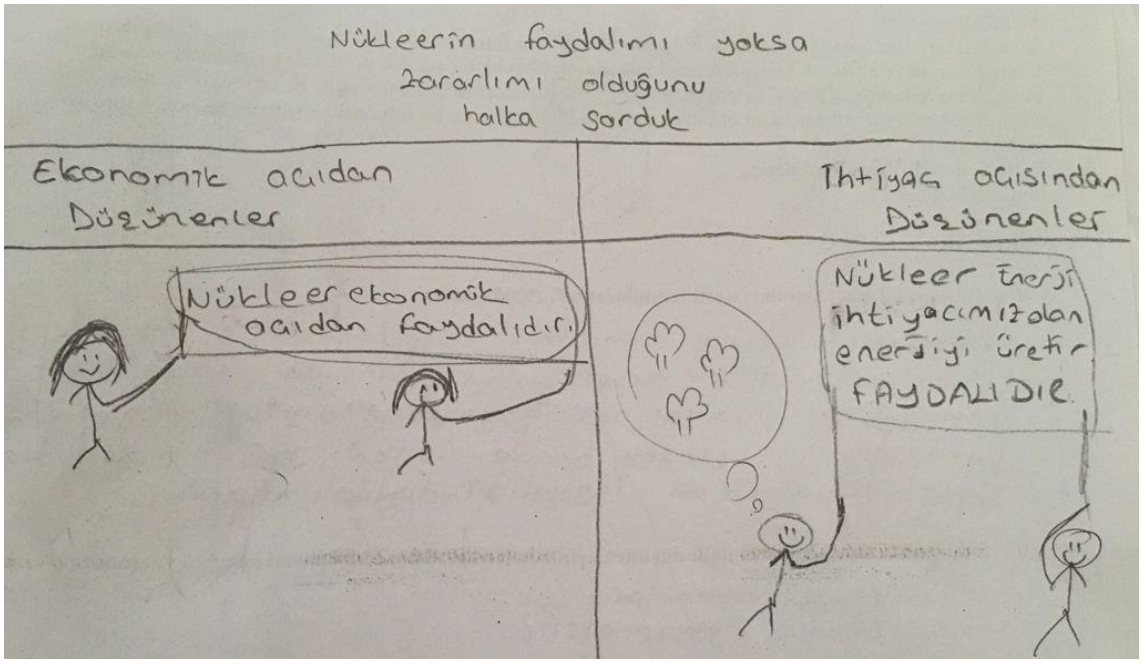

Figure 4.20 Drawing of B46 coded student

-Mental Models in the 'Nuclear Power Plant' Category

Middle school students developed 2 types of mental models for the "*Nuclear Power Plant*" category. The frequency of using mental models in this category is 21. In other words, 21 (15,22%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is "Nuclear Power Plant drawings (13)", while the mental model with the lowest frequency value is "Nuclear power plant explosion (8)". Sample drawings of these findings are presented in Figure 4.21 and Figure 4.22.

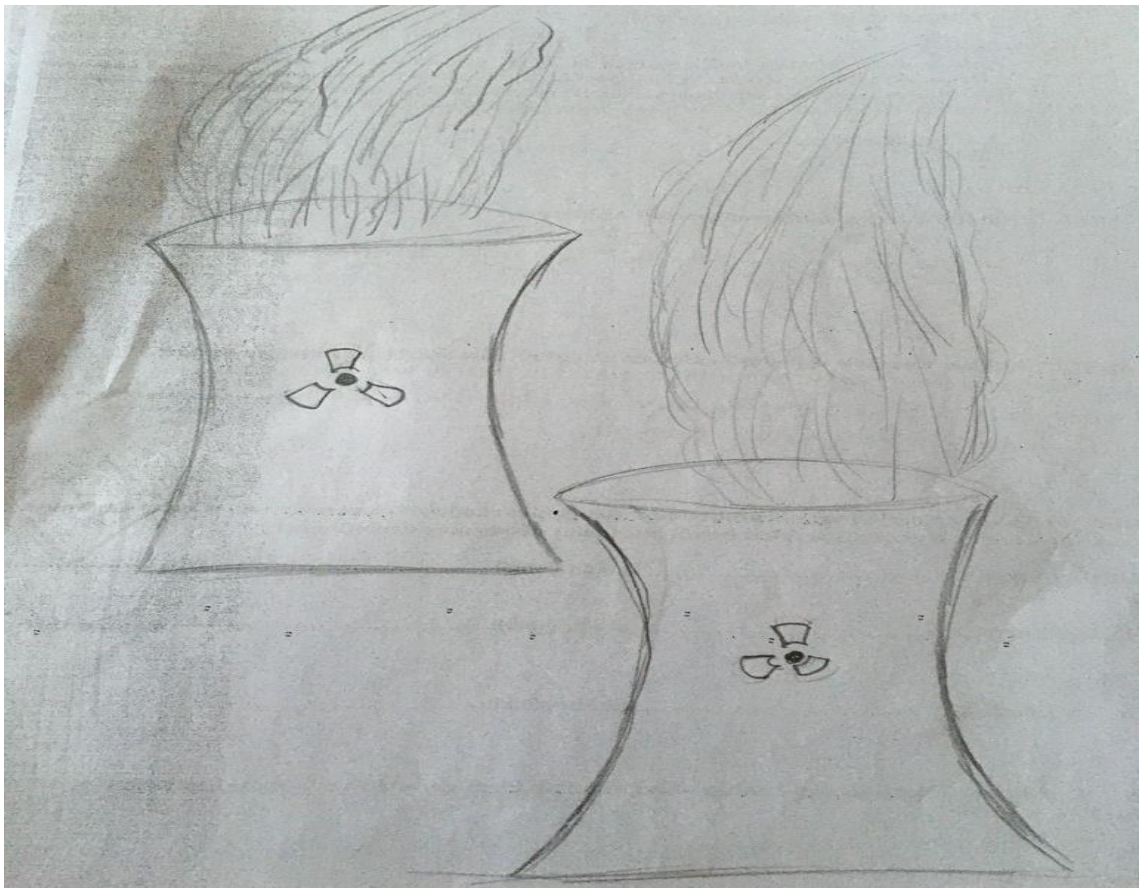

Figure 4.21 Drawing of A33 coded student

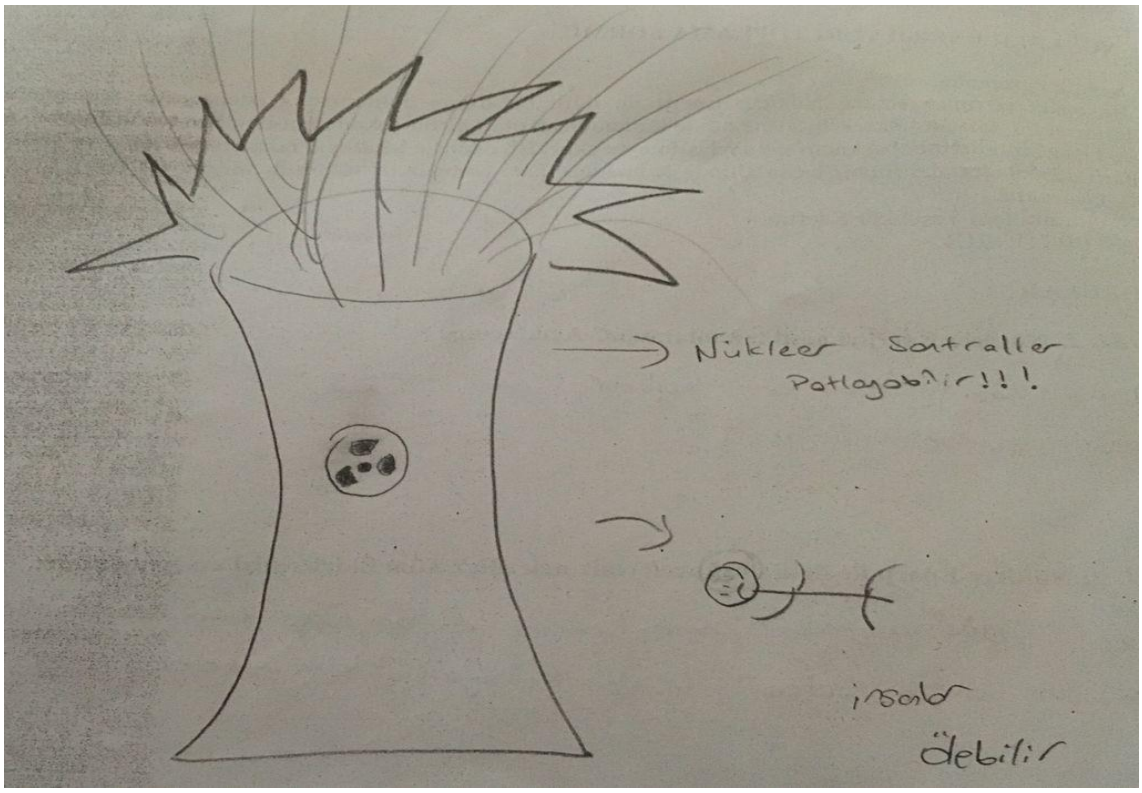

Figure 4.22 Drawing of B29 coded student

-Mental Models in the 'Nuclear Energy Generation' Category

Middle school students developed 2 types of mental models for the "*Nuclear Energy Generation*" category. The frequency of using mental models in this category is 14. In other words, 14 (10,14%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is "Atom (8)", while the mental model with the lowest frequency value is "Atomic Nuclei Fragmented (6)". Sample drawings of these findings are presented in Figure 4.23 and Figure 4.24.

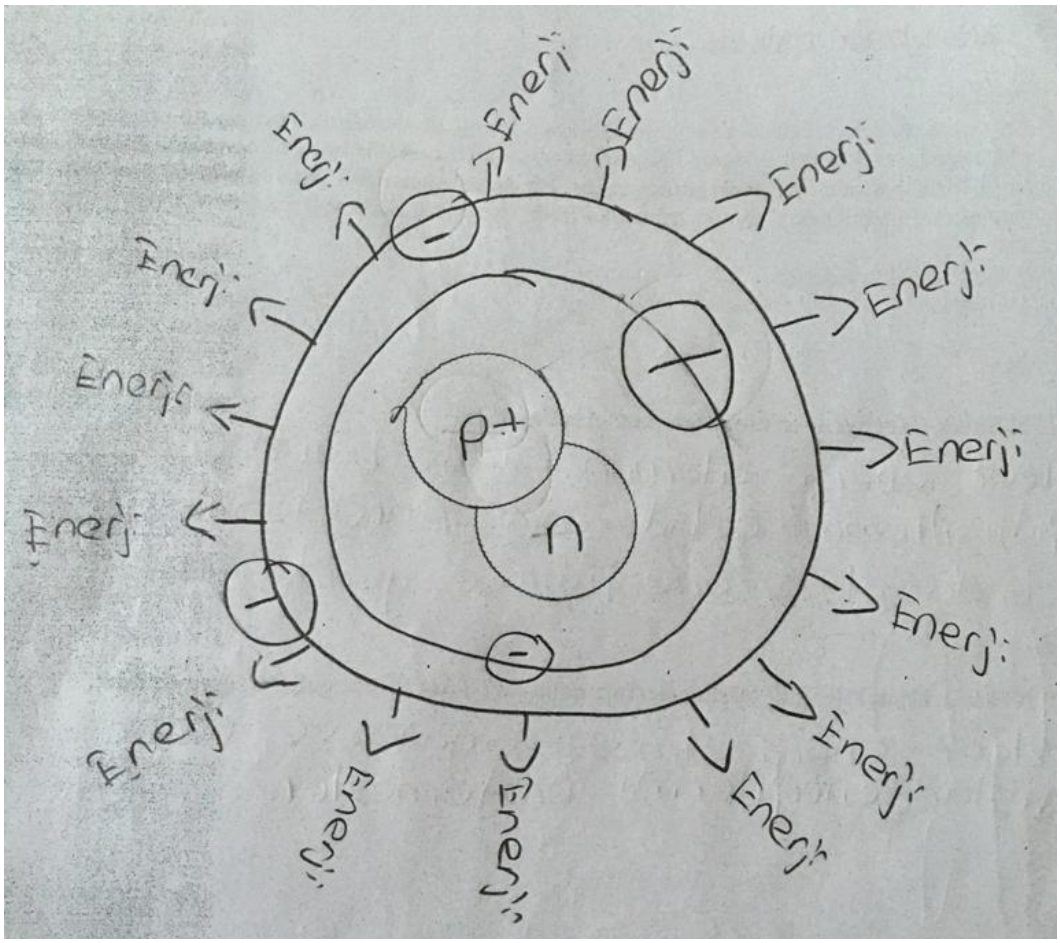

Figure 4.23 Drawing of C17 coded student

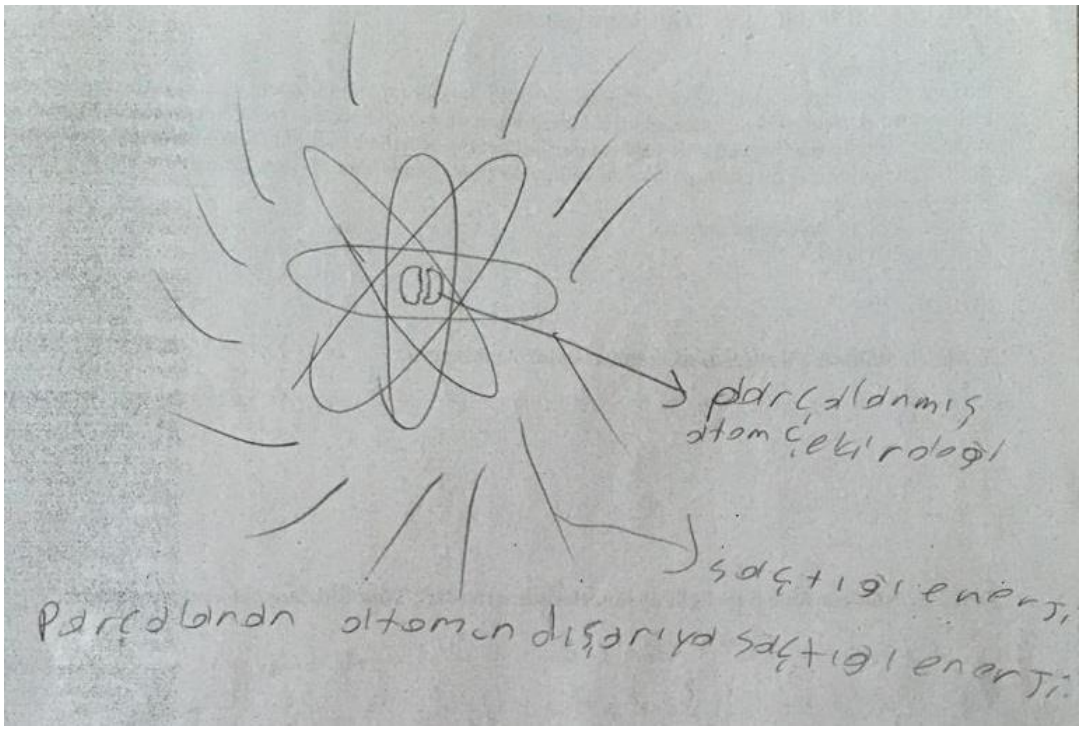

Figure 4.24 Drawing of C51 coded student

4.2.4 Findings on the Classification of Mental Models About Nuclear Energy

In this section, students' mental models related to Nuclear Energy are classified in accordance with the primitive, scientific and synthesis model definitions of Vosniadou and Brewer (1992). Information on the classification, frequency and percentages of mental models is given in Table 4.10.

Table 4.10 Findings on the classification of mental models about nuclear energy

Mental Model Category	f	%
Scientific	55	39,85
Synthesis	47	34,06
Primitive	36	26,09
Total	**138**	**100**

When the mental models drawn by the students about Nuclear Energy are examined 55 of the students (39,85%) produced scientific model, 47 of the students (34,06%) produced synthesis model and 36 of the students (26,09%) produced primitive model. Sample drawings of these findings are presented in Figure 4.25, 4.26 and 4.27.

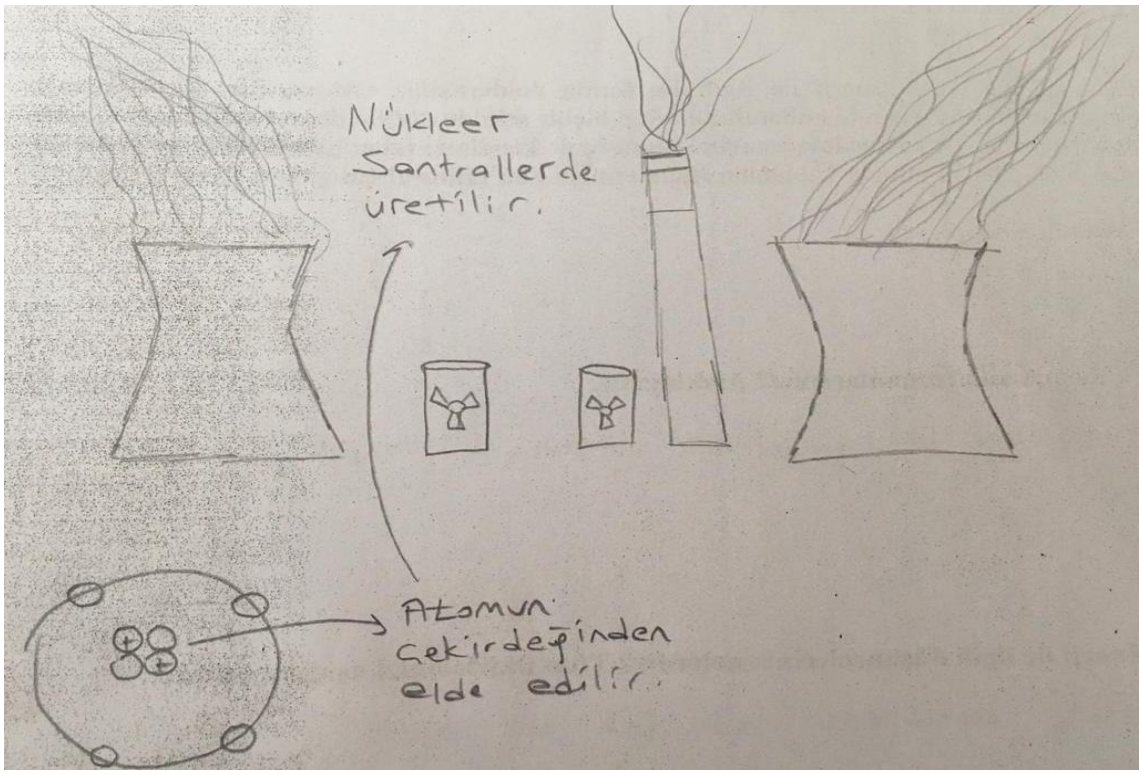

Figure 4.25 Drawing of C40 coded student (Scientific model)

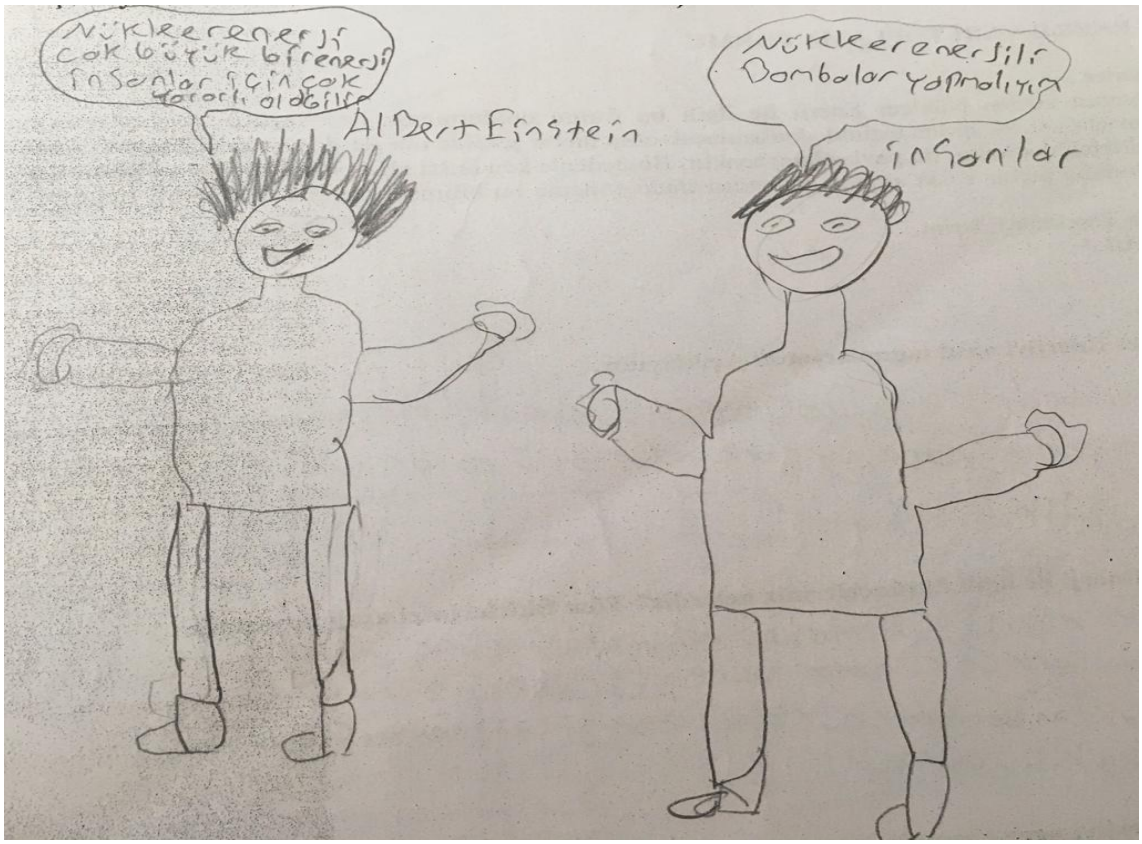

Figure 4.26 Drawing of B45 coded student (Synthesis model)

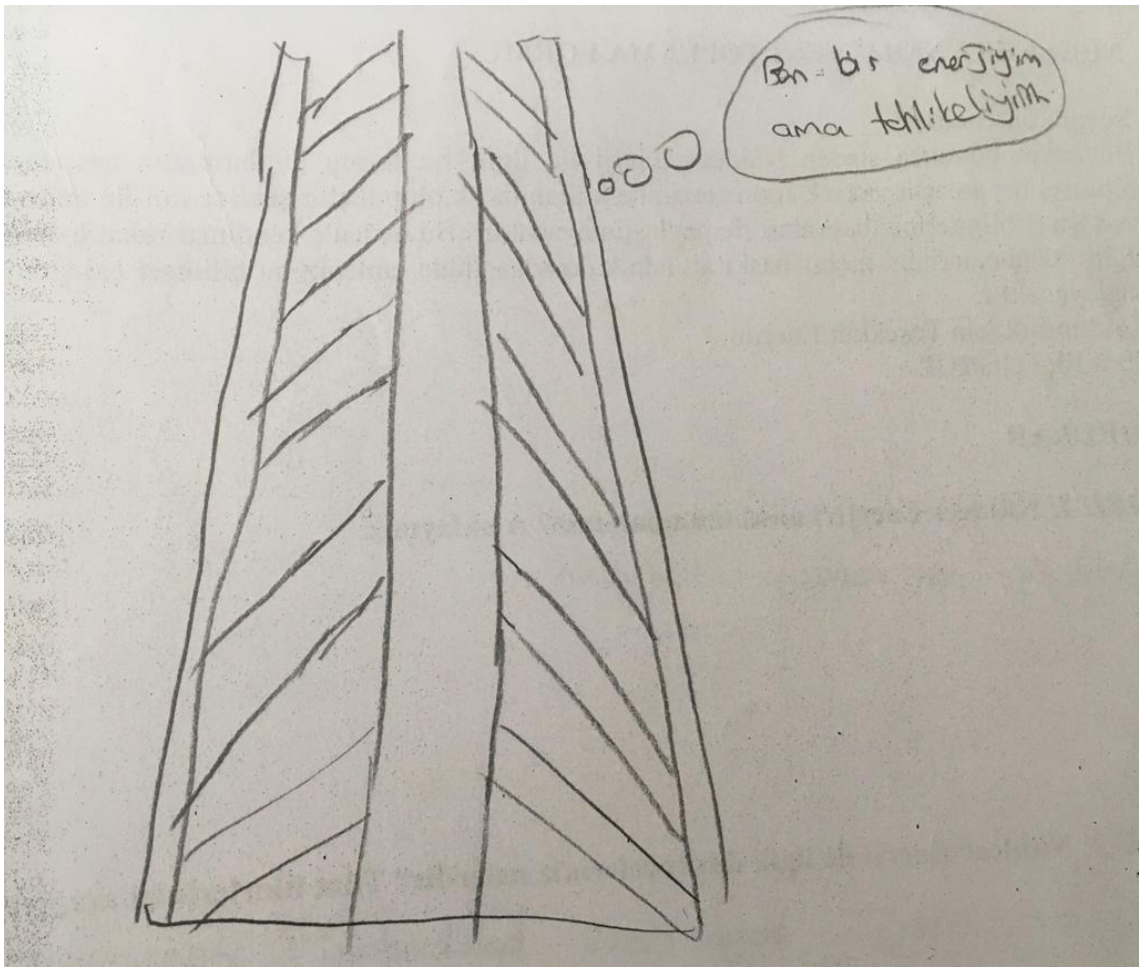

Figure 4.27 Drawing of A4 coded student (Primitive model)

4.2.5 Findings on Mental Models about Organ Donation

The conceptual categories obtained from the drawings that reflect the students' mental models for the Organ Donation, their frequency and percentages are given in Table 4.11. It is seen that a total of 14 types and 132 valid mental models related to the Organ Donation concept have been developed by middle school students under four conceptual categories.

Table 4.11 Findings on mental models about organ donation

Conceptual Category	Mental Models	The number of Types of Mental Models	f	%
Effects on People	Happy People (13) Healthy People (11) Slogans (8) People waiting to Donate Organ (5) Before and after organ donation (5)	5	42	31,82
Organs	Heart (21) Kidney (9) Healthy organs (5) Lung (4)	4	39	29,55
Social Dimension	Charity (14) Poster Works (9) Strengthening Social Ties (7)	3	30	22,73
Hesitation	Be in a quandary (13) Including risks (8)	2	21	15,90
Total		**14**	**132**	**100**

-Mental Models in the 'Effects on People' Category

Middle school students developed 5 types of mental models for the "*Effects on People*" category. The frequency of using mental models in this category is 42. In other words, 42 (31,82%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is "Happy People (13)", while the mental model with the lowest frequency value is "People waiting to Donate Organ (5) " and "Before and after organ donation (5) ". Sample drawings of these findings are presented in Figure 4.28 and Figure 4.29.

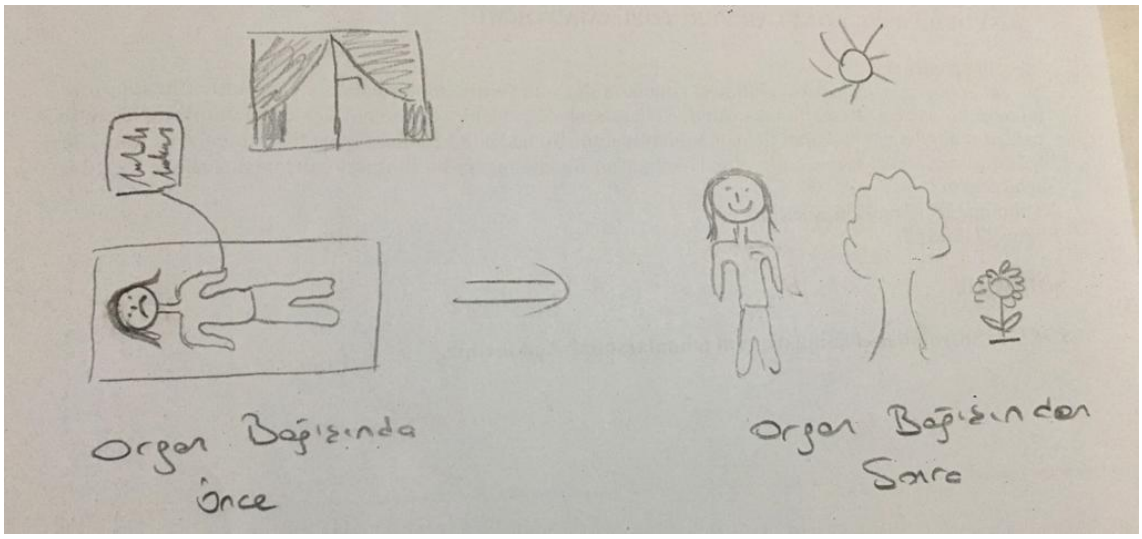

Figure 4.28 Drawing of B17 coded student

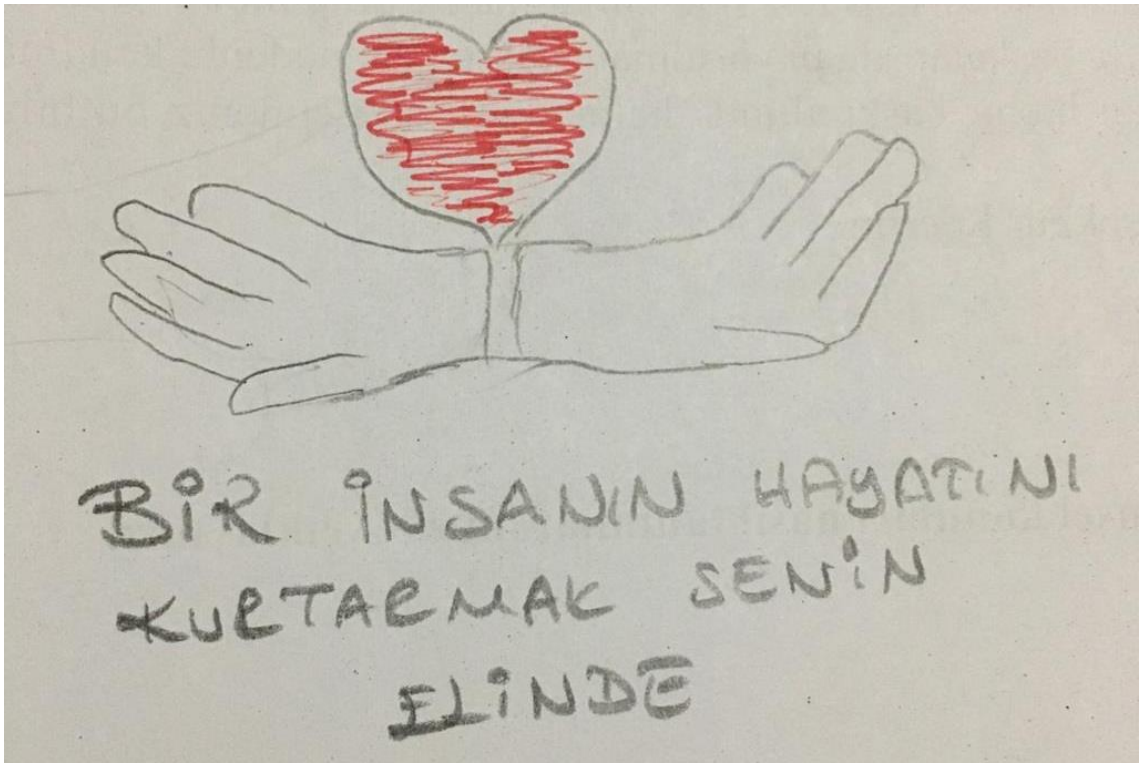

Figure 4.29 Drawing of C3 coded student

-Mental Models in the 'Organs' Category

Middle school students developed 4 types of mental models for the "*Organs*" category. The frequency of using mental models in this category is 39. In other words, 39 (29,55%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is "Hearth (21)",

while the mental model with the lowest frequency value is "Lung (4)". Sample drawings of these findings are presented in Figure 4.30 and Figure 4.31.

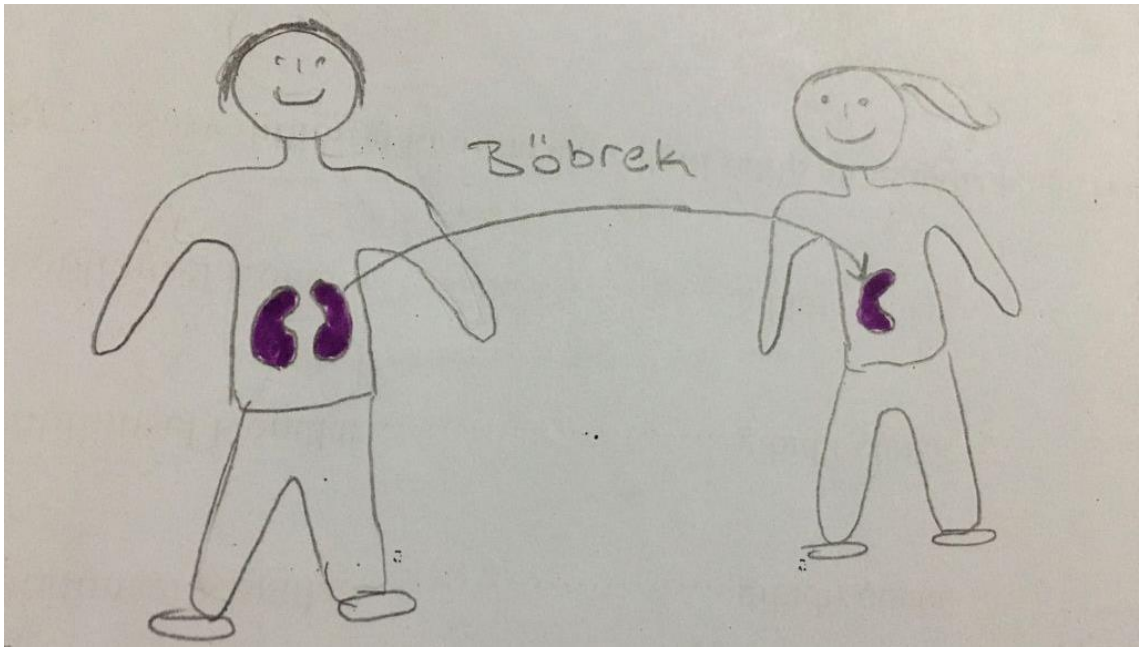

Figure 4.30 Drawing of B27 coded student

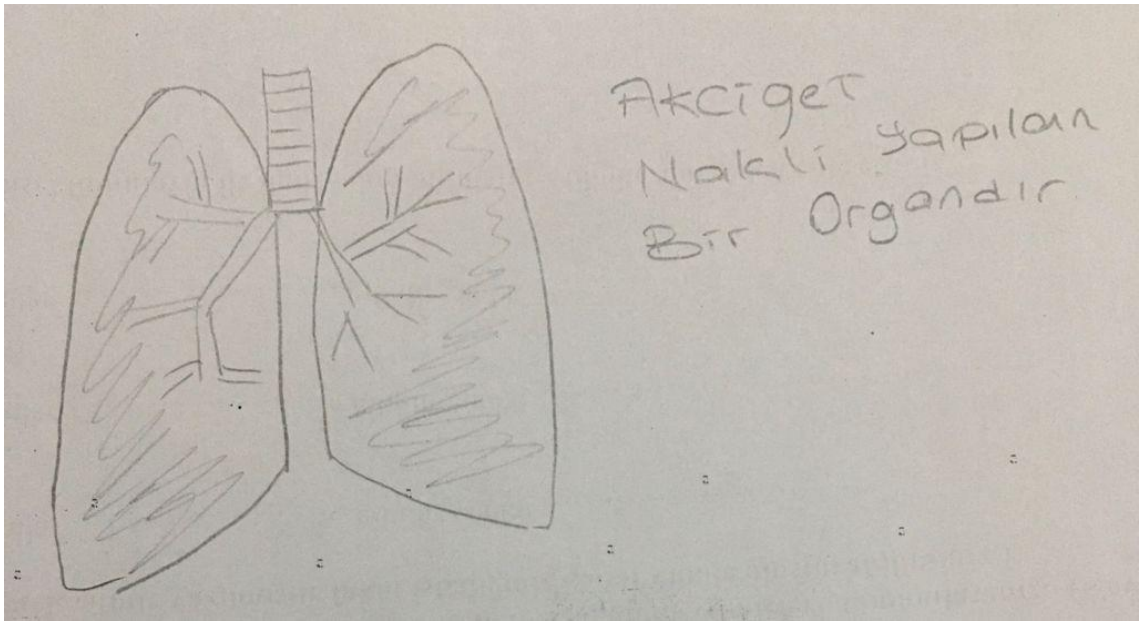

Figure 4.31 Drawing of C13 coded student

-Mental Models in the 'Social Dimension' Category

Middle school students developed 3 types of mental models for the "*Social Dimension*" category. The frequency of using mental models in this category is 30. In other words, 30 (22,73%) of the students produced mental models in this

category. In this category, the mental model with the highest frequency value is "Charity (14)", while the mental model with the lowest frequency value is " Strengthening Social Ties (7)". Sample drawings of these findings are presented in Figure 4.32 and Figure 4.33.

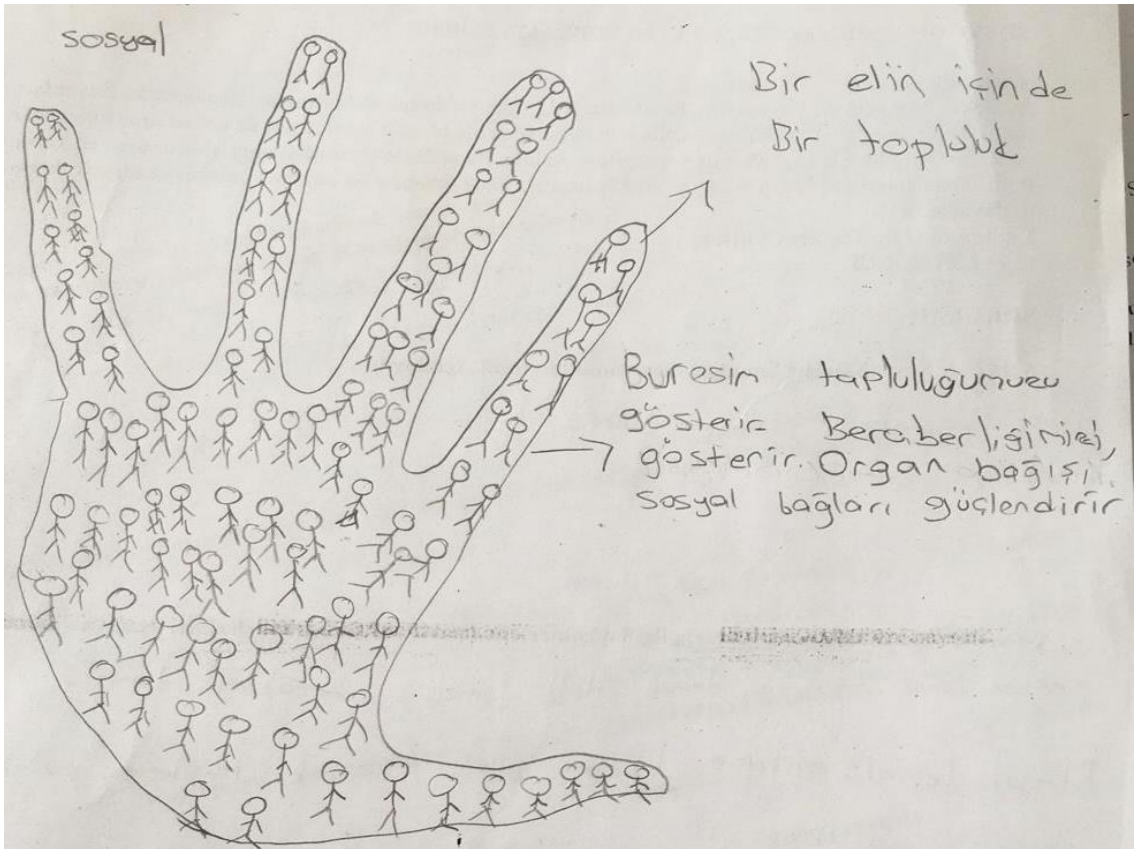

Figure 4.32 Drawing of B47 coded student

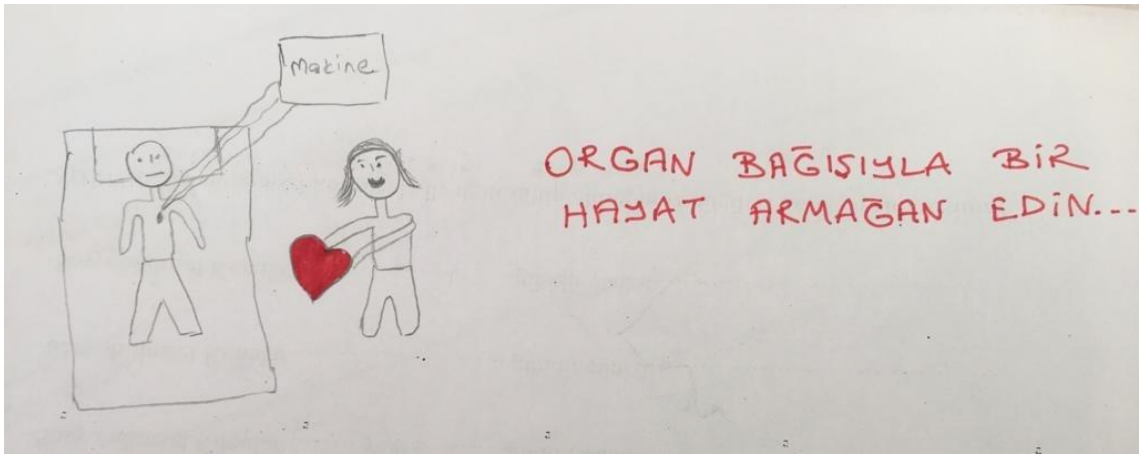

Figure 4.33 Drawing of A21 coded student

-Mental Models in the 'Hesitation' Category

Middle school students developed 2 types of mental models for the "*Hesitation*" category. The frequency of using mental models in this category is 21. In other words, 21 (15.90%) of the students produced mental models in this category. In this category, the mental model with the highest frequency value is " Be in a quandary (13)", while the mental model with the lowest frequency value is " Including risks (8)". Sample drawing of these findings are presented in Figure 4.34.

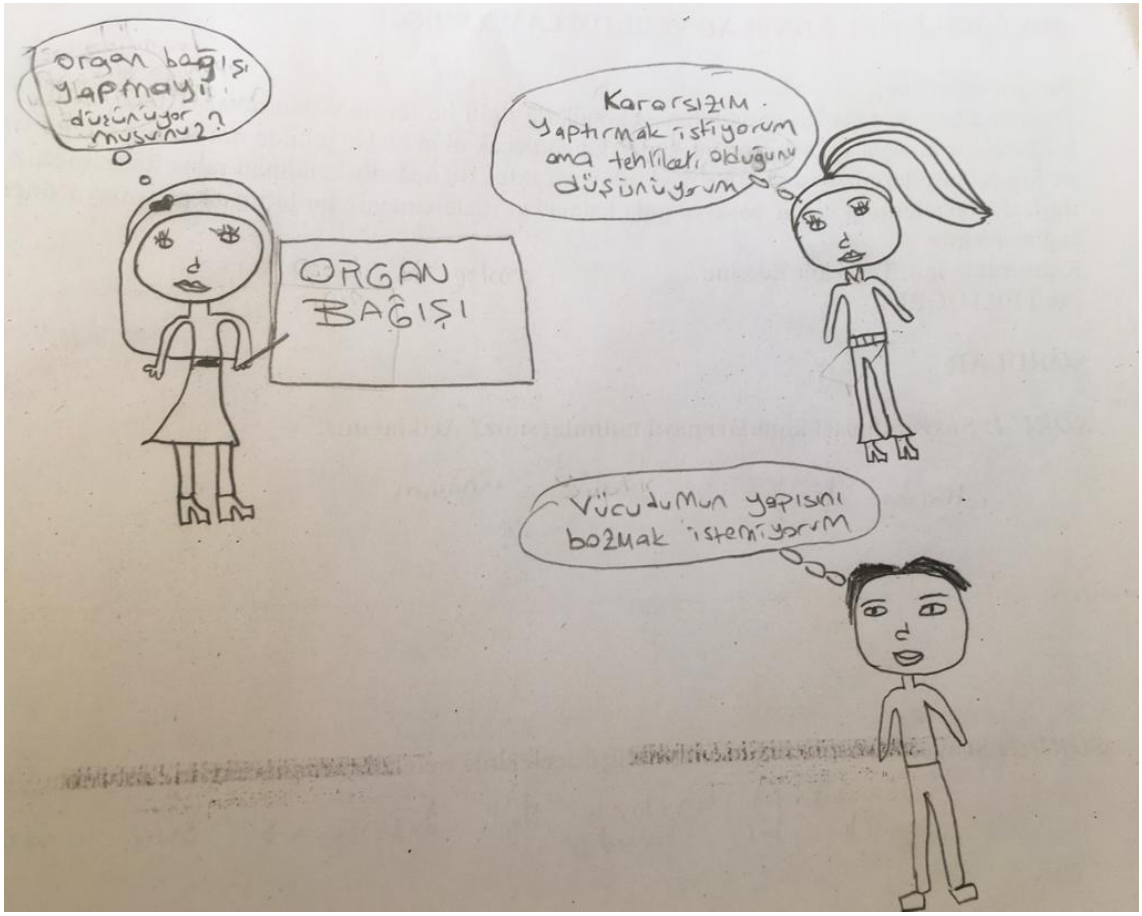

Figure 4.34 Drawing of C7 coded student

4.2.6 Findings on the Classification of Mental Models About Organ Donation

In this section, students' mental models related to Organ Donation are classified in accordance with the primitive, scientific and synthesis model definitions of Vosniadou and Brewer (1992). Information on the classification, frequency and percentages of mental models is given in Table 4.12.

Table 4.12 Findings on the classification of mental models about Organ Donation

Mental Model Category	f	%
Synthesis	63	47,73
Scientific	39	29,54
Primitive	30	22,73
Total	**132**	**100**

When the mental models drawn by the students about Organ Donation are examined 63 of the students (47,73%) produced synthesis model, 39 of the students (28,54%) produced scientific model and 30 of the students (22,73%) produced primitive model. Sample drawings of these findings are presented in Figure 4.35, 4.36 and 4.37.

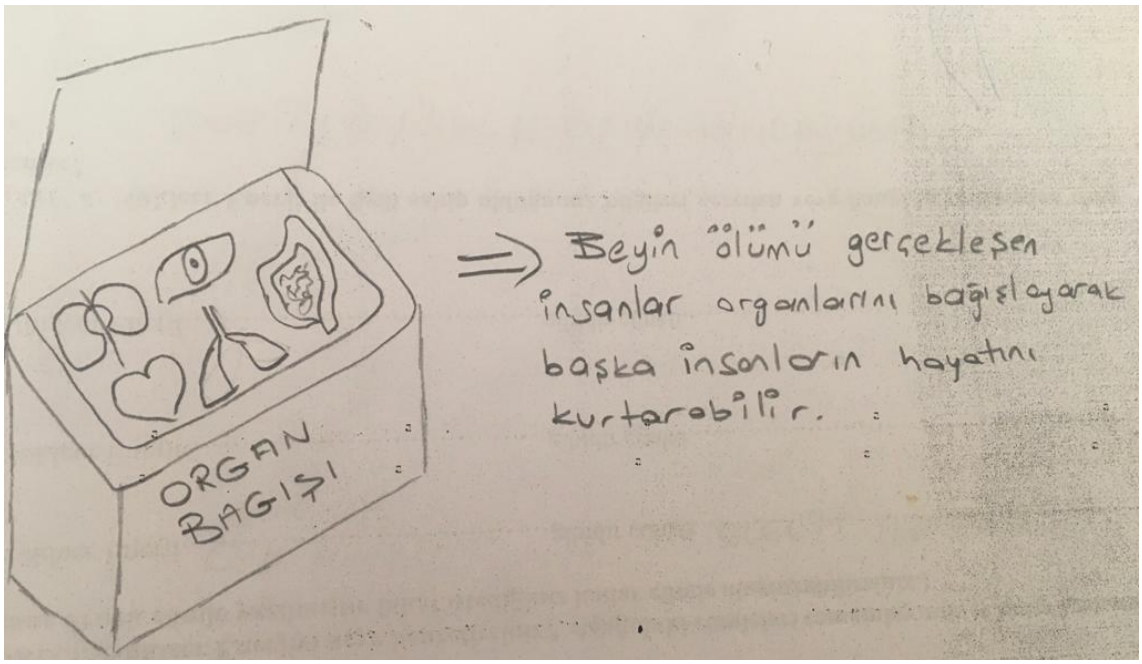

Figure 4.35 Drawing of C57 coded student (Scientific Model)

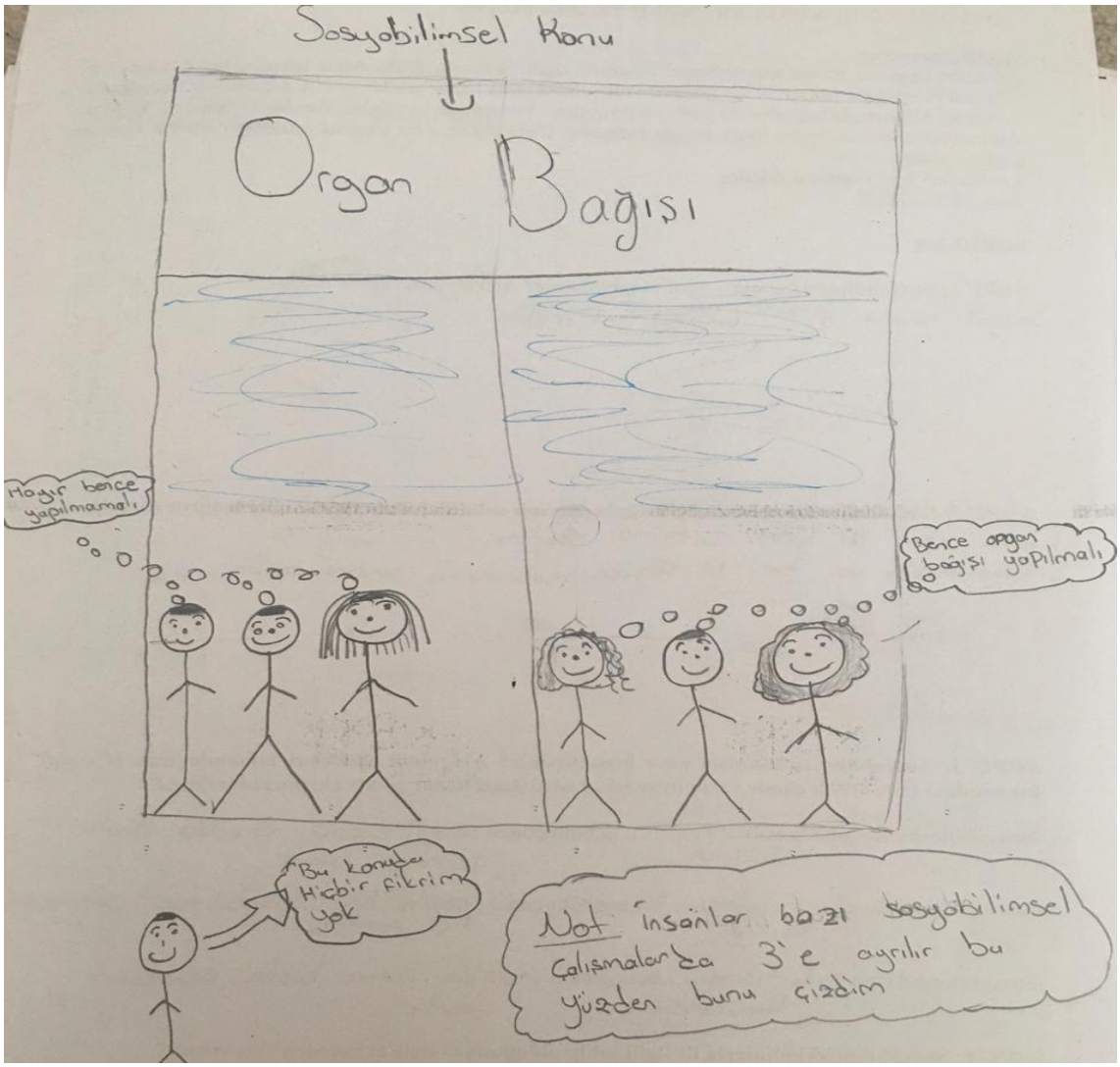

Figure 4.36 Drawing of B6 coded student (Synthesis Model)

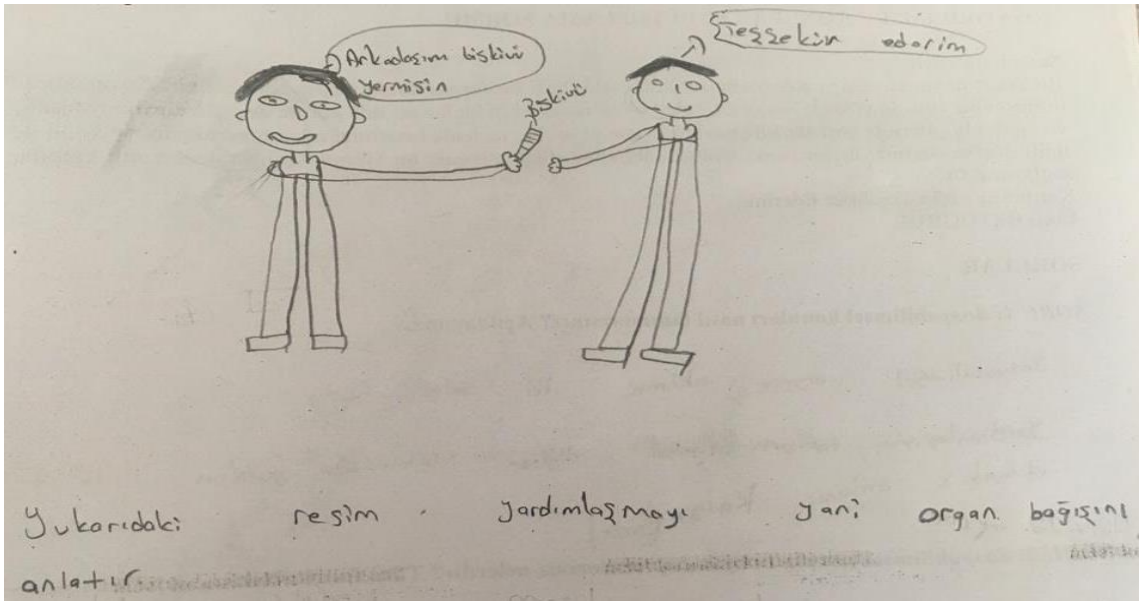

Figure 4.37 Drawing of A18 coded student (Primitive Model)

4.3 Findings on Attitudes Towards Socioscientific Issues

The third main research question of this study is: *What are the attitudes of the 6th, 7th, and 8th grade students towards socioscientific issues?* In this part, results regarding this research question are presented. Students' attitudes to socioscientific issues were determined by examining their answers to the question in the data collection tool.

4.3.1 Findings on Attitudes Towards GMO

In this section, the attitudes, frequencies, and percentages of the students about the GMO concept are given in Table 4.13. Students stated "Negative", "Positive", "Undecided" and "No Idea" opinions. There are 169 valid views about GMO.

Table 4.13 Findings on attitudes towards GMO

Students' Attitudes	f	%
Negative	69	40,83
Positive	49	28,99
Irresolute	38	22,49
No Idea	13	7,69
Total	**169**	**100**

While 69 of the students (40,83%) stated negative, 49 (28,99%) positive, 38 (22,49%) irresolute opinions about GMO, 13 of the students (7,69%) stated that they did not have any opinions about GMOs. Sample student sentences are given below.

C38: GMO may be the solution in the short term, but it has bad effects on living things in the long term.

B9: GMO application is useful when used consciously.

A4: I am undecided about GMOs because sometimes they have beneficial properties and sometimes they have harmful properties. While the emergence of new types of food is beneficial, the lack of old vitamins of some foods is harmful.

4.3.2 Findings on Attitudes Towards Nuclear Energy

In this section the attitudes, frequencies, and percentages of the students about the Nuclear Energy concept are given in Table 4.14. Students stated "Negative", "Positive", "Undecided" and "No Idea" opinions. There are 172 valid views about Nuclear Energy. Sample student sentences are given below.

A33: Nuclear energy is a non-renewable energy source and is harmful to the environment.

B2: Nuclear energy is an accessible, cheap and efficient energy source.

C7: I remain undecided about nuclear energy because while it has positive features in terms of economy and energy, it has negative features in terms of environment.

Table 4.14 Findings on attitudes towards nuclear energy

Students' Attitudes	**f**	**%**
Negative	72	41,86
Irresolute	45	26,16
Positive	39	22,67
No Idea	16	9,30
Total	**172**	**100**

While 72 of the students (41,86%) stated negative, 45 (26,18%) irresolute, 39 (22,67%) positive opinions about Nuclear Energy, 16 of the students (9,30%) stated that they did not have any opinions about Nuclear Energy.

4.3.3 Findings on Attitudes Towards Organ Donation

In this section, the attitudes, frequencies, and percentages of the students about the Organ Donation concept are given in Table 4.15. Students stated "Negative", "Positive", "Irresolute" and "No Idea" opinions. There are 168 valid views about Organ Donation.

Table 4.15 Findings on attitudes towards organ donation

Students' Attitudes	f	%
Positive	97	57,74
Irresolute	33	19,64
Negative	29	17,26
No Idea	9	5,36
Total	**168**	**100**

While 97 of the students (57,74%) stated positive, 33 (19,64%) irresolute, 29 (17,26%) negative opinions about Organ Donation, 9 of the students (5,36%) stated that they did not have any opinions about Organ Donation. Sample student sentences are given below.

A45: I support organ donation because I think saving lives is important.

B34: I am hesitant about organ donation, I actually support it, but I have fears.

C7: I do not favor organ donation because organ donation disrupts people's body order.

4.4 Findings About the Source of Information on Socioscientific Issues

The fourth main research question of this study is: " What are the sources of information that 6th, 7th and 8th grade students are affected by on socioscientific issues? . In this part, results regarding this research question are presented. Students' sources of information about socioscientific issues were determined by examining their answers to the question in the data collection tool.

4.4.1 Findings about the Source of Information on GMO

Middle school students were asked from where they obtained their knowledge about GMO and the source information, frequencies, and percentages of the students are given in Table 4.16. There are 161 valid answers about the source of knowledge on GMO.

Table 4.16 Findings about the source of information on GMO

Source of Information	f	%
Teacher	46	28,57
Internet	36	22,36
News	31	19,25
Family and Group Friends	23	14,29
Books	17	10,56
Documentary	8	4,97
Total	**161**	**100**

The answers given as sources of information about GMOs are teacher (f=46, 28,57%), Internet (f=36, 22,36%), News (f=31, 19,25%), Family and Group Friends (f=23 , 14,29%), Books (f=17, 10.56%), Documentary (f=8, 4,97%).

4.4.2 Findings about the Source of Information on Nuclear Energy

Middle school students were asked from where they obtained their knowledge about Nuclear Energy and the source information, frequencies, and percentages of the students are given in Table 4.17. There are 154 valid answers about the source of knowledge on Nuclear Energy.

Table 4.17 Findings about the source of information on Nuclear Energy

Source of Information	f	%
Internet	36	23,38
News	29	18,83
Science Course	26	16,88
Books	22	14,29
Documentary	14	9,10
Family and Group Friends	11	7,14
Social Studies Course	9	5,84
Technology Design Course	7	4,54
Total	**154**	**100**

The answers given as sources of information about Nuclear Energy are Internet (f=36, 23,38%), News (f=29, 18,83%), Science Course (f=26, 16,88%), Books

(f=22, 14,29%), Documentary (f=14, 9,10%), Family and Group Friends (f=11, 7,14%), Social Studies Course (f=9, 5,83%), Technology Design Course (f=7, 4,54%).

4.4.3 Findings about the Source of Information on Organ Donation

Middle school students were asked from where they obtained their knowledge about Organ Donation and the source information, frequencies, and percentages of the students are given in Table 4.18. There are 157 valid answers about the source of knowledge on Organ Donation.

Table 4.18 Findings about the source of information on Organ Donation

Source of Information	**f**	**%**
News	39	24,84
Internet	27	17,20
Science Course	25	15,92
Teacher	21	13,38
Books	19	12,10
Family and Group Friends	15	9,55
Banners	7	4,46
Newspaper	4	2,55
Total	**157**	**100**

The answers given as sources of information about Organ Donation are News (f=39, 24,84%), Internet (f=27, 17,20%), Science Course (f=25, 15,92%), Teacher (f=21, 13,38%), Books (f=19, 12,10%), Family and Group Friends (f=15, 9,55%), Banners (f=7, 4,46%), Newspaper (f=4, 2,55%).

5
RESULTS AND DISCUSSION

The study aims to examine the metaphorical perceptions and mental models of middle school students (6, 7, and 8th grades) regarding various socioscientific issues (GMO, Nuclear Energy, and Organ Donation). In this section, results, comments, and suggestions obtained from the results in line with the findings obtained in accordance with the purpose of the study are included. Results are presented according to general and sub-problems, respectively, and in the light of relevant studies in the literature.

5.1 Middle School Students' Metaphoric Perception Related to Socioscientific Issues

In this section, the metaphorical perceptions of middle school students towards GMO, Nuclear Energy, and Organ donation are evaluated according to the results obtained and studies in the literature.

5.1.1 Middle School Students' Metaphoric Perception Related to GMO

A total of 93 different and 143 valid metaphors were determined in 6 conceptual categories related to the concept of GMO by 180 middle school students. When the findings are examined, the categories in which mental models are included are as follows: "Effects on Health (f = 41)", "Change of Appearance (f = 31)", "Structural Changes (f = 29)", "Advantages (f = 19), "Contain Both Beneficial and Harmful Properties (f = 13)", "Uncertainty (f = 10)". When the metaphors produced by the students were classified based on their characteristics, conceptual metaphors (f=133) and ontological metaphors (f=10) were determined, and direction metaphors were not found. According to the results, it can be deduced that the students mostly formed concrete and conceptual metaphors about the concept of GMO. Few students made personification by displaying an abstract approach in metaphors about GMO. When the metaphors of middle school students regarding the concept of GMO are examined, it is seen that the developed

metaphors are in the category of "Effects on Health". The metaphors with the highest frequency values under this category are “unhealthy”, “hormone”, and “virus”. Most of the metaphors developed in this category are concepts depicting GMOs as being harmful to health, leading to deduce that students perceive so. In the study conducted by Yılmaz, Üner and Ercan (2015), it was revealed that 83.2% of university students think GMOs are harmful, and 64% think that the risks of GMOs are too high. When the metaphors were examined, it was seen that the students believed that GMO products were plant-based foodstuffs, that there were hormones in GMO products, and that GMOs made the food look bigger in volume. In the study of Öztürk, Ağapınar-Şahin and Güdü-Tüfekçi (2014) in which they investigated the knowledge and attitude of mothers about the concept of GMO, it was found that 56.5% of the mothers expressed GMO as a hormone food.

Students think that the areas of use of GMOs are generally in the food sector and that GMOs are mostly found in vegetables and fruits. In addition to food production, GMOs are used in a wide range from the health sector to the industrial sector. It is noteworthy that students do not associate GMOs with medicine, genetic engineering, or the pharmaceutical industry in terms of fields of use. In this respect, it can be said that the perception of the students that GMO products are only plant-based foodstuffs stemmed from the lack of knowledge. Demir and Düzleyen (2012) determined that students have misconceptions about GMO foods such as being hormonal, chemical, harmful, that they cause cancer, that they are generally used in the food industry, and that they change the taste and shape of foods. Some of the students created metaphors in the category of structural changes related to GMOs. In general, the explanation of the reasons for metaphors in this category is that gene transfer is obtained by giving genetically modified organisms different characteristics and obtaining artificial nutrients. In addition, students associated the structural changes caused by GMOs on foods with the concept of mutation. In parallel with this result, Uzunkol (2012) stated in her study that pre-service teachers have a perception that modified organisms have different forms. Furthermore, the common explanation of the metaphors is that genetically modified organisms are given features other than their required properties due to gene transfer.

In the metaphors created by the students regarding the advantages of GMOs, metaphors such as being nutrient-rich, undamaged products, long-lasting products, and product diversity were encountered. When the studies conducted in the literature examined, the potential benefits of GMOs were listed as the increase in the number of plant products, food production and quality, durable product, economic gain, and high product yield. Moreover, the results obtained were consistent with students' opinions (Arı & Kıvanç, 2019; Aydın & Ural-Keles, 2017; Ergin & Yaman, 2013; Atsan & Kaya, 2008; Çelik & Balık, 2007). In general, it was concluded that the students did not have sufficient knowledge about genetically modified organisms, they had misconceptions and the majority of them thought that genetic material modification technology was harmful (Demir & Düzleyen, 2012). Similar to the findings of this thesis study conducted by the researcher, it is seen that negative attitudes are dominant in most of the studies in the literature. In addition, studies on GMOs reveal that there is a lack of information and negative opinions are in the majority despite the change in the working group (Demirci, 2008; Gerçek, 2020; Kahveci & Özçelik, 2008; Morris & Adley, 2000; Shaow, 2002; Yılmaz, Üner & Ercan, 2015).

The metaphors created by middle school students and the explanations related to these metaphors showed that middle school students have many mistakes and secondhand information about GMOs. It is seen that the students think that the harmful effects of GMO are too much due to being misinformed and lack of information on the benefits. In order for students to have sufficient knowledge and more realistic perceptions about GMOs, more emphasis should be placed on GMO (Biotechnological Applications) subjects in education programs. That is because GMO, which is a notion quite up-to-date and widely used not only in the food sector but also in many sectors such as health, genetics, industry, and textile should be taught with all its positive and negative aspects. Based on the results obtained from this thesis and the research in the literature, it is seen that the students are also highly influenced by their teachers. Therefore, to prevent misinformation about GMOs, students should be provided with the right information through teachers from the first stages of education. To create such an environment, first of all, the teacher candidates who will educate others must have

the right information themselves. These prejudices, lack of knowledge, and misconceptions of teacher candidates can be prevented by giving more weight to biotechnology subjects in the education programs of the education faculties of the teacher candidates. In addition, considering the importance of metaphors in education, more metaphors can be used in the teaching-learning process to acknowledge students' perceptions and to explain concepts more easily and accurately.

5.1.2 Middle School Students' Metaphoric Perception Related to Nuclear Energy

A total of 94 different and 141 valid metaphors were determined in 6 conceptual categories related to the concept of GMO by 180 middle school students. When the findings are examined, the categories in which mental models are included are as follows: "Effects on Health (f = 33)", " Effects on the Environment (f = 32)", "Importance (f = 27)", "Take Measures (f = 22), "Generation of Nuclear Energy (f = 16)", " Nuclear Power Plant Descriptions (f = 11)". When the metaphors produced by the students were classified according to their characteristics, conceptual metaphors (f=134) and ontological metaphors (f=7) were determined, and direction metaphors were not found. According to the results, it can be deemed that the students created the most concrete and conceptual metaphors related to the concept of nuclear energy, as in the results of metaphors related to GMO. When the metaphors of middle school students regarding the concept of Nuclear Energy are examined, it is seen that the developed metaphors are in the category of "Effects on Health". The metaphors with the highest frequency values under this category are metaphors of “atomic bomb”, “dangerous”, “war”, “virus”, and “detrimental”. When the categories were evaluated in general, it was concluded that most of the metaphors formed in the minds of the students were negative. While the students focusing on the negative aspects of Nuclear Energy mainly talked about health and environmental risks, some students developed metaphors to take precautions against these risks. Sürmeli, Duru and Duru (2017) stated in their study that teachers have negative attitudes towards the use of nuclear energy and that they associate this situation with possible negative effects on nuclear accidents, ecological balance, natural

habitat, and living things. Ateş and Saraçoğlu (2013) determined that pre-service teachers think that nuclear power plants adversely affect the environment and living things, that necessary precautions are not taken about nuclear power plants, that radioactive materials will leak in nuclear power plant accidents, and that they could cause cancer in the region.

In another data obtained in this thesis study, middle school students who focused on the positive and important features of nuclear energy and created metaphors in this direction primarily stated the reasons for the benefits of nuclear energy such as economic growth and meeting the energy needs. Parallel to this result, in the study conducted by Ateş and Saraçoğlu (2013), some of the pre-service teachers argued that the use of nuclear energy would reduce the dependency on other countries to a minimum degree by meeting their own energy needs. It was observed that the students could consider the beneficial and harmful aspects of nuclear energy in terms of production, use, environmental and economic reflections in their metaphors, but they poorly structured the subject. In a study conducted by Özdemir (2014) with pre-service teachers, it was determined that almost all pre-service teachers did not have sufficient knowledge about nuclear energy, which is an extremely important and current socio-scientific issue. Some of the students perceived Nuclear Energy as a Nuclear Power Plant and produced metaphors for the Nuclear Power Plant.

In general, it was revealed that most of the students perceived nuclear energy primarily as harmful to health and the environment, and some of them perceived it as an important energy source when used carefully, referring to its power, and stating that it was beneficial. Therefore, it was emphasized that some of the students should be careful in its use, as it is a potentially harmful energy source. Similar to the results of this study, in most studies in the literature, it is seen that negative attitudes are dominant among a significant amount of teacher candidates and students (Bobat, 2006; Kılınc, Boyes & Stanisstreet, 2012; Sürmeli, Duru & Duru, 2017; Palabıyık, Yavaş & Aydın, 2010; Turan, 2017).

Nuclear Energy is a multifaceted socioscientific issue that includes many dimensions (Slovic, Finucane, Peters & MacGregor, 2004). It is very important to

enable students who will become citizens and scientists of the future to think multidimensionally. It will be possible to raise individuals who use resources effectively, produce solutions to the environmental problems they encounter, and consider many factors while seeking solutions with the education of nuclear energy. It is expected that teachers and teacher candidates who will transfer this kind of conscious thinking to future generations will have sufficient knowledge on socio-scientific issues that concern the environment. Therefore, while teaching Nuclear Energy, in Science Applications and Science courses, students can be guided by discussion activities such as interviews and argumentation, so that students can express themselves and become active participants.

5.1.3 Middle School Students' Metaphoric Perception Related to Organ Donation

A total of 79 different and 136 valid metaphors were determined in 8 conceptual categories related to the concept of Organ Donation by 180 middle school students. When the findings are examined, the categories in which mental models are included are as follows: " Opportunity to Start Over (f = 29)", " Life Saving (f = 23)", " Social Dimension (f = 17)", " Human Values (f = 16), " Uneasiness (f = 14)", " Vital Importance (f = 13)", " Religious Dimensions (f = 13)", " Emotions (f = 12)". When the metaphors of middle school students regarding the concept of Organ Donation are examined, it is seen that the developed metaphors are in the category of " Opportunity to Start Over ". The metaphors with the highest frequency values under this category are “reborn”, “new life”, and “luck” metaphors. When the metaphors produced by the students were classified according to their characteristics, conceptual metaphors (f=123), ontological metaphors (f=12), and direction metaphors (f=2) were identified. According to the results, it can be said that the students mostly formed concrete and conceptual metaphors about the concept of Organ Donation as in GDO and Nuclear Energy. However, metaphors containing more personification and direction have been identified compared to the metaphors produced on GMO and Nuclear Energy. When the categories were evaluated in general, it was concluded that most of the metaphors related to Organ Donation in the minds of the students had a positive and sentimental approach. When Tetik and Cebesoy (2019) examined the

thoughts of middle school students about the importance of organ donation in their research, the opinion most expressed by the students is that organ donation is important for ensuring social solidarity. Özer, Kilci and Gökçe (2016) determined in their study with seventh-grade students that they saw organ donation as saving lives and strengthened their feelings of cooperation and sharing. Few of the students developed negative metaphors about organ donation due to religious dimensions and the possibility of organ donation to create risky situations. In the study carried out by Tetik and Cebesoy (2018), the fact that middle school students want to receive information from health personnel and religious personnel about their organ donation status was interpreted as question marks arise in the minds of students not only in terms of health but also in terms of social and religious aspects. As a different result, Gökçe, Özer and Kilci (2016) reported that the willingness of students to donate organs is affected by cultural and religious factors in the study conducted with parents of students. The importance and necessity of organ donation can be mentioned in the Religious Culture and Moral Knowledge courses in the school for students who approach organ donation negatively from a religious point of view. Students can be taken to organ donation centers in order to increase awareness of organ donation and to clarify misconceptions.

5.2. Middle School Students' Mental Models Related to Socioscientific Issues

In this section, the mental models of the middle school students towards GMO, Nuclear Energy, and Organ donation are evaluated according to the results obtained and studies in the literature.

5.2.1 Middle school students' mental models related to GMO

A total of 15 different and 139 valid mental models were determined in 4 conceptual categories related to the concept of GMO by 180 middle school students. When the findings are examined, the categories in which mental models are included are as follows: "Change in Appearance (f = 81)", "Effects on the Quality (f = 22)", "Negative Effects on Health (f = 18)", "The Effect on the Production Process (f = 18). The most widely used mental model with a large

frequency value is "Larger fruit/vegetable/animal (48)". After this mental model, the most used mental models are " High fruit/vegetable yield (10) ", " Different colored fruit/vegetable (9) " and " Different shapes fruit/vegetable (9) ". In mental models, it has been observed that the majority of the drawings are that GMO changes the appearance of the products. It has been observed that the students draw GMO fruits/vegetables, animals, and plants very large in their drawings, and they draw people who consume GMO foods as larger than their normal size and even obese. In this case, it is seen that most of the students associate the GMO concept with hormones while explaining their mental models. In general, it can be said that students' mental models about GMO contain negative views. When the mental models drawn by the students about GMO were classified according to their characteristics, synthesis models (f=58), scientific models (f=43) and primitive models (f=38) were identified. It has been seen that most of the mental models drawn by the students about GMO are a synthesis of their own interpretations and the scientific knowledge they learned at school.

In the thesis prepared by Ertaş-Karaaslan in 2017, the metaphors and visual images of 189 preservice teachers related to genetically modified organisms (GMOs) were examined and similar results were obtained with this study. The highest category obtained from teacher candidates' drawings is "Appearance or structural change (f = 90)" and the drawings were found to contain generally negative characteristics of GMOs. Similarly, Yenilmez-Türkoğlu and Öztürk (2019) observed that pre-service teachers frequently used injectors in their mental models related to GMOs and they drew GMO products larger. This finding indicates that GMO and hormone use are confused. In addition, in the study conducted by Yenilmez-Türkoğlu and Öztürk (2019), as a different result from this study, there were new fruit depictions that emerged by combining two different fruits in relation to GMO. When the mental models of the students about the production process and quality of the students regarding the benefits of GMO are examined; it was found that GMO products made explanations about the ease of production activities, product yield in a short time, products with high nutritional content and the financial aspect of production. In parallel with this result, Bilen and Özel (2012) concluded in their study that middle school students

support the idea that farmers can make more production with GMOs and contribute to the country's economy. It has been revealed that middle school students generally use herbal products in their mental models related to GMO, and their effects on animals are mentioned in few drawings. This situation shows that most of the students perceive genetic modification as limited to plants. Ertaş-Karaaslan (2017) interpreted in his study with pre-service teachers that they mostly show GMO products on herbal products as they are not aware of or do not know about their applications on organisms such as animals and bacteria. GMO is basically the introduction of new features to living things by gene transfer, but students' drawing in the form of obtaining unnatural products with different appearances by injecting hormones, additives, or drugs supports the lack of knowledge and misconceptions about GMOs. Mohapatra, Priyadarshini and Biswas (2010) found that both teachers and students have misconceptions about the subject in their studies investigating the knowledge and attitudes of teachers and students in studies on genetically modified foods. In order to reduce students' concerns about GMOs, to provide them with information about the areas where GMOs are used, and to eliminate existing misconceptions, information can be provided by biotechnology experts.

5.2.2 Middle School Students' Mental Models Related to Nuclear Energy

A total of 22 different and 138 valid mental models were determined in 5 conceptual categories related to the concept of Nuclear Energy by 180 middle school students. When the findings are examined, the categories in which mental models are included are as follows: "Effects on Living Things (f=50)", "Effects on The Environment (f=30)","Advantages (23)", "Nuclear Power Plant (21)", "Nuclear Energy Generation (14) ". When the mental models drawn by the students about Nuclear Energy were classified according to their characteristics, scientific models (f=55), synthesis models (f=47) and primitive models (f=36) were determined. It can be said that students are inclined to use the scientific knowledge they learned at school in the mental models they draw about nuclear energy.

It was seen that most of the drawings in the mental models of the students were related to the negative effects of nuclear energy on living things and the environment. As a result of the study conducted by Sürmeli, Duru and Duru (2017), it was observed that teachers had negative attitudes about both the use of nuclear energy and the establishment of power plants. They stated that the reason for this situation was related to possible nuclear accidents, the negative effects of nuclear energy on ecological balance, natural habitat and living things. As a result of the negative thoughts of the students reached in this study, the result of this research is in harmony with each other. Ateş and Saraçoğlu (2013), in their studies examining the opinions of pre-service science teachers on nuclear energy, found that nuclear technology has an important place in the world, that nuclear energy will reduce the dependence on foreign countries and provide economic gain in meeting the energy need. The mental models in the "Advantages" category in the present study also support these findings. It was seen that a small number of middle school students had the atom and atomic nucleus model in their minds about the Generation of Nuclear Energy, and they knew that the energy released by the splitting of the atom is nuclear energy. Based on the mental models, it was seen that the students had conceptual information in their minds about this subject, but they had a lack of knowledge. In the study of Kaplan (2019) examining the conceptual structures of middle school students about nuclear energy, it was concluded that the concept of the atom is present in middle school students' minds regarding the formation of Nuclear Energy and that the energy released by the atomic fragmentation is nuclear energy. Moreover, middle school students are aware that nuclear energy has started to take place in our country.

5.2.3 Middle School Students' Mental Models Related to Organ Donation

A total of 14 different and 132 valid mental models were determined in 4 conceptual categories related to the concept of GMO by 180 middle school students. When the findings are examined, the categories in which mental models are included are as follows: " Effects on People (f = 42)", "Organs (f = 39)", " Social Dimension (f = 30)", "Hesitation (f = 21)". The most widely used mental model with a large frequency value is "Heart (21)". After this mental model, the

most used mental models are " Charity (14) ", "Happy People (13) " and "Be in a quandary (13) ". When the mental models drawn by the students about Organ Donation were classified according to their characteristics, synthesis models (f=63), scientific models (f=39) and primitive models (f=30) were determined. It has been seen that most of the mental models drawn by the students about organ donation are a synthesis of their own emotions and the scientific knowledge they obtained at school.

In general, it was seen that most of the drawings were about the positive effects of organ donation. This finding supports the findings of studies conducted with different research groups in the literature. Akçöltekin (2014) stated that teachers' attitudes towards organ donation were very high and it was due to teachers' awareness of the vital importance of organ donation, in their study conducted with classroom teachers. In addition, students have included heart, kidney, and lungs in their drawings of organ donation. In this case, it has been observed that students have a limited understanding of organs that can be donated. It was also revealed from the drawings of the students that they confused organ transplantation with organ donation. Caymaz and Aydın (2020) reached the conclusion that students had misconceptions about organ donation and organ transplantation in their test before argumentation-based instruction. In the same study, the students were asked the question of which organs or tissues can be transplanted successfully, and it was mostly answered as the heart, lungs, and kidneys. In the study conducted by Tetik and Cebesoy (2018), a significant majority of middle school students stated that they were aware of kidney, liver, and heart transplantations, but the number of students who were aware of bone marrow and cornea transplantation was less. On the other hand, a study conducted by Gürkan and Kahraman (2019) points out that the third-grade teacher candidates only consider the heart and kidney as organs to be donated shows that their knowledge on this subject is very limited.

5.3 The Approaches of the Middle School Students Towards Socioscientific Issues

When the students' approaches to GMOs were examined, it was observed that they generally exhibited a negative attitude. 69 of the students (40.83%) stated negative, 49 (28.99%) positive, 38 (22.49%) irresolute opinions about GMO, 13 of the students (7.69%) stated that they did not have any opinions about GMOs. As a similar result, Gerçek (2020) found that when students' opinions about GMOs were examined, 23 were positive, 167 were negative, and 11 were neutral. However, there is not such a big difference between the number of students with positive and negative scores. When the students' approaches to Nuclear Energy were examined, it was observed that they generally exhibited a negative attitude. While 72 of the students (41.86%) stated negative, 45 (26.18%) irresolute, 39 (22.67%) positive opinions about Nuclear Energy, 16 of the students (9.30%) stated that they did not have any opinions about Nuclear Energy. A study by Palabıyık, Yavaş and Aydın (2010) includes the question “What is the first thing that comes to your mind when you think of a nuclear power plant?” to which 64.2% of the 1,074 participants answered "negative"; while 35.8% of them stated that they had "positive" opinions. Among the negative opinions, radiation, hazardous waste, poison, Chernobyl-explosion, pollution-environment, and cancer are the first notions that come to mind, while energy supply takes the first place among the positive opinions. When these data are evaluated in general, the negative attitudes es of the students about GMO and Nuclear Energy are more common, but the number of students who are negative and/or undecided about Nuclear Energy is higher. The high number of students who are unsure about Nuclear Energy can be interpreted as the students are aware of the fact that Nuclear Energy is a powerful energy source as well as it could cause harm. Regarding this issue, although it is seen that students and teachers generally have prejudices against nuclear power plants, they believe that the nuclear power plant is beneficial and are concerned about its dangers (Ateş & Saraçoğlu, 2013). When the students' approaches to Organ Donation were examined, it was observed that they generally exhibited a positive attitude. 97 of the students (57.74%) stated positive, 33 (19.64%) irresolute, 29 (17.26%) negative opinions about Organ

Donation, 9 of the students (5.36%) stated that they did not have any opinions about Organ Donation. Considering the results of the study conducted by Soysal and Kaya (2019) on the thoughts of university students about organ donation, it was determined that 76.4% of the participants in the 17-20 age group had a positive opinion about organ donation, while 23.6% were negative. While 88.9% of the participants aged between 21-24 gave a positive answer, only 11% gave a negative answer. Various visits can be made to out-of-school learning environments within the framework of formal education to improve students' knowledge levels and raise awareness about socioscientific issues such as GMO, nuclear energy, and organ donation. In order to provide out-of-school learning and to improve or change students' attitudes, school trips can be organized to Laboratories on GMO, research centers on Nuclear Energy, and organ donation centers on Organ Donation.

5.4 The Source of Middle School Students' Knowledge on Socioscientific Issues

The answers given by the students as information sources about GMO were teacher (f=46, 28.57%), Internet (f=36, 22.36%), News (f=31, 19.25%), Family and Group Friends (f=23 , 14.29%), Books (f=17, 10.56%), Documentary (f=8, 4.97%). Özel and Gökmen (2020) revealed that university students know most about GMOs from the news (76.5%), social media (28%), lessons, and school (27%). Looking at the results, it is seen that teachers and media have a great role in the formation of students' ideas.

The answers given by the students as information sources about Nuclear Energy were Internet (f=36, 23.38%), News (f=29, 18.83%), Science Course (f=26, 16.88%), Books (f=22, 14.29%), Documentary (f=14, 9.10%), Family and Group Friends (f=11, 7.14%), Social Studies Course (f=9, 5.83%), Technology Design Course (f=7, 4.54%). The fact that students talk about the internet, news, and documentaries as a source of information about Nuclear Energy shows that the media is very important in raising awareness about socioscientific issues. In support of this result, Özdemir and Çobanoğlu (2008) state that pre-service science teachers state that visual and written media, periodicals, environmental

lessons, and textbooks are the sources of their knowledge on Nuclear Energy. In Akçöltekin and Doğan's (2013) research, the teachers' use of television and the Internet as sources of information about nuclear energy also supports this result.

The answers given by the students as information sources about Organ Donation were News (f=39, 24.84%), Internet (f=27, 17.20%), Science Lesson (f=25, 15.92%), Teacher (f=21 , 13.38%), Books (f=19, 12.10%), Family and Group Friends (f=15, 9.55%), Posters (f=7, 4.46%), Newspaper (f= 4, 2.55%). It is seen that the media and the school have great importance for students to obtain information about organ donation. These findings are in line with the results of studies conducted with different sample groups in the literature. Çetin and Harman (2012) stated in their study with high school students that they obtained information about organ donation on the internet (36.00%), TV (44.00%), and school (30.00%). Sakmen, Genç and Arslan (2020) stated that 6th-grade students heard and learned about organ donation from their teachers (47.6%) from television (16.6%) and books (11.9%). Soğukpınar, Karışan and Aktamış (2019) stated that most of the 7th and 8th-grade students learned about organ donation from their teachers and on the internet. Knowing the sources that students are affected by and obtaining information on socioscientific issues can provide information to teachers in terms of misconceptions and prejudices that students have. Interviews with students after the findings can provide more comprehensive information on this subject.

In general, when the results of the research are examined, it has been concluded that middle school students have negative perceptions and approaches towards the concepts of GMO and Nuclear Energy, but they have positive perceptions and approaches towards Organ Donation. It has also been observed that students are highly influenced by the media and teachers on socioscientific issues. While the students produced more metaphors and mental models on GMO and Nuclear energy, they produced fewer mental models and metaphors on Organ donation. This may be due to the frequency of the coverage of the issues in the media. When the mental models of the students are examined, it can be said that they show a more objective approach by creating more scientific models on Nuclear Energy, but they show a subjective approach by creating more synthesis models on GMO

and Organ Donation. It was observed that the same metaphors and mental models were created by the students in a small number. This is because students' prior knowledge, cultural structures, perspectives, personal experiences, and perceptions are different. Considering the importance of metaphors and mental models in education, teachers can give more weight to the use of metaphors and mental models in education to reveal students' perceptions of the subjects and to enable students to express concepts more easily and accurately. By using metaphors and mental models in teaching and evaluation processes; students' previous learning, approaches, misconceptions, and incomplete learning can be detected. Hence, this action can help to the source of the problem to be spotted. To prevent students from getting the wrong information and to correct their missing information or misconceptions, students should be provided with the right information through teachers, and for this, the teachers who will provide instruction should have the right information. In this respect, it is necessary to give more weight to socioscientific issues in the education programs of education faculties where pre-service teachers could experience the practicum.

In future studies, the results can be compared by using different and larger study groups and concepts. The study can be made more comprehensive by using the interview method to spot the underlying causes of the missing/wrong information and misconceptions that students might have.

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PUBLICATIONS FROM THE THESIS

Conference Paper

1. Ertuğrul, E., & Topçu, M.S., (2020). *Investigation of Studies on Mental Models Related to Socioscientific Issues.* In International Pegem Conference on Education (IPCEDU 2021), Online Conference.