MIDDLE SCHOOL STUDENTS' INFORMAL REASONING QUALITY, ATTITUDES TOWARDS SOCIOSCIENTIFIC ISSUES AND MOTIVATION TO LEARN SCIENCE

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ABSTRACT

MIDDLE SCHOOL STUDENTS' INFORMAL REASONING QUALITY, ATTITUDES TOWARDS SOCIOSCIENTIFIC ISSUES AND MOTIVATION TO LEARN SCIENCE

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The aim of the present study was investigating the relationship between students' informal reasoning quality regarding socio-scientific issues (SSI), attitudes toward SSI and their motivation to learn science. Data were obtained by using Informal Reasoning on SSI questionnaire, Pupils' Attitudes Towards Socio-scientific Issues (PASSI) and Students' Motivation toward Science Learning (SMTSL). The participants were 523 middle school students in 7th and 8th grades in Artuklu district of Mardin. Correlational research approach was used. The data were analyzed by using Pearson correlation analysis and multiple regression analysis. Pearson correlation analysis results revealed that there was a significant and positive correlation between students' informal reasoning quality scores and the variety of informal reasoning modes they use. In fact, the results of multiple regression analysis showed that self-efficacy and relevance institution significantly contributed to the prediction of informal reasoning quality of middle school students. However, it was observed that other sub-dimensions of motivation and attitude did not contribute to the estimation of students' informal reasoning. It also has been found that the

informal reasoning quality of middle school students is low. The reason might be that students are not familiar with socio-scientific issues. The integration of socio-scientific issues into science classes might be helpful for increasing their informal reasoning quality.

Keywords: Socio-scientific Issues, Informal Reasoning Quality, Attitudes Towards Socio-scientific Issues, Motivation to Learn Science

ÖZ

ORTAOKUL ÖĞRENCİLERİNİN İNFORMAL AKIL YÜRÜTME KALİTELERİ, SOSYOBİLİMSEL KONULARA KARŞI TUTUMLARI VE FEN ÖĞRENME MOTİVASYONU

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Bu çalışmanın amacı, öğrencilerin sosyo-bilimsel konulara (SBK) ilişkin informal muhakeme kalitesi, SBK'ye yönelik tutumları ve fen öğrenme motivasyonları arasındaki ilişkiyi araştırmaktır. Veriler, SBK Üzerinde İnformal Akıl Yürütme anketi, Öğrencilerin Sosyo-bilimsel Konulara Yönelik Tutumları (PASSI) ve Öğrencilerin Fen Öğrenmeye Yönelik Motivasyonları (SMTSL) kullanılarak elde edilmiştir. Araştırmaya Mardin'in Artuklu ilçesinde 7. ve 8. sınıflarda öğrenim gören 523 ortaokul öğrencisi katılmıştır. Çalışmada ilişkisel araştırma yaklaşımı kullanılmıştır. Veriler Pearson korelasyon analizi ve çoklu regresyon analizi kullanılarak analiz edilmiştir. Pearson korelasyon analizi sonuçları, öğrencilerin informel muhakeme kalitesi puanları ile kullandıkları informel muhakeme modlarının çeşitliliği arasında anlamlı ve pozitif bir ilişki olduğunu ortaya koymuştur. Aslında, çoklu regresyon analizinin sonuçları, öz-yeterlik ve kurumlara ilginin ortaokul öğrencilerinin resmi olmayan muhakeme kalitesinin tahminine önemli ölçüde katkıda bulunduğunu göstermiştir. Ancak motivasyon ve tutumun ölçeklerinin diğer alt boyutlarının öğrencilerin informal muhakemelerini tahmin etmede katkı sağlamadığı görülmüştür. Ayrıca ortaokul öğrencilerinin informel akıl

yürütme kalitelerinin düşük olduğu tespit edilmiştir. Bunun nedeni, öğrencilerin sosyo-bilimsel konulara aşina olmaması olabilir. Sosyo-bilimsel konuların fen derslerine entegre edilmesi, informal muhakeme kalitelerinin arttırılmasına yardımcı olabilir.

Anahtar Kelimeler: Sosyo-bilimsel Konular, Informal Akıl Yürütme Kalitesi, Sosyobilimsel Konulara Yönelik Tutum, Fen Öğrenme Motivasyonu

To my beloved family…

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LIST OF ABBREVIATIONS

ABBREVIATIONS

SSI- Socio-scientific Issues

TAP- Toulmin's Argumentation Pattern

PASSI- Pupil's Attitude Toward Socio-scientific Issues

SMTSL- Stundets' Motivation Toward Science Learning

NOS- Nature of Science

PST- Pre-service Science Teachers

IRI- Informal Reasoning Interview

ATSIS- Attitudes Towards Socio-scientific Issues Scale

SE- Self-efficacy

SLV- Science Learning Value

ALS- Active Learning Strategies

PG- Performance Goal

AG- Achievement Goal

LES- Learning Environment Stimulation

MAOTS- Mastery Approach Orientation Towards Science

EFA- Exploratory Factor Analysis

KMO- Kaiser Meyer Olkin

MRC- Multiple Regression Correlation

CHAPTER 1

INTRODUCTION

The rapid development in science and technology created additional dilemmas for the society. Biotechnological studies such as gene therapy, therapeutic cloning or global warming are called as dilemmatic issues because they cause a lot of controversies and debates in society. In other words, contradictory and conflicting thoughts about these issues cause a dilemma in society. These dilemmas related to community are seen as an important context for researchers to study socio-scientific issues (SSI). SSI are ill-structured problems that do not have definite solutions and that many perspectives should be considered while making decisions about the issues (Sadler et al., 2007). Many studies have been conducted in science education to investigate students' informal reasoning regarding SSI, such as genetic engineering, environmental problems, effects of technological products on human health, etc. Topçu (2008) said that when people in the society faced with such dilemmas, they try to understand and find solutions by creating new ideas and claims about the problems. Analyzing an SSI requires using cognitive processes to reach a reosoning. There are different types of reasoning and this study will primarily investigate informal reasoning. Informal reasoning includes both cognitive and emotional processes to cope with and solve these dilemmas in SSI (Öztürk, 2011).

1.1 Informal Reasoning Quality in Science Education

Analyzing and evaluating arguments based on reasons and establishing of claim-support relationship is at the center of informal reasoning (Cerbin, 1988). In informal reasoning, the premises are fixed and unchanging, and the conclusions are clear (Sadler, 2004). The assumptions, arguments, or conclusions put forward about any SSI involving informal reasoning are not flexible and straightforward, decisions

made on these issues are certain, and premises cannot be changeable. (Perkins et al., 1991). The conclusions and premises that emerge from informal reasoning are not definitive or are either supportive or contradictory. Problems using informal reasoning, unlike formal reasoning, are ill-structured rather than well-structured. According to Sadler (2004), evaluating complex structured problems that do not have definite solutions and finding answers like SSI is provided by informal reasoning. Informal reasoning comprises cognitive and affective processes. These processes are used to solve controversial problems. According to Shaw (1996), in general, people use informal reasoning to decide what to support and what actions to take in both supportive and contradictory situations. Since SSI problems are ill-structured and open-ended, finding solutions to and dealing with such issues is only possible by using informal reasoning (Öztürk, 2011). Informal reasoning about SSI has been discussed in many ways and defined in different ways. For example, Patronis et al. (1999) defined informal reasoning about SSI by considering social, ecological, and economic aspects, while Wu et al. (2003) defined this process by associating it with science and technology. According to Kuhn (1991), who carried out most of his studies by using Toulmin's argumentation model, the quality of informal reasoning is defined in terms of consistency, internal consistency, and the ability to perceive multiple perspectives. That is, when a person presents coherent arguments from multiple perspectives without contradicting his/her other views, that means the person's informal reasoning quality is high. On the other hand, if an individual's informal reasoning quality is based on a single point of view and exhibits contradictory and ambiguous arguments, his/her informal reasoning quality is insufficient and shows us that the complexity of the subject cannot be conceptualized by him/her. Informal reasoning quality studies for SSI have so far been studied by primary school students (Khishfe, 2014), high school students (Dawson et. al., 2017), both pre-service (Öztürk, Yılmaz-Tüzün, 2017) and in-service science teachers (Liu et al., 2019). This study was carried out with middle school students. I conducted this study to evaluate the informal reasoning quality of students related to SSI. I used Toulmin's Argumentation Pattern (TAP) while making the evaluation. In this model,

there are four different dimensions: data, claim, warrant, and backing, but I used the version of Topçu et al. (2010) that is improved based on Toulmin's model and includes a claim, justification, counterargument, and rebuttal sub-dimensions.

This study investigates middle school students' informal reasoning quality regarding SSI. There are many studies investigating the informal reasoning quality of students, their attitudes toward SSI, and their motivation to learn science separately, but there is no study examining the relationship between these three variables. Informal reasoning includes evaluating a situation from both its positive and negative aspects. While deciding what to believe and what to do about the situation people use their informal reasoning. Hence, informal reasoning quality includes the ability to defend one's own view by basing it on scientific evidence and presenting counterarguments and rebuttals to those who have an opposing view.

1.2 Previous Informal Reasoning Studies

Özden (2020) investigated the informal reasoning of middle school students and their informal reasoning quality regarding SSI. Özden interviewed students about scenarios related to organ transplantation, recycling, and the use of forest areas, which are socio-scientific issues. According to this research, logical, emotional, and intuitive modes of informal reasoning were used in the solutions to SSI issues by the students. In this study, Özden concluded that while middle school students are creating solutions to socio-scientific problems, they are using not only cognitive but also emotional processes. This study is a guide for my study that it can be handled in many contexts while investigating students' informal reasoning quality. It also justifies related research question 1: What are the students' informal reasoning quality regarding SSI (Global warming, genetically modified food)? I chose these scenarios because they both have the same structure, and the language of the scenarios is clear and understandable for middle school students. Each of the scenarios includes a brief explanation of the SSI and both positive and negative aspects of these issues with justifications.

The studies about SSI in science classrooms have an emphasis on informal reasoning. For example, Wu and Tsai (2007) carried out qualitative and quantitative research to investigate the informal reasoning of high school students on an SSI about whether the fourth nuclear power plant should be built in the area or not while there is an energy shortage issue in Taiwan. As a result of the research, it was revealed that the students made their informal reasoning by considering the issue with more than one perspective, and they tried to consider scientific evidence while making their decisions. Also, very few of the students were able to produce counterarguments and rebuttals, and this research could help for justification of related research question 1. As mentioned before, SSIs are ill-structured problems that do not have concrete solutions, and many perspectives should be considered while making decisions about the issues (Sadler et al., 2007). People use informal reasoning when dealing with such issues. Informal reasoning is generally a process that includes logic, knowledge, the ability to analyze knowledge, and the application of thinking skills. The quality of informal reasoning is determined by argumentation, which is a process that explains how a controversial and inconclusive subject is thought. The quality of informal reasoning also explains how an inconclusive subject is interpreted from every aspect, how a decision is made, and what decisions are based on. If an individual does not contradict his/her own decision in argumentation and takes many points of view while making a decision that means this individual's informal reasoning quality is high. Moreover, if an individual has high informal reasoning quality, s/he can present counterarguments and rebuttals to those who have opposing views.

1.3 Attitudes Towards SSI

According to Newhouse (1990), attitude can be defined as positive or negative feelings towards a person, an object, or a problem. Due to the emphasis on students' attitudes towards SSI, I used the Osborne et al.'s (2003) definition: "beliefs, values or feelings towards a subject such the enterprise of science, school science, the

impact of science on society, etc." (p.1053). In several studies, SSIs are intertwined with both science and society. When people speculate on SSI, they consider both the benefits and harms of SSI to society based on scientific evidence. Therefore, in many studies, SSI education has been assumed as an attitude towards science. In this study, it is studied how informal reasoning quality is predicted by the students' attitude toward SSI. SSI departs from science by focusing not only on the content of science but also on the social dimensions of this content of science (Topçu, 2010). Attitude can be defined as students' understanding of a situation by incorporating it into their mental representations as well as their existing knowledge. Attitude toward SSI, on the other hand, can be explained as having a tendency as a result of test hypotheses and evaluating evidence, as well as considering previous attitudes when dealing with controversial issues (Stenseth et al., 2015). For example, when the students' attitudes towards global warming and genetically modified organisms are examined in this study, what is examined is not only the students' attitudes towards science but also their attitudes towards global warming and genetically modified organisms, which are socio-scientific issues. Attitudes towards SSI can be more complex because the science here is related to our daily lives. Evaluating scientific knowledge for everyday problems involves not only what is right to learn about the world, but also what needs to be done to make a decision. In order to decide what to do, it is necessary to evaluate SSI from scientific, moral, economic, and social perspectives. Studies have revealed that SSI-oriented science teaching affects students' science attitudes positively (Day & Bryce 2013; Sadler 2009). However, several studies discussed how science attitude affects students' informal reasoning quality regarding SSI and how it affects their learning by evaluating existing scientific information (Jho et al., 2014). Understanding the relationship between students' science attitudes and their ability to make a judgment about science claims encourages practices in which they can understand how they can use the given information about science claims to reach a decision (Sandoval et al., 2014). According to Jho et al. (2013), understanding science has a reciprocal relationship with attitudes toward science and the context of decision-making in the everyday world. Therefore, studying SSI gives

students the chance to examine problems, make decisions about real-world problems, express their understanding, and develop their ability to conclude. This makes education about SSI important. Science educators assumed that a positive attitude towards science would make it easier for students to make decisions about science-related social issues, and they are trying to develop this situation (Jho et al., 2013).

Studies investigating attitudes towards science and SSI shed light on this study. According to Osborne et al. (2003) attitudes toward science do not consist of a single unitary structure, but rather a large number of infrastructures, all of which contribute to varying degrees of individual attitudes toward science. According to Osborne et al. (2003), many components were taken when measuring attitudes toward science. Although there are many components, these components were not included in the study.

One of the variables examined in this study is students' attitudes toward SSI. Jho et al. (2014) examine the relationship between scientific knowledge, attitude, and decision-making on SSI about nuclear power plants in Korea. In their study, the students were first given a pre-test questionnaire by the researchers, and then the students were given training on nuclear energy. After this teaching, a post-test questionnaire was applied and students' understanding of nuclear energy was examined and it was investigated to what extent their attitudes toward the subject changed. According to the results, while the scientific knowledge of the students, which is another variable of their research, improved significantly after the instruction, there was no change in their attitudes toward SSI. Yerdelen et al. (2018) conducted a study to improve the attitudes of pre-service teachers toward SSI. The authors prepared a semester-long SSI course and applied it to pre-service science teachers and pre-service social science teachers. They measured the participants' attitudes towards SSI as a pre- and post-test with the Attitudes towards Socio-scientific Issues Scale, which has three different sub-dimensions: liking of SSI, interest, and usefulness of SSI, and anxiety towards SSI. Research results showed that both groups achieved similar gains from this course. In addition, as a result of

the research, it was observed that liking, interest, and usefulness of SSI improved for both groups, but no significant change was observed in anxiety toward SSI. Moreover, Jho et al. (2014) conducted a study on students' science understanding, attitudes, and decision-making about SSI related to nuclear energy in Korea were examined. The researchers prepared SSI-focused instruction to reflect and encourage students' understanding of nuclear energy attitudes and decision-making. Researchers administered pre- and post-questionnaires to 89 participants. Students' preferences and decisions about nuclear power plants were evaluated. According to the results, while students' understanding of science improved significantly, no change was observed in students' attitudes and decision-making toward to issue. In addition, the researchers concluded that attitude and decision-making are linked to some extent, but science is not related to attitude. These results show us that attitude is accepted as a fixed characteristic of a person, and it does not change easily (Jho et al., 2014). These studies were also thought of as a guide and helped justification for related research question 2 of our study: What are the middle school students' attitudes towards SSI?

According to Aikenhead (2006), the majority of young people stated that they have a positive attitude toward the emphasis on scientific and technological issues for society. Based on this, we can say that using science outside of school will increase students' interest and abilities in learning science and it can be achieved by putting scientific literacy at the center and working with SSI (Aikenhead, 2006). Students are familiar with SSI topics from the social and natural world. SSIs are related to the social world because they are closely related and affecting society, and they are related to the natural world because they cover topics such as global warming and hydroelectric power plants which are topics that concern about nature. It is thought that students' motivation to learn these topics in science classes could be high, so in this study, students' motivation to learn about these topics is investigated.

1.4 Motivation to Learn Science

There have been many definitions of the concept of motivation in the literature. Deci and Ryan (1985) separate motivation in three main categories as “intrinsic motivation", "extrinsic motivation", and "amotivation". Deci and Ryan (2000) describe intrinsic motivation as motivation that creates inherent interest or curiosity. Motivation is a complex structure that explains individuals’ behavior and desire to learn about different activities (Çavaş, 2011). Students’ motivation to learn science is explained as “students’ active engagement in science-related tasks for achieving a better understanding of science” (Lee and Brophy, 1996, as cited in Çavaş, 2011). The motivation to learn science helps students to develop their science knowledge conceptually (Çavaş, 2011). Tuan et al. (2005) stated that students' learning purpose is very significant in structuring their understanding of science concerning "learning value" and "learning strategies". According to Glynn and Koballa (2006) in Mintzes and Leonard’s book named “Handbook of College Science Teaching”, if college science students have control over what and how they will do, they are more motivated to learn, which emphasizes the significance of “self-determination”. Students' motivation to learn science contributes to the development of scientific literacy skills such as learning science, obtaining evidence-based results, and learning how to define scientifically encountered questions (Glynn & Kittleson, 2011).

Just as inferences were made about college students' motivation to learn science, I also made inferences about middle school students' motivation to learn science in this study. SSI are issues that have an important place in society and have a scientific basis, as well as has both national and global dimensions, and requires to be dealt with within the values and ethics (Britt et al., 2011). In a study conducted by Britt et al. (2011) study to investigate how students' interests, engagements, self-efficacy, and attitudes developed with SSI. 6 cases were developed under the guidance of the teachers, and these cases were introduced to the students. Two different scales were used in the study, while one of them measured students' learning goals, attitudes

towards science, and self-efficacy, the other scale included working on socio-scientific cases. As a result of the analysis, students found the cases interesting, especially the girls, and they were very interested in the cases and claimed that they learned argumentation skills. The researchers claimed that the more interesting the students found the case, the more likely they were to learn. What I expected from this study is that there will be a positive relationship between students' attitudes towards SSI and their motivation to learn science. In addition, students with argumentation skills, that is, high informal reasoning, are expected to have high motivation for learning science.

According to Sadler (2011), many researchers agree that SSI are one of the important incentives for bringing science education to a skill-oriented point. Gulacar et al. (2020) conducted a study and in this study, they integrated sustainability-oriented SSI into the general chemistry course curriculum to see the effects of SSI on students' motivation to learn science and their self-efficacy. The study was prepared from Prezi, one of the digital learning platforms. The learning environment posed also included challenges such as the structure and properties of phosphate, its economic importance, and uses and supply risks. The study examined the effects of the intervention on students' motivation and self-efficacy. 760 participants completed pre- and post-intervention questionnaires, as well as participated in group discussions in specific roles. According to the analysis of open-ended questions and the results of statistical tests, the subject and related digital materials were positively received by the students. The results of the study showed that the integration of SSI into the general chemistry course increased the motivation of the students, and even more specifically, the ability of the students to find relevance in the material used in the course. The fact that they could connect the information given with reality and the discussion activity increased their chemical self-efficacy. In addition, the change in students' self-efficacy with the SSI measured in this study helped me to establish a connection with self-efficacy, which is one of the sub-dimensions of the PASSI questionnaire. While the findings showed that there was no significant difference between male and female students, the data showed that ethnic groups perceived the

intervention differently. In this study, I also examined the relationship between informal reasoning quality regarding SSI and students' motivation to learn science by using a questionnaire Students' Motivation toward Science Learning (SMTSL) developed by Tuan et al. (2005) which includes self-efficacy sub-scale to measure elementary school students' motivation to learn science. This questionnaire consists of 6 different scales that are self-efficacy, active learning strategy, science learning value, performance goal, achievement goal, and learning environment stimulation. There are many studies conducted with the sub-dimensions of motivation. For example, Lau and Roeser (2002) expressed that there is a significant correlation between self-efficacy and science achievement in a study they conducted. They stated that self-efficacy, which is one of the sub-dimensions of motivation, positively affects science achievement. In addition, Özkan (2003) conducted a study to explain the relationship between motivation and achievement, and the results were similar. In Özkan's study conducted with 10th-grade Biology students, the researcher stated that there is a positive relationship between self-efficacy and achievement variables. In fact, Tuan, Chin and Shiehc's (2005) explained the relationship between elementary school students' motivation to learn science with self-efficacy, active learning strategy, science learning value, performance goal, achievement goal, and learning environment stimulation, which are all sub-dimensions of motivation. They stated that among these sub-dimensions, the one with the highest correlation with science achievement was self-efficacy. One of the variables of this research is informal reasoning. However, science and mathematics achievement could be measured using students' critical thinking skills and formal operational reasoning (Bitner, 1991). Based on this, it could be said that informal reasoning includes formal reasoning because critical thinking and formal operational reasoning skills are processes that require informal reasoning. Lawson et al. (2007) stated that there is a positive relationship between reasoning ability and self-efficacy, based on the fact that high reasoning skills will make students more confident in their own success. These studies have helped me in the context of the relationship between motivation to learn science and informal reasoning quality, but this study investigated how

motivation to learn science predicts informal reasoning quality and there is no study examining this yet. Since there are no studies that examined how informal reasoning quality is predicted by the motivation to learn science, it would not be ethical to claim about this topic without any scientific evidence.

1.5 Relationship Among SSI Informal Reasoning Quality, Attitudes Towards SSI and Motivation to Learn Science

SSI in science education means the use of these topics in dialogue, discussion, and debate by students. The nature of these issues is controversial and deciding to resolve these issues requires moral reasoning and consideration of ethical concerns. The purpose of using these issues in science education is to attract students' attention and to use evidence-based reasoning to understand scientific knowledge (Zeidler & Nichols, 2009). Science education is important in the modern world so that future citizens can make decisions about science-based claims, so to enable students to actively participate in SSI discussions and argumentation, the educational environment should allow them to practice the skills they need and learn science content (Gray & Bryce, 2006). Research about SSI in science education is generally conducted in the context of informal reasoning quality. SSI involves the use of reasoning processes while making arguments and making evaluations about the topics (Shaw, 1996). Both formal and informal reasoning processes use while thinking about SSIs but since SSIs are ill-structured and do not have definite solutions, the informal reasoning process using more because the conclusions and premises that emerge from informal reasoning are not definitive or are either supportive or contradictory. The purpose of this study is to examine how students' informal reasoning quality toward SSI is predicted by their attitudes toward SSI. There are many studies examining the relationship between attitudes toward SSI and the quality of informal reasoning. As mentioned before attitude toward SSI, can be explained as having a tendency as a result of testing hypotheses and evaluating evidence, as well as considering previous attitudes when dealing with controversial

issues (Stenseth et al., 2015). Science education aims to create positive attitudes toward science. Therefore, it is important to explore how students understand their attitudes toward science in the context of SSI (Xiao et al., 2017). According to Yerdelen et al. (2018), the fact that pre-service science teachers with positive attitudes towards SSI are more likely to participate in discussions related to these controversial issues and this makes attitudes towards SSI important because in this case, pre-service science teachers will be enthusiastic about applying decision-making related to SSI in their classrooms.

According to Osborne et al. (2003), the reason why motivational and attitudinal studies in science education cannot be explained definitively is that researchers cannot distinguish between attitude as a science concept and as a school subject. Apart from this, the explanation of motivation to learn science, which is another variable of this study, in the context of informal reasoning and attitude can also clarify the purpose of the research.

Glynn et al. (2006) defined motivation as an "internal state that arouses, directs, and sustains students'' (p.1089). There have been many studies on motivation in science education so far. Student motivation is students' participation in lessons that they find important and valuable for them (Glynn et al., 2006). Students with high motivation are willing to learn and participate in classes, which makes them academically successful (Schunk et al., 2008). According to Bandura (1997), belief in one's abilities is defined as 'self-efficacy'. This concept is closely related to ability. If a person has no ability and so low self-confidence about a task, it will decrease his/her performance, similarly, if the person has the ability for a task and it means this person has high self-confidence, it will increase the success of that person in that task (Bandura, 1997). Motivation and self-efficacy are strongly linked to each other and students' abilities (Simons et al., 2014). Some studies investigated the relationship between SSI and motivation to learn science. For example, Gülacar et al. (2020) found that when SSI was applied to chemistry courses, students' motivation to learn chemistry improved. Meinhold and Malkus (2005) conducted a study to investigate students' (decision makers of the future) attitudes, concerns, and

knowledge about the world's environmental problems. They considered self-efficacy as an important issue because it is closely related to 'self-perception', 'locus of control', and 'pro-social development'. Researchers have observed that children who take action for the environment feel better, and their self-esteem and self-efficacy levels increase. In this study, the common sub-dimension that will be addressed in the scales of attitude towards SSI and motivation to learn science is self-efficacy. Based on the study of Meinhold and Malkus (2005), it can be deduced that attitude towards SSI and motivation to learn science are positively related to each other. Sinatra et al., (2012) found in a study they conducted that students' interests and subject knowledge were positively related to scientific consensus and that personal interest was a stronger predictor than the subject. The researcher of the present study also focused on the relationship between informal reasoning quality and attitude toward science and motivation to learn science.

1.6 Research Questions

1- How is the middle school students' informal reasoning quality regarding SSI (Global warming, and genetically modified food)?
2- What are the levels of middle school students' attitudes towards SSI?
3- What are the levels of middle school student's motivation to learn science?
4- What are the middle school students' reasoning modes on SSI (Global warming, genetically modified food)?
5- How can the middle school students' informal reasoning quality regarding SSI be predicted by attitudes towards SSI and motivation to learn science?

1.7 Significance of the Study

This study aimed to determine the relationships between students' informal reasoning quality, their attitudes toward SSI, and their motivation to learn science. Examining the attitudes of students towards SSI by using PASSI provided us to

explore the sub-dimensions of the attitudes separately. The findings provide important information to teachers to better address students' attitudes toward SSI when they eager to plan SSI based instruction.

Also, the results would be helpful to provide feedback for science educators and curriculum developers to produce new ideas about the implementation of the SSI in science classrooms.

The variables of this study are informal reasoning quality regarding SSI, attitudes toward SSI, and motivation to learn science makes the study significant because there are few studies in the literature examining the relationship between these variables. In addition, examining the relationships between these variables with multiple regression provides a new understanding of the literature. In that providing information about the predictors of the informal reasoning quality may help teachers and researchers to consider how attitudes toward SSI and motivation to learn science can be used to improve students' informal reasoning quality.

The curriculum developers can also use findings of this study to better integrate SSI teaching practices into science courses. For example, they can suggest using different SSIs for each unit in the science curriculum and have students make arguments for this issue at the end of each socio-scientific topic.

CHAPTER 2

LITERATURE REVIEW

The main purpose of this study is to examine the relationship between middle school students' informal reasoning quality, attitude towards SSI (global warming and genetically modified organisms) and their motivation to learn science. In this section, the studies that have been done in this field and that can guide this study are summarized.

In this section, firstly, studies in science literature involving informal reasoning with SSI, then students' attitudes towards SSI and finally studies covering students' motivation to learn science are summarized.

2.1 Informal Reasoning Quality Regarding SSI

Sadler and Zeidler (2004) found that individuals tended to establish relationships and produce solutions for SSI using three different informal reasoning models. These models describe the decision-making of individuals. In the interviews conducted with the students, the researchers identified three different inclusive models: rationalistic, emotive, and intuitive informal reasoning. If the student's ideas are causal and involve rational calculations, it is informal rationalistic reasoning. Eisenberg (2000) pointed out that if the individual approaches the subject with moral feelings such as empathy or sympathy and cares about the well-being of others, this is consistent with emotional informal reasoning. Intuitive informal reasoning, on the other hand, is based on emotions such as emotive informal reasoning, but it includes more immediate reactions (Sadler & Zeidler, 2004).

Kuhn (1962) said that reasoning tends to be molded into logic and mathematics, often in the case of science. In addition, a naturally occurring phenomenon leads to social

consequences as it dissolves. The fact that there is more than one viewpoint about SSIs in society is why they have become controversial. Baron et. al. (1991) stated that in reasoning, we plan to accept the results and reject previous information about a topic. In the factual evolvement of science, the reasoning was usually studied as part of logic and mathematics and matched with formal reasoning. Although the results of science are presented in the formal reasoning language that is heavily based on logic, these results are caused by informal reasoning. In scenarios where informal reasoning is used, both sides can form arguments, and a judgment can be made by informal reasoning due to the nature of this reasoning. In education reasoning, individuals examine complex problems by producing solutions unclearly (Sadler 2004). According to Zohar and Nemet (2002), suggestions or decisions created by informal reasoning are made according to the advantages and disadvantages of the topic. SSIs are absolute choices for the implementation of informal reasoning because these issues are ill-structured, controversial, and open-ended (Kuhn, 1993). Sadler and Zeidler (2004) carried out a study to determine informal reasoning patterns used while making decisions about SSI. SSIs have become a debatable subject with the development of biotechnology in the field of cloning, stem cells, and genetically modified foods; and with the environmental problems originating from climate change, use of lands, and exotic materials (Sadler & Zeidler, 2004). They indicated that SSIs are different from other issues for they can be interpreted from numerous perspectives with various solutions. Sadler et al. (2005) stated that there are many factors influencing informal reasoning. For instance, Sadler and Zeidler (2004) aimed to investigate to what extent the students are affected by those factors while explaining different SSI, and they mainly focused on the moral considerations. They used qualitative methods which are semi-structured interviews and applied to 30 college students about genetic engineering. They collected data from 15 participants who have experience in natural science courses and 15 participants from psychology classes who have limited experience in natural science. All participants are from a public university in the Southeastern United States. The researchers applied a two-phased interview, the first one includes different questions

about 6 genetic engineering scenarios to make participants create rationales, positions, counter-positions, and rebuttals while the second one is based on the factors that influence the participants to present arguments. To ensure reliability and validity, they used "investigator triangulation", "member checking" and "audit trail" methods. The results of the study show that there are three main informal reasoning patterns which are rationalistic (rational explanation), intuitive (immediate reaction), and emotive (emotional explanation). Moreover, some explanations present that participants integrate different informal reasoning patterns for the same scenarios. The study supported the idea that all factors including morality are integrated while making decisions about SSI. This study leads us for predicting middle school students' informal reasoning quality.

Tweney (1991) pointed out that even though the outcome of science can be submitted in the form of formal reasoning and deduction, the results themselves come through informal reasoning. Perkins (1985) and, Means and Voss (1996) argued that assignments that are used in classrooms are informal based on their features. Since the skills of informal reasoning can have great significance, the importance of informal reasoning is progressively emphasized by educational researchers (Kuhn, 1993). The informal reasoning of students on SSI is gaining more and more interest among science educators. In a study conducted by Wu and Tsai (2007), they analyzed the informal reasoning of high school students on a socio-scientific topic and developed an analytical framework to deeply understand all aspects of this topic. 71 10th-grade students that include 45 males and 26 females who study in a different classroom in a high school in Taiwan participated in this study. The study investigated the informal reasoning of students in a debate about whether the fourth nuclear power plant should be built in the area or not while there is an energy shortage issue in Taiwan. Students were informed about the pros and cons of the different methods to produce electric power and the basic principles of nuclear power in their physics course before the study was carried out. Wu and Tsai (2007) developed an integrated framework by using the summation of the analysis methods of the prior studies. They used some qualitative indicators to represent the informal

reasoning of learners. They used “qualitative indicators” to assess the argumentation and decision-making of students on SSI. Researchers developed an open-ended questionnaire to measure students' informal reasoning about nuclear energy use. Students were asked by the researchers whether they supported their ideas about establishing a nuclear power plant in Taiwan. Students summarized this situation in terms of security, economy, and ecological aspects, indicating both its advantages and disadvantages. After the questionnaire was applied, they analyzed students’ informal reasoning qualitatively based on qualitative indicators and some quantitative measures. From the results of the study, they concluded that almost a quarter of the participants were intuitively aimed at making their decisions regarding the use of nuclear energy. After reading the report, students who decided by using evidence-based thinking more intended to change their ideas and reconsider the contrary of intuitive thinkers. It is implied that science educators should take into consideration the decision-making steps of the students to raise them as rational thinkers. Since one of this study’s research questions is “What are the students' informal reasoning quality regarding SSI (Global warming, and genetically modified food)?” The reason for choosing these topics during research is issues are based on scientific concepts and problems, and they are controversial. In the study, these topics were chosen because it was desired to conclude by using reasoning rather than putting people's views into a certain context and pattern. The findings of Wu and Tsai’s study are in a guiding position for us to answer the question. Based on this study, we can say that students' informal reasoning about SSI can change depending on the evidence and lead them to rethink such issues. As it was said before, integrating SSI into science teaching may lead to important improvements in science teaching when it is used as an educational tool to improve students’ scientific literacy. Dawson and Venville (2009) conducted research for purpose of explaining the importance of scientific literacy by interpreting high-school Australian individuals’ informal reasonings and argumentation on a specific SSI, biotechnology. Christensen (2001) pointed out that “scientific literacy is about preparing future citizens to make personal and collective decisions on SSI” (p.142).

Dawson and Venville (2009) assumed that there will be a positive relationship between the quality of informal reasoning, argumentation techniques, and scientific literacy which is necessary for presenting claims and rationalizing arguments. The study was applied to 30 high school students, 10 of whom are 8th graders, 14 of whom are 10th graders and 6 of whom are 12th graders from six metropolitan high schools in Perth. Data was collected via semi-structured interviews which had a prepared interview guide. The participants from each level were grouped as three or two to make them feel less pressure than in a one-to-one interview. They have been asked some questions to explain their opinions about biotechnology, genetic testing, and genetically modified foods for 30-60 minutes and the interview session was audiotaped. The researchers analyzed transcripts of interviews by taking into consideration argumentation patterns developed by Toulmin and informal reasoning patterns developed by Sadler and Zeidler (2005a). They have been classified as rationalistic, intuitive, and emotive. According to Sadler and Zeidler (2005a), if people instinctively and momentarily present ideas to the SSI it is “intuitive”, if they approach such issues with their feelings or other people's well-being, it is “emotive”, or if the person expressing his/her opinion using logic and reasoning and approaching such issues with scientific concepts, it is "rationalistic". Then, they have been categorized into argumentation levels (1-5) according to using rationales, data, warrants, qualifiers, and supporting their ideas with examples while explaining their ideas. To ensure reliability, the interviews were coded by two researchers independently. The results show that all students from each grade level dominantly explain their opinions with 179 different statements, mostly using intuitive (59 statements) and emotive (51 statements) informal reasoning patterns and using level 2 (101 statements) argumentation pattern which includes claim and supporting examples. The fact that the informal reasoning quality of the high school students participating in this research is mostly intuitive about SSI is also a clue for this study that will be conducted with middle school students and serves the same purpose. It is understood that the informal reasoning qualities of the majority of the middle

school students participating in this study were included in the intuitive class, and these findings were taken into account when analyzing the results of the study.

Many studies have been conducted in which informal reasoning and SSI are investigated together. Sadler (2004) based these studies on specific issues such as the conceptualization of the nature of science (NOS) and the interpretation of materials involving informal reasoning. Sadler also emphasized that it is important to determine what kind of relationships exist between sociology-based informal reasoning, how data are interpreted, and the evaluation of information. Therefore, Topçu's (2008) approach sheds light on how data can be collected and evaluated in this study, which aims to measure middle school students' informal reasoning quality toward SSI. Topçu (2008) carried out this study to investigate informal reasoning patterns of pre-service science teachers' (PSTs') about SSI and factors affecting their informal reasoning. Participants of the study were senior elementary 39 PSTs who participated voluntarily from a public university in Ankara 13 of them were male while 26 of them were female. Since the participants had completed their biology, chemistry, and physics course as must courses. It is assumed that their previous knowledge about gene therapy, cloning, and global warming is sufficient. In the study, 7 different SSIs were used to examine the rationalistic, emotive, and intuitive and informal reasoning patterns of participants, which included gene therapy, cloning, and global warming. It is used two different interview standards to investigate the informal reasoning patterns of pre-service science teachers (PSTs) about SSI and the factors affecting their informal reasoning. Whereas the Informal Reasoning Interview (IRI) protocol was used to examine informal reasoning, the Moral Decision-Making Interview protocol was applied to describe informal reasoning and the factors affecting informal reasoning. During interviews that have the same conditions, participants expressed their judgments about controversial issues. Constant comparative data analysis method (Glaser & Strauss, 1967) was used to analyze data. It is concluded from the study that, PSTs easily state a claim for informal reasoning quality (rationalistic, emotive, and intuitive) regarding SSI, but they faced difficulties when they formulated counterarguments and rebuttals.

From this point of view, we can say that even university students who have completed the science curriculum in almost every aspect and reached a certain level have difficulty in producing counterarguments and rebuttals although they can easily put forward claims about SSI, it was very difficult for middle school students who are at the beginning of science education to put forward counterargument and rebuttal about such issues.

2.2 Argumentation and Informal Reasoning

Sadler (2004) defined SSI as complex and open-ended dilemmas related to issues such as health, environment, and economy that require a multi-faceted perspective, often do not have definitive solutions and concern society. Zeidler et al. (2011) stated that SSIs are included in science education as a way to improve students' scientific literacy so that they can decide on situations in their daily lives. When these issues are included in science learning, they lead students to participate actively in the lessons (Karpudewan & Roth, 2016). Integrating SSI into science learning provides students' with active participation in subject knowledge, informal reasoning, decision-making, and argumentation (Zeidler & Nichols, 2009). According to Aleixandre et al. (2007), argumentation motivates students to explain their thoughts by basing data and evidence on theory and hypotheses while supporting or refuting claims. In argumentation, students develop criteria, and while they are doing that they use the language of science. They are also evaluating and explaining the claims, evidence, and justifications, which increases their self-confidence (Kim, Anthony & Blades, 2014). That is why argumentation plays an important role in the treatment of SSI. Venville and Dawson (2010) conducted a study to investigate the effect of classroom-based argumentation on high school students' argumentation skills, informal reasoning, and conceptual understanding of genetics. They presumed two 10th-grade classes as an argumentation group and two 10th-grade classes as comparison groups (n = 46). This research was conducted as a case study in a school with an embedded quasi-experimental design. The argumentation group took a 50-

minute class providing professional learning and learned argumentation skills. In the next two lessons, both the argumentation group and comparison group discussed scientific issues from different aspects. According to the findings, it was observed that the argumentation group improved significantly in the complexity and quality of their arguments compared to the comparison group, and they included more rational informal reasoning in their explanations. It was revealed that both groups showed significant improvement in their understanding of genetics, but the development of the discussion group was significantly better than that of the comparison group, even after a brief intervention with only three lessons, in the structure and complexity of the students' arguments, the degree of rational informal reasoning, and the significant improvement of students in terms of conceptual science, which shows the importance of the study. From this point of view, it was assumed that SSI-based teaching used in science courses contributes to students' rational informal reasoning skills.

Argumentation is an effective method in science education. It is beneficial in many aspects when SSIs are discussed and informal reasoning about SSI, especially as it enables students to consider a subject from every angle, express an opinion, make a decision, defend their own view, and present rebuttal and counterarguments to opposing views. It has been an important data collection tool in many of the studies conducted by researchers on SSI. In this part of the study, the place of argumentation in the context of informal reasoning on SSI is mentioned since I used Toulmin's Argumentation Patterns (TAP) while evaluating the informal reasoning quality of the students.

2.3 Attitudes Toward Science and SSI

One of the characteristics of SSI is that they can be discussed in democratic societies. Bizer et. al. (2003) said the fact that people participate in such discourses and form judgments by evaluating such issues relatively and permanently, reflects their attitudes towards such issues. Etymologically, attitude can mean a stance, but it has

more than one definition. One of the well-known definitions made by Ajzen (1988) is “the tendency to respond positively or negatively to an object, person or institution”. Moreover, Eagly and Chaiken (1993) explained attitudes as “a psychological disposition in which an entity is expressed to a certain extent by evaluating its favor and disfavor” (p.1). However, as it was said before, in this study, I used Osborne et al. (2003)’s definition of attitude; “beliefs, values or feelings about science initiative, school science, the impact of science on society, etc.” Because I measured the attitudes of students towards SSI since SSI are the issues that concern the society and as a part of school science. As mentioned earlier, attitude is people's understanding of a situation by including their mental processes as well as their existing knowledge. However, the attitude toward SSI is explained as the tendency on the subject while dealing with controversial issues by testing hypotheses and evaluating evidence together with previous attitudes (Stenseth et al., 2015). In recent years, the examination of students' attitudes toward science has reached an important point and many studies have been conducted examining students' attitudes towards science (Topcu, 2010; Hacieminoğlu, 2016). In this study, it was not investigated the attitude toward science, but the attitude towards SSI. Schibeci (1983) clarified that the attitude towards science is an emotional rather than a cognitive orientation. According to Freedman (1997), attitudes toward science can be affected by many variables. For example, studies have shown that students who receive applied laboratory education have a positive attitude toward science (Freedman, 2002). Based on this, we can make a reconciliation that students' attitudes towards SSI can also be affected by many variables and develop. In this study, attitudes toward SSI were taken into consideration, but when we review the literature, although there are studies related to attitudes toward science, there are not enough studies investigating attitudes toward SSI. For example, Stenseth et al. (2010) conducted a study to predict attitudes towards two SSIs (potential risk associated with nuclear power plants and human-induced climate change). The sample consisted of 153 senior Norwegian secondary school students. As a result of the study, it was found that subject knowledge is a better predictor of attitudes towards nuclear power plants than

attitudes towards the subject matter, whereas the subject's motivation is a better predictor of attitudes towards climate change than the subject. Therefore, more knowledgeable students were less concerned about the potential risk of nuclear power plants than less knowledgeable students, and more motivated students seemed more likely to decide that climate change is human-induced than less motivated students. In fact, while students' subject knowledge was at different levels, their interests and attitudes also differed accordingly. It is different that while the interaction between subject knowledge and interests. In addition to the environmental consequences of the problems related to resources and energy consumption, energy is one of the important issues in today's world because of its local, political, and economic contexts. Energy great interest to us as consumers in terms of health and well-being (DeWaters et al., 2013). In a study, conducted by Ntona et al. (2015) to investigate the views and attitudes of secondary school students in this energy context, which is one of the SSI. They carried out the research in the Grevana region of Macedonia and selected the participants of the research from a total of 249 students, from five different middle schools. The reason they chose these students was that they thought they were the most suitable group to get their knowledge and views on the energy-saving issue. The reason for the researchers to carry out this study is to examine the attitudes and habits of students to develop positive environmental behavior for sustainability. According to the research findings, the attitudes of the students towards energy are that they believe that they are responsible for the consequences of their actions and that they have the ability to contribute to saving energy. Very few of them think that they cannot bring about any change by taking responsibility for the energy-saving issue. The results of this study are in a guiding position for me because, in this study, a conclusion has been reached about the attitude towards energy consumption and saving, which are some of the SSI. This helped me to relate attitudes towards these issues and global warming and genetically modified food, and the results are highly responsive to research question 3: What are the middle school students’ attitudes towards SSI?

Topcu (2010), developed and validate the Attitudes towards Socio Scientific Issues Scale (ATSIS) which is used for undergraduate students from science education to determine the scale's validity. Topçu also applied the scale to 216 undergraduate students from science education, elementary education, and social sciences departments to ratify the factorial structure of the scale. There are four different dimensions of ASTIS; "Liking of SSI", "anxiety towards SSI", "usefulness of SSI" and "interest of SSI". At the end of the study, the relationships between these dimensions were also analyzed. For example, while there was a positive correlation between students' interest in SSI and their liking for SSI, there was a negative correlation between interest in SSI and anxiety towards SSI. Moreover, this scale can distinguish between students with major and non-major students. After the scale was applied, the predictions about the attitudes of the students with majors towards SSI were positive, while those without majors would be negative and these predictions were confirmed.

Moreover, Topcu's this study has detailed students' attitudes towards SSI in many respects and has brought a deep clarification to this issue. As it was said before, there is a need for studies that measure students' attitudes toward SSI, especially middle school students. Unlike many of the scales that measure the attitudes toward SSI, the Attitudes Towards Socio-scientific Issues Scale (ATSIS) not only helps to increase the number of studies conducted in that field but also enables the subject to be handled from different dimensions. Therefore, developing scales measuring students' attitudes toward SSI will greatly contribute to the literature., However, Pupil's Attitudes Toward SSI (PASSI) scale, developed by Klaver and Molen (2020), measuring middle school students' attitudes towards SSI, was used in this study, since ATSIS measures attitudes towards science, not SSI, and was developed for university students. Kapici and Ilhan (2016) investigated the attitudes of pre-service teachers toward SSI and their views on nuclear power plants in a study they conducted. The research was conducted with 60 pre-service science teachers and 60 pre-service social studies teachers. In the quantitative part of the study, ATSIS was developed by Topcu (2010) and it was applied to pre-service science teachers and

pre-service social studies teacher candidates. This part of the study showed that the majority of the participants had positive attitudes toward the interest and usefulness of SSI. In the qualitative part of the study, group discussions were held about what nuclear power plants are and how they work, and as a result of this discussion, it was observed that the candidate teachers did not have sufficient scientific knowledge about this subject. The results showed that SSI, besides attracting the attention of teacher candidates, creates religious, moral, and ethical doubts at some points in its applications. In the discussion part, it was revealed that teachers in pre-service science and pre-service social studies have different views on establishing a nuclear power plant. Moreover, Yerdelen et al. (2018) conducted a study for a similar purpose to investigate the attitudes of Pre-service Teachers toward SSI using ATSIS. In this study, an SSI course was applied to two different groups studying in science education and non-science education throughout the semester, thus it was desired to observe whether this course affected students' attitudes towards SSI in a similar way. To see this, the researchers applied ATSIS before and after the course. They found that both pre-service science teachers and non-science pre-service teachers provided similar contributions in terms of interest and usefulness of SSI, liking SSI, and anxiety towards SSI. After the SSI course, no change was observed in the anxiety towards SSI of the students in both groups, whose liking of SSI and interest and usefulness of SSI increased. The fact that these two studies are conducted with university students makes this research significant because examining the attitudes of middle school students towards SSI will bring a more detailed explanation to the literature in this field. Another study on students' attitudes towards SSI was conducted by Jho, Yoon, and Kim (2013) to examine the relationship between understanding of science, attitudes, and the decision-making of students on SSI. Researchers chose the nuclear energy issue in Korea for this study. In this study, SSI-based instructions have been developed to enable students to understand and reflect knowledge, attitudes, and decision-making about nuclear energy in their society. Pre and post-questionnaires were applied to 89 students who attended these instructions to determine their understanding of the issue. As a result of the study, it was

concluded that students' understanding of science improved significantly during the course they took, but there was no change in their attitudes and decision-making about nuclear energy. When the relationships between these three variables are examined, it is revealed that attitude and decision-making are connected at a certain level, but science knowledge does not have any significant connection with attitude. The data of the study were analyzed using correlation and regression. The results revealed that attitudes towards nuclear energy are related to decision-making and that attitudes affect students' decision-making. In addition, while the students' science content knowledge improved throughout the research process, their attitudes toward nuclear energy remained stable.

Namdar et al. (2020) conducted a study whose aim was to examine the role of media literacy and attitudes toward SSI, which are two main predictors of informal reasoning. Participants were 208 pre-service science teachers. The researchers chose hydroelectric power plants as the socio-scientific topic, and the participants filled out an open-ended attitude and informal reasoning questionnaire about it. Both qualitative and quantitative methods were used for data analysis. While analyzing their informal reasoning quality, it is found that answers generally include supporting arguments rather than counterarguments and rebuttals. However, the researchers concluded that while media literacy level predicted informal reasoning but attitudes toward SSI did not explain informal reasoning. The study of Namdar et al. (2020) offers us an important conclusion since one of the aims of this study is to examine how the informal reasoning of middle school students is predicted by attitudes towards SSI. They explained that there is no relationship between the informal reasoning quality of pre-service science teachers and their attitudes toward SSI. Based on this, I have considered the possibility that middle school students' attitudes toward SSI may not predict the students' informal reasoning.

2.4 Motivation in Science Learning

One of the aims of this study is to investigate how students' informal reasoning quality predicts their motivation to learn science and to examine the relationship between these two variables. Therefore, it is important to examine the studies in the literature on students' motivation to learn science. Although there is no study in the literature examining the relationship between these two variables, explaining students' motivation to learn science sheds light on many aspects for me. In this part of the study, it is explained which variables are related to the students' motivation to learn science and what their profits are. According to Brophy (1998), motivation to learn science is "a student's tendency to find academic activities meaningful and worthwhile and to try to get the intended academic benefits from them." (p. 205-206). There have been studies that deal with motivation in science learning from many aspects. For example, students' motivation to learn science is explained as students' active engagement in science-related tasks for achieving a better understanding of science" (Lee & Brophy, 1996). Many studies related to the motivation to learn science have been carried out and many results have been reached as a result of these studies. To illustrate, motivation to learn science helps students to develop their science knowledge conceptually (Çavaş, 2011). Tuan et al. (2005) emphasized that students' learning goal is also crucial to construct scientific understanding according to "learning value and learning strategies" (as cited in Çavaş, 2011). According to Glynn and Koballa (2006), if college science students have control over what and how they will do, they are more motivated to learn, which emphasizes the significance of "self-determination".

Moreover, Çavaş (2011) conducted a study to examine the factors affecting the motivation of Turkish primary school students towards learning science and examined the motivation of students in terms of gender and grade level, and also looked at the relationship between students' attitudes toward science and their motivation to learn science. Students' Motivation toward Science Learning (SMTSL) questionnaire developed by Tuan et al. (2005) and translated into Turkish by Yilmaz

and Cavas (2007) was used to measure students' motivation. After the scale was translated into Turkish, its validity and reliability were tested. The Turkish version of the scale consists of 6 sub-scales and 33 items. The participants of the research are 376 primary school students studying at 6 public schools in İzmir. 188 of them are females and 188 of them are males. She conducted the study by taking into consideration different factors such as "self-efficacy (SE) (7 items), science learning value (SLV) (8 items), active learning strategies (ALS) (5 items), performance goal (PG) (4 items), achievement goal (AG) (5 items), and learning environment stimulation (LES) (6 items) scales." To analyze data, descriptive statistical analysis, t-test, ANOVA, and Pearson correlation were used. According to the independent t-tests used for analyzing whether there is a difference between females and males, female students are more motivated to learn science. In order to analyze whether there is a difference between students for science motivation, attitude, and achievement in terms of grade level, ANOVA was used, and the results show that students' science motivation, attitude, and achievement are significantly affected by grade levels. The results of the study showed that students' motivation to learn science affects their attitudes toward science. As a result of the research, students with high motivation also had a positive attitude towards science and related to this, students' science success increased. Researchers concluded that students with high motivation to learn science have positive attitudes toward science and these students are more successful in learning science. This research is important because it reveals students' motivation to learn science and their attitude toward science, and how these two variables are related to each other. This research could be helpful to interpret and make some reconciliations with the relationship between science learning motivation and attitude toward SSI in this study. Since the variables of this study are attitudes toward SSI and motivation to learn science, motivation to students with high motivation to learn science also have positive attitudes towards science gave me the chance to make some predictions about this study. In his study, I expected students with high motivation to learn science to have positive attitudes towards SSI, which is one of the dimensions of science. I also thought that these two variables,

which had a positive relationship between them, would reveal similar results while predicting the other variable of the research, informal reasoning quality.

In fact, a study was conducted by Sevinç et al. (2011) using the same scale to examine primary school students' motivation levels for learning science. In this study, which was carried out with 6th, 7th, and 8th-grade students, they concluded that students' gender, academic achievement, and taking private lessons had significant effects on students' motivation to learn science. Çavaş (2011) and, Watters and Ginns (2000) indicated that motivation is known as a complex psychological concept that tries to explicate behavior and effort in different activities. Various features are associated with motivation such as curiosity, permanence, learning, and performance (Barlia & Beeth, 1999). According to Barlia (1999), motivation is critical educational quantity because it supports the performance of both new learning and previously learned skills strategies behaviors. Lee and Brophy (1996) pointed out that since the "motivation for science learning" concept has a vital role in the conceptual change process, critical thinking process, and scientific process skills, it has great importance on science learning. As mentioned before, informal reasoning for SSI includes critical thinking processes. As explained here, the fact that motivation to learn science has an important role in critical thinking processes shed light for me in this study. Since one of the aims of this study is to explain how motivation to learn science predicts informal reasoning, it is expected that there will be a positive relationship between motivation to learn science and informal reasoning at the end of the study, based on these findings.

Furthermore, Güvercin, Tekkaya, and Sungur (2010) stated that "students' motivation for science learning decreased as the grade level increased and girls' motivation for science learning was higher than boys" based on their research that investigate how gender and grade level of primary schools' science learning motivation. Students' motivational level was found to have a considerable impact on their science attitudes and achievement in science (Güvercin et. al 2010). Sevinç et. al. (2011) conducted a study to investigate the motivation levels of primary school students toward science learning. The participants of the study were 518 students

from 6th, 7th, and 8th grade in three different middle schools in Trabzon. The mean value of the ages of the female students is 12 while the males' mean value of the age is 13. While they were chosen, researchers ensured that the socio-economic level of schools are similar, they coded the schools as A, B and C. Students were chosen randomly. It was investigated by researchers that the education level of mothers is primary while fathers' are secondary. A survey method was used in this study. Researchers used the Turkish version of a questionnaire "Students' Motivation toward Science Learning (SMTSL) that consists of 35 Likert scale items consisting of 6 degrees (Strongly disagree, disagree, no opinion, agree, strongly agree), which has been translated into Turkish by the Yılmaz and Cavaş (2007). A statistical package program was used for analyzing data. In the questionnaire, students were given 5 points for 'Strongly agree' choice while 'Strongly disagree' choice was 1 point. After collecting data, two-way ANOVA was used to investigate whether parental education level affects motivation. In addition, according to academic success, Kruskal Wallis test was used to determine the importance of motivation levels of students for science learning. It is revealed from the study results, female students are more highly motivated than male students for science learning. Motivation level is increasing with academic success and tutoring, and it is not affected by the laboratory activities and parents' educational levels. This means that examining and explaining students' motivation to learn science from different perspectives would be a good way to improve science education. Conducting such research will have many benefits, such as the arrangement of the science curriculum, the teaching methods and techniques to be used in the lessons, and the understanding of the aspects of pre-service teachers to improve themselves. Besides, Mubeen and Norman (2014) researched the motivation of science students in the province of Punjab in Pakistan. The participants of the study conducted with 600 students from a public college. They used Science Motivation Questionnaire (SMQ) developed by Glynn and Kobala (2006) and focused on five main categories which are intrinsic motivation and personal relevance (10 items), self-efficacy and assessment anxiety (9 items), self-determination (5 items), career motivation (2 items), and grade

motivation (4 items). According to the results, there was no significant difference in responses for 21 of 30 items between women and men. There are some differences in items 4, 5, 16, 18, 19, 22, 24, 25, and 27. These items show that men are confident about taking "A" grade in a science subject while they think it is not significant to have high grades than the science they learn. On the other hand, women are confident that they will perform better in science projects and labs instead of taking "A" grade. Cassady and Johnson (2002) said that it is because of "differential assessment anxiety". Moreover, men are aware of their capabilities in science whereas women are anxious about their future careers in science, which shows the difference in internal motivation. Mubeen and Norman (2014) focused on the factors affecting motivation in science and they mentioned that teachers can affect motivation but there are other factors out of the teacher's control. In conclusion, they pointed out that motivation is "multivariate", and it is not easy to measure motivation in terms of a small range of supposed factors. This makes it valuable for many studies examining motivation to learn science.

Chumbley, Haynes, and Stofer (2015) measured motivation to learn science focusing on agricultural STEM. They aimed to find out the factors affecting the motivation of secondary New Mexico students who are enrolled in agricultural science courses (539 students) and whether there is a relationship between motivation, grade level, and gender. They used Science Motivation Questionnaire II modified by Glynn, Brickman, Armstrong, and Taasoobshirazi (2011). The questionnaire is mainly developed by Glynn and Koballa (2006). The instrument consists of 25 Likert scale items and the categories are intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation. In the questionnaire, the word "science" is replaced by "agricultural science". The participants are 322 males and 196 females from 9th (153), 10th (154), 11th (125), and 12th (85) graders. The results show that one of the important motivators for agriculture students is grade motivation, especially getting an "A" in agriculture science courses (M=4.16), and self-efficacy which is believing getting an "A" in agriculture science courses (M=4.15). The least important motivator is career motivation, which is having a career in agriculture

science (M=3.33), and self-determination, which is preparing for the lesson (M=3.38). Moreover, the study shows that there is a difference between the motivation levels of males and females. Females are more motivated to learn agriculture science. Males and females also have the highest mean score in grade motivation (males: 3.89; females:4.19). As for the grade level, motivation to learn agriculture science increases when the grade level increases except in one category, grade motivation. Motivation decreases between the 11th and 12th grades. Finally, there is no significant correlation between gender and grade level in terms of all categories.

Another study describing science learning motivation was carried out by Chan and Norlizah (2017). This study focused on the relationship between students' science achievement and their motivation for science learning. Moreover, they paid attention to whether gender differences and parental education affect their achievement and motivation for science learning. Sarıbıyık, Altunçekiç and Yaman (2004) stated that science learning will be more effective if students are motivated for science learning. There is a significant relationship between students' motivation and achievement in science learning (Pintrich & Schunk, 2002). According to these assumptions, the researchers have selected randomly 165 participants from ten secondary schools in Pahang, Malaysia. To measure their motivation for science learning, a questionnaire was applied to the participants, which is one of the quantitative data collection tools. In the questionnaire, the questions are about gender, mothers' and father's education level, and the average score in science subjects based on the results of the midterm examination in 2013. It is revealed that students have higher achievement scores in science subjects if they are motivated to learn science. Moreover, it is indicated that female students are more motivated to learn science than male students although different studies support no gender differences in motivation toward science learning. When their achievement in science subjects is compared to their motivation, there is a positive correlation between them. The study also revealed that parental education does not affect students' motivation and achievement in science learning. The learning environment is an important factor rather than parental

education. Furthermore, Fortus and Touitou (2021) carried out a study about changes in students' motivation to learn science by focusing on the goal orientation theory. Various studies showed that there is a positive correlation between students' goal orientation towardsscience and their parents' or science teachers' goal orientations. Students' goal orientations are influenced by different environmental factors such as peers, parents, teachers, or school culture. The study is based on 2x2 model (mastery and performance x approach and avoidance) which is a different version of goal orientation theory. If the students are mastery approach oriented, they are motivated to learn and understand the specific topic internally. On the other hand, if the students are mastery avoidance oriented, they avoid understanding and complete a task successfully. Fortus and Touitou (2021) conducted this research by focusing on the mastery approach orientation towards science (MAOTS) to improve a now model that clarifies the changes to students' goal orientations towards science during a single school year. First, they explained various factors affecting the students' goal orientations such as school culture, peers, science teachers, gender, and parents. They stated that school culture has a key role to shape students' engagement, motivation, and achievement. Similarly, parents and science teachers influence students' motivation with their support and encouragement. Although the influence of peers is unclear, Vedder-Weiss and Fortus (2013) pointed out that peers have a minor effect on individuals' goal orientation toward science compared to the effect of parents, science teachers, and school culture. Moreover, studies showed that there are gender-based differences in terms of boys' and girls' goal orientation toward science. Based on these explanations, they collected data twice from 5-8 grades of five schools in Israel, once in October and once in May-June. They used a questionnaire in this study, and they divided the questionnaire into sections to clarify each theoretical construct. For this study, they focused on "students' personal mastery-approach orientation towards science (MAOTS) and their perceptions of their schools', parents', science teachers' and peers' emphasis on MAOTS." After the first year of data collection, they eliminated a section about peers' emphases from the questionnaire for the youngest students because they found that there is no significant

relationship between students' goal orientation towards science and peers' emphases. This study indicated that "teachers were the most influential factor, followed by parents, with school culture playing the smallest role."

As it has been said before, many studies have been conducted explaining the different dimensions of motivation, its relations with different variables in science education, what it affects, and what it is affected by. However, a few studies are showing how motivation to learn science predicts informal reasoning quality Therefore, in this part of the study, to provide a better understanding of motivation, it has been tried to be discussed in every aspect of it in detail.

2.5 Summary of the Literature Review

All in all, it is analyzed how individuals' informal reasoning quality can be measured, what are the essential factors affecting individuals' motivation in science learning and their attitudes towards science by taking into consideration individuals' explanations and argumentation skills for given SSI.

First, it is explained that there are three different informal reasoning models which are rationalistic, emotive, and intuitive (Sadler & Zeidler, 2004). Eisenberg (2000) described rationalistic informal reasoning as "causal and rational calculations", emotive informal reasoning as "feelings including empathy and sympathy", on the other hand, intuitive informal reasoning as "immediate reaction". In order for SSIs are controversial in society, individuals inevitably explain their opinions from various points of view. Zohar and Nemet (2002) supported that opinions and implications developed by informal reasoning depend on the advantages and disadvantages of the topic. In addition, the study conducted by Sadler and Zeidler (2004) showed that there are various factors affecting informal reasoning patterns such as "personal experiences, social considerations, morality, perception of complexity, and emotions." Wu and Tsai (2007) also supported that idea with their research on high school students' opinions about the nuclear power plant, and they

concluded that students create ideas according to advantages and disadvantages of the nuclear power plant. Their suggestions can change depending on the evidence. Moreover, Dawson and Venville (2009) strengthened the importance of scientific literacy by suggesting the positive relationship between the quality of informal reasoning, argumentation techniques, and scientific literacy. The present study will be carried out in light of these findings and contribute to finding out whether there are different factors affecting the informal reasoning of secondary school students (7th and 8th grade) considering their scientific literacy.

Second, Sadler (2004) described SSI as controversial and open-ended topics because they can be interpreted from different points of view in society. Thus, Zeidler et al. (2011) supported that SSI should be used in science education to improve students' scientific literacy. It is proved that integrating SSI into science teaching provides active participation of students (Zeidler & Nichols, 2009). Aleixandre et al. (2007) stated that students can explain their thoughts with data and scientific evidence in order to support claims. The study conducted by Dawson and Venville (2010) showed that the argumentation method used in the classroom improved the quality of students' arguments on an issue.

Third, according to Stenseth et al. (2015), the attitude toward SSI is defined as how people tend to deal with controversial issues by evaluating hypotheses and evidence. Stenseth et al. (2010) carried out a study about attitudes toward nuclear power plants and human-induced climate change. The results of the study indicated that students' attitudes and interests vary as their subject knowledge varies. In this study, the Pupils' Attitudes Towards SSI (PASSI) scale developed by Klaver and Molen (2020) will be used because the Attitudes Towards Socio-Scientific Issues (ATSIS) scale developed by Topçu (2010) is for university students and it measures the attitudes towards science. There have been some studies about university students' attitudes toward SSI but there has not been enough research about middle school students' attitudes toward SSI. Thus, this study will contribute to the literature by taking into consideration the previous studies.

Finally, in this study students' informal reasoning quality and their motivation to learn science will be investigated. Çavaş (2011) carried out a study about primary school students' motivation to learn science and the factors affecting their motivation levels. The results showed that students' motivation to learn science positively affects their attitudes toward science. High motivation enables students to learn science successfully.

CHAPTER 3

METHODOLOGY

In this chapter of the study, it is mentioned about research design, participants, instruments, data collection, data analysis, internal and external validity and assumptions of this research.

3.1 Research Design

This study aims to explore the relationship between students' informal reasoning quality, attitude toward SSI, and motivation to learn science. For this aim, the correlational research method was used in this study to understand the relationships among middle school students' informal reasoning quality, attitudes toward science, and their motivation to learn science. According to Gay (1996), a correlational study is a study to find the relationship between more than two variables. I considered this definition while analyzing the data. Correlational studies explain whether an increase or decrease in one variable causes an increase or decrease in another variable. Researchers performing the correlational study examine whether and to what degree the two variables change together. According to Tan (2014) correlational studies aim to determine the relationship between two or more variables. I investigated if there is any relationship between students' informal reasoning quality and attitudes towards SSI and motivation to learn science in this study.

3.2 Participants

The sample of this study is 523 7th and 8th graders from six different public middle schools in Artuklu district of Mardin. The target population of this study included all the 7th and 8th grade students in Artuklu district of Mardin. There are 51 middle schools in total in Artuklu. However, in this study data is collected from six different

middle schools which is approximately %10 of the accessible population. I used Convenience Sampling in this study because it is easy to reach participants for me since I am working in a public middle school in Artuklu district of Mardin. Also, it is easy for me that transport easily. While collecting data I was careful about the schools that it collected data from. Schools in different parts of the region were selected to best reflect the accessible population. In addition, purposeful sampling was also used in this study. The reason is the possibility that the instruments to be used in the research are not suitable for younger age groups 7th and 8th-grade students participated in the study because it was thought that this age group was at sufficient cognitive level to comprehend the purpose of the scales used, fill the scales by their purpose and realize the importance of the study compared to the lower grades. As presented in Table 3.1, %45,3 of the participants were male and %54.7 of them female. Most of the students were born in 2009 (about %68 of them) and %31,7 of them were born in 2008. In addition, to have information about the economic status of the students, I also collected information about the working status of the parents. While % 91of the fathers have a job only %23,1 of the mothers have a job. Even in this study, information was obtained about students' knowledge levels and sources of knowledge for each SSI. Only %5,9 of the students stated that they do not have any knowledge about global warming. %10,3 of the students mentioned that they do not have any knowledge about genetically modified food issues. Students also mentioned the source of their prior knowledge about global warming and genetically modified issue. Many of the students got their knowledge about global warming and genetically modified food from school and the internet. For global warming, %54.3 of the students got their prior knowledge from school while %19.3 of them got their knowledge from the internet. On the other hand, %48,6 of the students took their prior knowledge about genetically modified food from the internet while %18.5 of them took it from radio and TV.

Table 3.1 *Characteristics of the Sample*

Variables	**N**	**%**
Gender		
Male	237	45.3
Female	286	54.7
Year of Birth		
2008	166	31.7
2009	357	68.3
Work Status of Father		
Yes	476	91
No	47	9
Work Status of Mother		
Yes	121	23.1
No	402	76.9
Knowledge Level About Global Warming		
Feel Confident	297	56.8
Few Knowledge	195	37.3
Never Heard	31	5.9

Knowledge Source About Global Warming		
School	284	54.3
Internet	101	19.3
Radio and TV	94	17.9
Social Environment	44	8.5
Knowledge Level about Genetically Modified Food		
Feel Confident		
	266	50.9
Few Knowledge	203	38.8
Never Heard	94	10.3
Knowledge Source About Genetically Modified Food		
School	84	16.1
Internet	254	48.6
Radio and TV	97	18.5

Social Environment	88	16.8

3.3 Data Collection

The data collection started after ethical permissions were obtained from both Middle East Technical University Ethics Committee and Ministry of Education. The data were collected from six different middle schools in Artuklu in the fall semester of the 2022-2023 academic year. Voluntary participation from both the students and parents before applying the instruments permission has been obtained. I informed students and parents about the purpose of the study, and I stated that their answers and reactions to the scales would not be shared with anyone. I collected the data in the students' classrooms and approximately one class hour. First, I joined the class during a normal school hour and mentioned the purpose of the study and informed the students about their answers would not be shared with anyone, and they were told that they could also use a nickname to be anonymous instead of their own name. Then, volunteer participation forms were distributed to students and if there is a student who doesn't want to participate in the study, he/she did not take the form. After this step, the Informal Reasoning on Socio-scientific Issues Questionnaire is distributed to students and waited for them to fill this scale. Then, the Pupils' Attitudes Towards Socio-scientific Issues and Students' Motivation Toward Science Learning Scale were distributed to students respectively. Before each scale was distributed, students were informed in detailly about how to fill the scales and all the scales were collected at the same time during a class hour.

In Table 3.2, it is presented that the summary about data collection procedure, data analysis and limitations of the study.

Table 3.2 *General Information about Data Collection and Data Analysis*

Data Collection Procedure	Data Analysis	Limitations of the Study
For the pilot study; Face-to-face data collection with the paper and pencil format lasts 25 min.	Exploratory Factor Analysis	The findings are limited to the six public middle schools in Artuklu.
For the main study; Face-to-face data collection with the paper and pencil format lasts a class hour.	Validity and Reliability	The findings of the study are limited to relying on these written answers.
	Multiple Regression	Research was carried out within the framework of only two of the socio-scientific issues.

3.4 Instruments

Three different instruments were used in this study. (1) Two scenarios of Informal Reasoning on Socio-scientific Issues Questionnaire which includes three different scenarios originally to measure the quality of informal reasoning and developed by Khishfe et al. (2017), (2) PASSI Scale developed by Klaver and Molen (2020) and I adapted it into Turkish to measure students' attitudes towards socio-scientific issues and (3) Students' Motivation toward Science Learning (SMTSL) developed by Tuan, Chin and Shiehc's (2005) and translated into Turkish by Yilmaz and Cavas (2007).

3.4.1 Informal Reasoning on Socio-scientific Issues Questionnaire

Mehrad et al. (2009) noted that qualitative research measures are made in many ways. In qualitative research, abstract ideas and thoughts are at the forefront, followed by empirical data. Qualitative research is a mixture of ideas and data. In contrast to quantitative research, variables can change easily and are flexible (Morse et al., 2001). In this study, I used the Informal Reasoning on Socio-scientific Issues questionnaire (Appendix C) that includes global warming, acid rain, and genetically modified food scenarios and was taken from the study of Khishfe et al. (2017). This instrument was applied to high school students (Khishfe et al., 2017; Wu & Tsai, 2007) and pre-service science teachers (Ozturk & Yilmaz-Tuzun, 2017) in previous studies. This questionnaire was translated into Turkish and adapted for 8th graders by Irmak (2021). The questionnaire included three SSI (global warming, acid rain, and genetically modified food) but in this study two of them (global warming and genetically modified food) was used since there are two more scales, it is convenient for them to fill in a class hour. There are open-ended questions in each scenario in the scale. These scenarios have been chosen because each SSI was presented in scenarios by considering both positive and negative aspects. In the scale, first a short definition and explanation about each SSI, and then examples of both positive and negative aspects of this issue were given. Four open-ended questions were asked.

1. What is your opinion on whether or not to take measures against global warming/genetically modified food?

2. What information would you use to defend your opinion to your friends?

3. What information can your friend who has an opposite view to yours use to defend his/her view?

4. What information would you use to defend your own opinion (which you stated in Question 2) against your friend's opinion and information?

These questions are allowing students to make claims, justifications, counter arguments and rebuttals about the issue. While evaluating the students' answers to open-ended questions, I used Toulmin's Argumentation Pattern (TAP), which was developed by Toulmin and edited by Topcu, Sadler, and Yılmaz-Tüzün (2010), which measures students' argumentation levels. The scenarios were also developed for middle school students in Turkish.

3.4.2 Pupils' Attitudes"Towards"Socio-scientific"Issues (PASSI) Questionnaire

To measure the students' attitudes toward SSI, PASSI questionnaire (Appendix D) developed by Klaver and Molen (2020) was used. PASSI questionnaire consisted of 48 items originally. After validity and reliability analysis have been done, Klaver and Molen removed some problematic items, and it has 27 items finally. After translating the PASSI questionnaire, expert opinion was obtained from three experts, one of whom was an English teacher, one experienced science teacher, and one science education researcher, and opinions were expressed by the experts about the language and extent of the translation. In the scale, students' responses were evaluated on a four-point Likert scale with response scale options as 1 point for strongly disagree, 2 points for disagree, 3 points for agree, and 4 points for strongly agree options. The scores that students will receive for this scale vary between 27 and 108.PASSI Questionnaire consists of 9 subscales which are relevance institutions, personal relevance, relevance school, relevance science and technology, positive feelings, concern, self-efficacy, collective efficacy, dependency on others and each subscale includes five or six items. When Klaver et al. (2020) conducted a pilot study of this scale, they found 9 different sub-scales.

1.*Relevance Institutions:* Relevance Institutions subscale was defined as to what degree students think it is significant for institutions to move in the direction of resolving SSI.

2.*Personal Relevance:* Personal Relevance means the degree to which students think it is important that they act to solve the SSI when they are older.

3.*Relevance School:* Relevance school was defined as the degree to how important it is for students to learn SSI at school.

4.*Relevance Science and Technology*: Relevance Science and Technology "was defined as to what degree students believe that science and technology are related to solving SSI.

5.*Positive Feelings*: This subscale was defined as the degree to which students have positive feelings when dealing with SSI.

6.*Concern*: Concern means to what degree students think SSI worrying.

7.*Self-efficacy*: Self-efficacy is defined as the degree to which students perceive themselves to be able to participate in the SSI.

8.*Collective Efficacy*: Collective efficacy is the degree of students' belief that their class can participate in the SSI.

9. *Dependency on Others*: Dependency on others is defined as the degree of students' feelings about depending on others for engaging in SSI.

At the end of the pilot study, eight factors that can be clearly distinguished according to the EFA results were determined and these sub-dimensions can be replicated with other sub-dimensions. Klaver and Molen (2020) calculated the reliability scores of these sub-dimensions. The reliability scores of these sub-dimensions are presented in varies between 0.76 and 0.93. Uraschi et al. (2015) stated that according to a generally accepted rule, when the cornbach-alpha score is between 0.6-0.7, the scale is at an acceptable level, and when it is 0.8 or more, it shows that the scale has a very good reliability level.

Table 3.3 *Composite Reliability Scores of the PASSI and sub-scales.*

Sub-Scales	Number of Items	Example Item	Composite Reliability Scores
Relevance Institutions	3	"I believe that countries must think about solutions for world issues."	.83
Personal Relevance	4	"I myself will do something to solve world issues when I'm older."	.86
Relevance School	4	"I think we should learn about world issues at school."	.93
Positive Feelings	4	"I really enjoy investigating world issues."	.89
Concern	3	"I'm really worried about world issues."	.93
Self-Efficacy	3	"I'm very good at collecting information about these world issues."	.85
Collective-Efficacy	4	"I think my class is very good at discussing world issues."	.86
Dependency on Others	2	"I need the help of others to think about solutions for world issues."	.76

As can be seen from Table 3.2, Composite Reliability scores of the sub-scales varies between 0.76 and 0.93.

3.4.2.1 Reliability of the Turkish Version of the PASSI

According to Roberts et al. (2006) reliability indicates the rigor and trustworthiness of research. If research achieves its purpose, it should not mislead those who use it. This is achieved by consistently measuring the characteristics of the variable in the research. After adapting the scale to Turkish, I checked the reliability of the Turkish version of the PASSI. It is presented in Table 3.3 the reliability score of the Turkish version of the PASSI.

Table 3.4 *Reliability Statistics of Turkish Version of PASSI*

Cronach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,805	,810	27

Taber (2017) stated that if Cronbach Alpha value of a scale described between 0.76-0.95, the scale's reliability is fairly high. As can be seen in Table 3.3 the Cronbach alpha value of the Turkish version of the PASSI which has 27 items is .81 which means scale is reliable (Uraschi et al., 2015).

3.4.2.2 Exploratory Factor Analysis for Turkish Version of PASSI

I adapted to Pupils's Attitudes Towards Socio-scientific Issues Scale into Turkish. I conducted the pilot study of the PASSI in September 2022. I applied the questionnaires after obtaining parental permissions, permission from the Ministry of National Education, and Middle East Technical University Ethical Committee. I determined the sample size as N=164 for this analysis and the participants were two different public school in Artuklu. Before the questionnaires were given to the students, the students were informed about SSI. I administered the questionnaires to the students in their classrooms, lasting approximately 25 minutes during class hours.

During the session, I paid attention that the students did not exchange ideas with each other and did not interfere with each other. Before analysis, I checked sample size, normality, outliers, KMO, and Barlett's Test of Sphericity. I collected the data from 7th and 8th grade students from two different middle school in Mardin and there was no missing data. According to Boomsa et al. (1985), N=50 in the EFA model with 6 to 12 indicator variables per factor, while N>100 is required for the EFA model with 3-4 indicators per factor if communalities are above .5 after extraction. I applied reverse code for three negative phrased items in 'Concern' sub-scale.

Table 3.5 *Kaiser Meyer Olkin and Barlett's Test of Turkish Version of PASSI*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	,742
Barlett's Test of Sphericity Approx. Chi-Square	1761,182
df	351
Sig.	<,001

Kaiser (1974) stated that the KMO values should be greater than .60 for the data to be suitable for factor analysis. I checked Kaiser-Meyer-Olkin (KMO) and Barlett's Test of Sphericity. KMO = .74 was bigger than .60 which means data is appropriate for the Explaratory Factor Analysis. Moreover, Barlett's Test of Sphericity was significant, $(\chi 2$ (351) =1761,182 $p < .001)$. Results indicated that data was appropriate for EFA. Multi-group EFA measurement was performed to test on a total sample of participants N= 164. The scale includes 8 sub-sample originally. I performed to test with 8 factors first, but the items were not fitted appropriately to the factors. Then, I applied the test with 7 factors and 'positive feelings' and 'self-efficacy' factors combined and called self-efficacy together in this study. Also, one of the items that is included in 'positive feelings' factors by the Klaver and Molen (2020), placed in the 'collective efficacy' factor in this pilot study. As seen in Table 3.5, factor analysis of the Turkish version of PASSI was performed with 7 sub-dimensions. The first three items loaded the "relevance institution" sub-dimension,

as in the original scale. Item 4, item 5, item 6 and item 7 fitted with the “personal relevance” factor as they are supposed to be. While item 8, item 9, item10, and item 11 loaded the “relevance school” factor, item12, item 13, item 14, and item 15 appropriately fitted with the “positive feelings” factor. In fact, since the factor analysis was carried out with 7 factors, item 19, item 20 and item 21, which should fit with the self-efficacy factor, were combined with the “positive feelings” factor in the Turkish version of PASSI. These items are acceptable in the new dimensions they loaded, because while adapting the scale, convergence and discrimination power of the sub-dimensions of the PASSI are calculated and supported, PASSI sub-dimensions have discriminant and convergent validity power (Klaver & Molen, 2020). Apart from that, other items have been fitted in accordance with the dimensions they need to be found. According to McDonald et al. (2002), absolute fit indices shows whether the previous model fits the sample data explains which model is the best. This criterion contributes crucial indication of how well the suggested theory fits the data. The data of present study showed good model fit of the 7 factors.

Table 3.6 *Exploratory Factor Analysis of Turkish Version of PASSI*

ITEMS	FACTORS						
	SE	CE	CO	DO	PR	RS	RI
Item 1							-,688
Item2							-,551
Item 3							-,680
Item 4					,683		-,353
Item 5					,765		
Item 6					,665		
Item 7					,533		
Item 8						,799	
Item 9						,878	
Item 10						,868	
Item 11						,720	
Item 12	,357						
Item 13	,608						
Item 14	,571						
Item 15	,682						
Item 16			,896				
Item 17			,908				
Item 18			,889				
Item 19	,796						
Item 20	,645						
Item 21	,768						
Item 22		,661					
Item 23		,703					
Item 24		,815					
Item 25		,824					
Item 26				,913			
Item 27				,872			

(RI:Relevance Institutions, PR:Personal Relevance, RS:Relevance School, CO:Concern, SE:Self-Efficacy, CE:Collective Efficacy, DO:Dependency on Others)

As can be seen in Table 3.6, the reliability scores of the sub-scales varies between .52 and .89. Moreover, reliability score of the Turkish version of PASSI scale is .81.

After deciding the clearly distinguished the seven factors, I calculated the reliability scores of the sub-dimensions. In Table 3.6 it is presented the Cronbach-Alpha coefficients of the seven sub-dimensions of the Turkish version of the PASSI.

Table 3.7 *Cronbach Alpha Coefficients of the Turkish Version of PASSI and sub-scales*

Sub-Scales	**Number of Items**	**Example Item**	**Cronbach-Alpha Coefficient**
Relevance Institutions	3	"I believe that countries must think about solutions for world issues."	.60
Personal Relevance	4	"I myself will do something to solve world issues when I'm older."	.73
Relevance School	4	"I think we should learn about world issues at school."	.86
Concern	3	"I'm really worried about world issues."	.89
Self-Efficacy	7	"I'm very good at collecting information about these world issues."	.75
Collective-Efficacy	4	"I think my class is very good at discussing world issues."	.81
Dependency on Others	2	"I need the help of others to think about solutions for world issues."	.80
PASSI	27		.81

3.4.2.3 Exploratory Factor Analysis of Turkish Version of PASSI with Actual Data

I determined the sample size of the study as N=522. I administered the questionnaires to the students in one class hour, that lasts approximately 40 minutes. After applied the scales, I was conducted factor analysis for the scales with sample of this study. Before analysis, I checked sample size, normality, outliers, KMO, and Barlett's Test of Sphericity. The participants were 7th and 8th grade students from 6 different middle schools in Mardin and there was no missing data. As mentioned before, N=50 in the EFA model with 6 to 12 indicator variables per factor, while N>100 is required for the EFA model with 3-4 indicators per factor if communalities are above .5 after extraction (Boomsa et al. 1985). I applied reverse code for three negative phrased items in 'Concern' sub-dimension.

Table 3.8 *Kaiser Meyer Olkin Test for Turkish Version of PASSI with Actual Data*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	,860
Barlett's Test of Sphericity Approx. Chi-Square	5564,697
df	351
Sig.	<,001

As stated before, the KMO values should be greater than .60 for the data to be suitable for factor analysis (Kaiser 1974). I checked Kaiser-Meyer-Olkin (KMO) and Barlett's Test of Sphericity. KMO = .86 was bigger than .60 which means data is appropriate for the Explaratory Factor Analysis. Moreover, Barlett's Test of Sphericity was significant, *($\chi 2$* (351) =5564,697 $p < .001$). Results indicated that data was appropriate for EFA. Multi-group EFA measurement was performed to test on a total sample of participants N= 522. I conducted exploratory factor analysis for Turkish version of the PASSI. Turkish version of the PASSI has 7 factors. As can be seen in Table 3.8, all the items loaded factors appropriately.

Table 3.9 *EFA for Turkish Version of PASSI with Actual Data*

ITEMS	FACTORS						
	SE	CE	CO	DO	PR	RS	RI
Item 1							,479
Item2							,529
Item 3							,681
Item 4					,792		
Item 5					,816		
Item 6					,753		
Item 7					,659		
Item 8						,790	
Item 9						,859	
Item 10						,826	
Item 11						,817	
Item 12	-,398						
Item 13	-,711						
Item 14	-,744						
Item 15	-,688						
Item 16			,864				
Item 17			,882				
Item 18			,890				
Item 19	-,584						
Item 20	-,452						
Item 21	-,590						
Item 22		,768					
Item 23		,797					
Item 24		,752					
Item 25		,801					
Item 26				,855			
Item 27				,861			

I conducted a reliability test for Turkish version of the PASSI with actual data (N=523) to show reliability of the present study. I calculated the reliability scores of the seven sub-dimensions. The Cronbach-Alpha scores of the seven dimensions are presented in Table 3.10.

Table 3.10 *Cronbach-Alpha Coefficients of Turkish Version of the PASSI and Sub-scales with Actual Data*

Sub-Scales	**Number of Items**	**Example Item**	**Cronbach-Alpha Coefficient**
Relevance Institutions	3	"I believe that countries must think about solutions for world issues."	.68
Personal Relevance	4	"I myself will do something to solve world issues when I'm older."	.78
Relevance School	4	"I think we should learn about world issues at school."	.85
Positive Feelings	4	"I really enjoy investigating world issues."	.70
Concern	3	"I'm really worried about world issues."	.89
Self-Efficacy	3	"I'm very good at collecting information about these world issues."	.76
Collective-Efficacy	4	"I think my class is very good at discussing world issues."	.77
Dependency on Others	2	"I need the help of others to think about solutions for world issues."	.71
PASSI	27		.77

As can be seen in Table 3.10, the reliability scores of the sub-scales varies between .68 and .89. Moreover, reliability score of the Turkish version of PASSI scale with actual data is .81.

3.4.3 Students' Motivation Toward Science Learning (SMTSL) Questionnaire

A questionnaire Students' Motivation toward Science Learning (SMTSL) (Appendix C) developed by Tuan, Chin and Shiehc's (2005) and translated into Turkish by Yilmaz and Cavas (2007) to measure motivation to learn science of the elementary students. While developing the scale, the researchers conducted the study with 1407 middle school students in Central Taiwan who differed in grade, gender, and achievement. While they were translated this scale into Turkish, Yılmaz and Cavas (2007) used Equamax rotation for factor analysis of the scale and the factor analysis result was the same as that of Tuan and Shieh. 2 items were removed from the scale because the factor loadings were below 0.3. The Turkish version of the scale consists of 33 items with 6 sub-scales. This version of the scale was directly taken from Yılmaz and Cavas (2007) in this study.

The questionnaire included 33 Likert scale items consisting of 5 degrees of response (strongly disagree, disagree, no opinion, agree, strongly agree). SMTSL consists of six different subscales namely: self-efficacy, active learning strategy, science learning value, performance goal, achievement goal and learning environment stimulation. The scores that students will receive for this scale vary between 33 and 165.

Table 3.11 *Cronbach Alpha Coefficients of the SMTSL and sub-scales*

Sub-Scales	**Number of Items**	**Example of Item**	**Cronbach-alpha Scores**

Self-efficacy: Students' self-beliefs about their ability to perform well in the science learning process.	7	"I am not confident about understanding difficult science concepts."	0,71
Science learning value: Important aspects of values, such as gaining problem-solving competence, experiencing inquiry activities, encouraging one's own thoughts, and relate science with daily life.	5	"When learning new science concepts, I connect them to my previous experiences."	0,74
Active learning strategies: Students' usage of a variety of strategies actively by using their previous background to create new knowledge.	7	"When I meet science concepts that I do not understand, I still try to learn them."	0,85
Performance goal: Students' desire to compete with their classmates and to get the teacher's attention.	3	"I participate in science courses so that the teacher pays attention to me."	0,54
Achievement goal: Felling pleasured of students because they increase their proficiency and achievement in science education.	5	"During a science course, I feel most fulfilled when the teacher accepts my ideas."	0,77
Learning environment stimulation: Factors that affects students' motivation in learning science like curriculum, teaching method etc.	6	"I am willing to participate in this science course because it is challenging."	0,77
SMTSL	33		0,87

As can be seen from Table 3.11, the Cronbach's alpha reliability coefficient of the whole scale is 0.87, while that of the sub-scales varies between 0.54 and 0.85. This Table directly taken from the study of Cavas and Yılmaz (2007).

3.4.3.1 Exploratory Factor Analysis for SMTSL

I conducted Exploratory Factor Analysis for Turkish version of SMTSL with the actual data that has N=522. I administered the questionnaires to the students in their classrooms and it took approximately 25 minutes. After applied the scales, I was conducted factor analysis for the scales sample of this study. Before analysis, I checked sample size, normality, outliers, KMO, and Barlett's Test of Sphericity. The participants were 7^{th} and 8^{th} grade students from 6 different middle schools in Mardin and there was no missing data. As mentioned before, N=50 in the EFA model with 6 to 12 indicator variables per factor, while N>100 is required for the EFA model with 3-4 indicators per factor if communalities are above .5 after extraction (Boomsa et al. 1985). As stated before, the KMO values should be greater than .60 for the data to be suitable for factor analysis (Kaiser 1974). I checked Kaiser-Meyer-Olkin (KMO) and Barlett's Test of Sphericity. KMO = .87 was bigger than .60 which means data is appropriate for the Explaratory Factor Analysis. Moreover, Barlett's Test of Sphericity was significant, $(\chi 2\ (253) = 4089.120\ p < .001)$. Results indicated that data was appropriate for EFA. Multi-group EFA measurement was performed to test on a total sample of participants N= 522. I conducted exploratory factor analysis for Turkish version of the SMTSL. SMTSL has 6 factors. As can be seen in Table 3.12, all the items loaded factors appropriately.

Table 3.12 *EFA for Turkish Version of SMTSL with Actual Data*

	FACTORS					
ITEMS	SLV	SE	AG	PG	LES	ALS
Item 1		,761				
Item 2		,743				
Item 3		,755				
Item 4		,798				
Item 5		,780				
Item 6		,746				

Item 7		,760			
Item 8					-,640
Item 9					-,794
Item 10					-,594
Item 11					-,614
Item 12	,300				-,560
Item 13	,809				
Item 14	,743				
Item 15	,681				
Item 16	,502				
Item 17	,622				
Item 18			-,701		
Item 19			-,755		
Item 20			-,723		
Item 21			-,752		
Item 22		-,613			
Item 23		-763			
Item 24		-,825			
Item 25		-,769			
Item 26		-,756			
Item 27				,616	
Item 28				,637	
Item 29				,652	
Item 30				,644	
Item 31				,603	
Item 32				,669	
Item 33				,601	

(SE:Self-efficacy, ALS:Active Learning Strategies, SLV:Science Learning Value, PG:Performance Goal, AG:Achievement Goal, LES:Learning Environment Stimulation)

3.4.3.2 Reliability Statistics for SMTSL

I conducted a reliability test for Turkish version of the STMSL with the actual data that has N=522 participants. As can be seen in Table 3.13 the reliability scores of the sub-scales varies between .62 and .82. The Cronbach Alpha Scores of the SMTSL is .72 that means the scale is reliable (Uraschi et al. 2015).

Table 3.13 *Cronbach-Alpha Coefficients of Turkish Version of SMTSL and Sub-scales with Actual Data*

Sub-Scales	**Number of Items**	**Example Item**	**Cronbach-Alpha Coefficient**
Self-efficacy	7	"I am not confident about understanding difficult science concepts."	.81
Active Learning Strategies	7	"When learning new science concepts, I connect them to my previous experiences."	.75
Science Learning Value	5	"When I meet science concepts that I do not understand, I still try to learn them."	.79
Performance Goal	3	"I participate in science courses so that the teacher pays attention to me."	.64
Achievement Goal	5	"During a science course, I feel most fulfilled when the teacher accepts my ideas."	.82
Learning Environment Stimulation	6	"I am willing to participate in this science course because it is challenging."	.62
SMTSL	33		.72

3.5 Data Analysis

I used both quantitative and qualitative analysis in the presents study. First, data from socio-scientific scenarios are analyzed qualitatively and then I used Toulmin's Argumentation Pattern (TAP) rubric that is developed by Topçu and Yılmaz Tüzün (2010) for quantizing the data. According to Loehnert (2010) quantizing is a method that involves converting qualitative data into numerical values. Data collected from PASSI and SMTSL is analyzed quantitatively since they are Likert type scales. It is conducted Multiple regression analysis to examine how informal reasoning quality is predicted by attitudes towards SSI and motivation to learn science. Test results evaluated at $\alpha = 0.05$ significance level. In this part of the study, it is mentioned that detailed information about data analysis process.

3.5.1 Informal Reasoning on Socio-Scientific Issues Questionnaire Analysis

3.5.1.1 Informal Reasoning Quality on Socio-scientific Issues Analysis

Toulmin's Argumentation Pattern (TAP) rubric is developed by Toulmin (1958) which is a framework for analyzing argumentation patterns. By looking at the answers given by the students to the questions asked in the scenarios, I classified their argumentation levels according to the rubric developed by Toulmin (1958). Topcu, Sadler, and Yılmaz-Tüzün (2010) used this rubric as a basis and developed Toulmin's rubric to facilitate the demonstration of the quality of informal reasoning of the participants. While the criterion used as 'claim' in Toulmin's rubric was used as 'claim' in this study, the criterion used as 'Data' by Toulmin was used as 'Justification', 'counter-position' used as 'warrant' and the last level, 'rebuttal', was used in the 'warrant'. While developing this rubric, Topcu, Sadler, and Yılmaz-Tüzün (2010) determined descriptive questions for each criterion in determining

students' informal reasoning quality. This rubric is shown in Table 3.6. Students' answers to the questions in the Informal Reasoning on Socio-scientific Issues questionnaire was evaluated by using this rubric. If the answers given by the students to the questions in the scale contain only claims, this student is evaluated in the claim criterion, if it includes both claim and justification, student is evaluated in the justification criterion, if the claims and justifications are supported by counter-position, students evaluated in the counter-position criterion, and if the answer includes rebuttal besides claim, justification and counter-position, students evaluated in rebuttal criterion and informal reasoning quality of students was determined. Based on this rubric, I evaluated the qualitative data quantitatively. Loehnert (2010) said that the transformation of qualitative, that is, non-numerical data, into quantitative, that is, numerical, is called 'quantizing'. While quantifying the data, I gave 1 point to the students whose informal reasoning quality was in the 'claim' criterion, 2 to the 'justification' criterion, 3 to the 'counter-position' criterion, and 4 to the 'rebuttal' criterion. Evaluation was made by taking into consideration the total points that the students got from their answers to the two scenarios given to them.

Table 3.14 *The Framework Used to Analyze Informal Reasoning Quality on SSI*

Criterion	**Descriptive Questions**
Claim	"Can a participants develop claims about the issue?"
Justification	"Can a participant develop justifications in addition to claims?"
Counter-Position	"Can a participant develop counter-positions in addition to claims and justifications?"
Rebuttal	"Can a participant develop rebuttals in addition to claims, justifications and counter-positions?"

- Claim refers to if a participant constructed only claim about socio-scientific scenario or not, should be done or not.
- Justification refers to if participants support their claims with arguments.
- Counter-position refers to if participants construct counter arguments about their previous perspectives or not.
- Rebuttal refers to constructing supportive arguments about their positions while considering counter arguments they constructed.

3.5.1.2 Informal Reasoning Modes on Socio-scientific Issues Analysis

In the present study it is used that the different version of the integrated framework developed by Wu and Tsai (2007). This framework uses both qualitative and quantitative indicators to investigate participants' decision making about SSI and analyze the quality modes of students' informal reasoning about global warming and genetically modified foods.

Students interpret their arguments on SSI from different perspectives and these perspectives are assessed by the reasoning mode indicator. According to the studies carried out with high school students, these perspectives were defined as “social-oriented”, “ecological-oriented”, “economic-oriented”, and “science and technology-oriented.” They have been taken into account while coding the students’ perspectives during the analysis process. Each reasoning mode helps us to measure the indicators. For instance, the fact that the students assert more social-oriented arguments shows they are oriented to justify their arguments from social-oriented perspectives. Similarly, the number of ecological-oriented argument represents that students are inclined to use ecological-oriented perspective. The number of economic-oriented argument indicates that they interpret issues from the economic-oriented perspectives. In addition, the number of science and technology-oriented arguments constructed by students shows what they have learned in science classrooms and how they use their knowledge learned in science classroom. All in

all, the number of reasoning modes indicates that students explain SSI from different perspectives. The reasoning mode scores of the students were calculated according to the number of modes they used. Some students used more than one perspective in their informal reasoning. For example, if a student constructed two socially oriented and two economic oriented arguments, s/he used two different informal reasoning modes. Therefore, the reasoning mode scores of the students were calculated according to the number of informal reasoning mode types they used.

3.5.1.3 Multiple Regression Analysis to Analyze How Informal Reasoning Quality is Predicted

According to Cohen et al. (1983), multiple regression/correlation analysis (MRC) is a flexible data analytics system, and it is commonly used. This analysis is used in studies where the relationship of any factor with a quantitative variable is examined. It is used when examining whether the quantitative variable is a function of the factors or whether there is any relationship with these factors. Here, while quantitative variable is expressed as dependent variable, factors are expressed as independent variables (Cohen et al., 1983). The relationship between these variables can be simple or complex. Multiple regression was used in this study. While informal reasoning quality of students was expressed as dependent variable, sub-dimensions of Pupil's Attitudes Towards SSI scale, in which students' attitudes towards SSI were measured, were used as a function of informal reasoning quality. That is, I took the factors of PASSI as independent variables while measuring how attitudes towards SSI predicted informal reasoning quality. In fact, while examining how students' motivation to learn science predicts informal reasoning quality, I expressed the sub-dimensions of the Students' Motivation to Science Learning scale as independent variables. That is, while the dependent variable of the study is students' informal reasoning quality regarding SSI, the independent variables are dependency on others, collective efficacy, relevance institutions, relevance school, concern, personal relevance, self-efficacy (attitude), performance goal, science learning value,

achievement goal, self-efficacy (motivation), active learning strategies, and learning environment stimulation. While performing the multiple regression analysis, I calculated the students' scores from items and the average score of sub-dimensions. Thus, each student's independent variable scores were calculated.

3.5.2 Pupil's Attitudes Toward Socio-scientific Issues Scale Analysis

PASSI is a Likert-type scale that has 27 items and four options which are 1 point for strongly disagree, 2 points for disagree, 3 points for agree and 4 points for strongly agree and scores taken from this scale vary between 27 and 108. The PASSI. Questionnaire consists of 7 subscales: dependency on others, collective efficacy, relevance institutions, relevance school, concern, personal relevance, self-efficacy (attitude) and each subscale consists of five or six items.

3.5.1 Students' Motivation to Science Learning (SMTSL) Scale Analysis

I used SPSS to analyze the data. This scale consists of 35 items developed by Tuan, Chin and Shiehc's (2005) and translated into Turkish by Yilmaz and Çavas (2007). There are 33 items in Turkish version because two of the items were problematic during the validating process. This scale is Likert type, the scale has 4 different options: Strongly agree, Agree, Disagree and Strongly Disagree. While conducting the study, I gave 4 points for strongly agree, 3 points for agree, 2 for disagree and 1 for strongly disagree and if the items were negative 5 points for strongly disagree and 1 point for strongly agree. Scores from this scale vary between 33 and 165 points.

3.6 Validity

According to Bailey (1991), validity is the reliability and accuracy of the study. In this part of the study, validity issues were mentioned.

3.6.1 Internal Validity Threats

The subject characteristics is one of the possible threats in this study. This threat arises when the characteristics of the subjects cause differences between groups in studies involving different variables (Baldwin, 2018). In order to control this threat, I selected all participants from 7th and 8th grade students and from public middle schools in the Artuklu district of Mardin, and highly avoided the threat of subject characteristics. However, features such as academic knowledge, socio-economic environment, family structure, cognitive development are characteristics that cannot be controlled. Location is one of the other threats to internal validity (Fraenkel et al., 2012). In order to eliminate this threat, the research was carried out in the students' own classrooms so that the students could have almost the same opportunities during the research. In addition, all of the schools where the research was carried out are public middle schools in Artuklu, that is, schools have almost same characteristics. According to Frankel et al. (2012) another internal validity threat is data collector characteristics. However, this threat was taken under control by applying all scales to all participants by the same researcher. Data collector bias, which is another threat to internal validity, may cause unconscious distortion of data during data analysis (Fraenkel et al., 2012). This threat was brought under control by evaluating different scales at different times. In addition, since the study includes moral, ethical and social dimensions, it was ensured that the answers would not be shared with anyone so that the students would not feel uncomfortable while giving their answers. Thus, ethics, which is one of the internal validity threats, has been taken under control.

3.6.2 External Validity Threats (Applicability)

The generalization of the results of a study to other places or to other individuals after it has been applied called external validity. According to Lincoln and Guba (1985), external validity is the state of transferability in qualitative research. The

external validity of this study was maintained by a broad and specific explanation of the participants, data collection tools and procedures, and data analysis.

3.7 Assumptions and Limitations

3.7.1 Assumptions

I assumed that;

1- Providing the same environmental conditions for all participants during the implementation of the research.
2- All students participate voluntarily in the study.
3- All students answer all questionnaires honestly and accurately.
4- During the administration of the study, students do not exchange ideas and do not interfere with each other.

3.7.2 Limitations

The limitations of this research are as follows;

1- Since the study was conducted in Mardin, Artuklu, the results of the findings are limited to the six public secondary schools in Artuklu, but the findings can be generalized to other 7^{th} and 8^{th} grade students with similar characteristics.

2- In the study, the students answered the questionnaires in written form and the results of the study are limited to relying on these written answers. Moreover, the fact that the Informal Reasoning on Socio-scientific Issues Questionnaire included open-ended questions made it difficult for me to evaluate the students' answers.

3- The variables of the research are the students' informal reasoning quality towards SSI and their attitudes towards SSIs, but this research was carried out within the framework of only two of the SSIs, global warming and genetically modified organisms. The use of different SSI may lead to different findings.

3.8 Ethics

The participants confirmed that they will not be affected physically or mentally at the end of the study. They also informed that they could withdraw from the study any time they wanted. I have to know the names of the participants in this study, but s/he informs students that they do not have to give their names and contact information. Participants signed at the consent form at the beginning of the questionnaire, and they were assured that their private information and answers would not be shared with anyone. I also informed participants that the answer that they give the questionnaires would not affect their science course grades. Permission obtained from the Ministry of Education and Ethical Committee of the Middle East Technical University for the study.

CHAPTER 4

RESULTS

In this part of the study, descriptive statistics about middle school students' informal reasoning quality, attitudes towards SSI, and motivation to learn science are given. In addition, correlational explanations between informal reasoning quality and attitudes towards SSI and motivation towards science are included.

4.1 Descriptive Statistics

4.1.1 Middle School Students' Informal Reasoning Quality Regarding SSI

Participants were given two different SSI, namely global warming and genetically modified food, and they were expected to construct claims, justifications, counter arguments and rebuttals for each issue. Thus, informal reasoning quality was measured. In addition, informal reasoning quality was calculated by giving one point for the claim, two for justification, three for the counter argument, and four for the rebuttal, which the students created for SSI. The results of informal reasoning for each SSI are included in this section.

Research Question 1: How is middle school students' informal reasoning quality regarding SSI (Global warming, and genetically modified food)?

Informal Reasoning Quality on Socio-scientific Issues Questionnaire was used to evaluate middle school students' informal reasoning quality.

4.1.1.1 Informal Reasoning Quality about Global Warming

It is calculated the descriptive statistics of the informal reasoning quality scores on global warming and the results are presented in Table 4.1.

Table 4.1 *Descriptive Statistics for Informal Reasoning Quality on Global Warming*

Mean	Std. Deviation.	Range
2.64	1.86	0-10

As presented in Table 4.1, the results revealed that students' overall mean score of informal reasoning quality regarding global warming is (*M*=2.64, *SD*=1.86).

The results presented in Table 4.2 revealed that the highest score of the students from the global warming scenario is 10, while the lowest score was 0. 9.9% of the participants got the minimum score of 0. While 23.7% of the sample scored one point from the scenario, only 1.7% of the sample scored two points from the scenario. Those who scored three points in the global warming scenario account for more than half (51.1%) of the participants. While 2.1% of the students got four points, very few students (0.4%) got five points. The students with the highest scores constitute 9.4% of the sample with six points and 1.7% with ten points.

Table 4.2 *Frequencies of Points Taken from Global Warming Scenarios*

Points	Frequency	Percent
0	52	9,9
1	124	23,7
2	9	1,7
3	267	51,1
4	11	2,1

5	2	0,4
6	49	9,4
10	9	1,7

As presented in Table 4.2 three points are taken frequently by the students. Also, students took a maximum of ten points and a minimum of zero points from the global warming scenario.

As can be seen in Table 4.3, the results showed that 9.4% of the students did not get any points because they did not construct any arguments about global warming. For the scenario, students who constructed only claims made up 25% of the sample. Almost half of the participants (50.9%) constructed arguments at the justification level. In addition, 9.9% of the participants' informal reasoning was at the counterargument level and only %4.8 of the sample achieved constructing rebuttal for global warming.

Table 4.3 *Middle School Students' Frequencies of Informal Reasoning Quality About Global Warming*

	Frequency	Percent
No Argument	49	9,4
Claim	131	25,0
Justification	266	50,9
Counter argument	52	9,9
Rebuttal	25	4,8

As can be seen in Table 4.3, students mostly generated justifications for the global warming scenario.

4.1.1.2 Informal Reasoning Quality About Genetically Modified Food

I calculated the informal reasoning quality scores on genetically modified food issue of students and the results are presented in Table 4.4.

Table 4.4 *Descriptive Statistics for Informal Reasoning Quality on Genetically Modified Food*

Mean	Std. Deviation.	Range
2.16	1.63	0-6

As can be seen in Table 4.4, students' mean score of informal reasoning quality regarding genetically modified food is slightly lower (*M*=2.16, *SD*=1.63) than their informal reasoning quality on global warming (M=2.64. SD=1.86).

The results presented in Table 4.6 revealed that the highest score of the students from the genetically modified food scenario is six, while the lowest score was 0. 14% of the participants got the minimum score of 0. While 32,9% of the sample scored one point from the scenario, 2,5% of the sample scored two points from the scenario. The majority of the sample (40,9%) got three points from genetically modified food scenario. In fact, while only 1.5% of the students got four points, 8.2% of the students scored six points from the genetically modified food issue and these are the students with the highest score.

Table 4.5 *Frequencies of Points Taken from Genetically Modified Food Scenario*

Points	Frequency	Percent
0	73	14,0
1	172	32,9
2	13	2,5

3	214	40,9
4	8	1,5
6	43	8,2

As it is showed in Table 4.5 students generally took three points from the genetically modified food issue. They took maximum six and minimum zero points from this scenario.

As can be seen in Table 4.6, the results showed that 13.4% of the students did not get any points because they did not construct any arguments about genetically modified food. For the scenario, students who constructed only claims made up 31% of the sample. Participations mostly (40.3%) constructed arguments at the justification level. In addition, 13% of the participants' informal reasoning was at the counterargument level and only %4.8 of the sample achieved constructing rebuttal.

Table 4.6 *Middle School Students' Frequencies of Informal Reasoning Quality about Genetically Modified Food*

	Frequency	Percent
No Argument	70	13,4
Claim	162	31,0
Justification	211	40,3
Counterargument	68	13,0
Rebuttal	12	2,3

As presented in Table 4.6 students generated justification mostly and rebuttal at least.

4.1.1.3 Informal”Reasoning”Quality”Regarding”Global”Warming and Genetically Modified Food

It is presented in Table 4.7, the mean scores of students' informal reasoning quality regarding global warming and genetically modified food of middle school students. Students' average score of relevance institutions is higher (*M*=3.18) than the mean score of personal relevance (*M*=2.97), while their average score of relevance school (*M*=2.93) is slightly higher than the average score of positive feelings (*M*=2.73). The overall average score of concern is calculated as (*M*=2.90). Students' mean score of self-efficacies (*M*=2.50) and mean score of collective efficacies (*M*=2.30) are not high. The mean score of dependency on others also low (*M*=2.26), but their average score of self-efficacies for motivation is lowest (*M*=2.19). Students have high scores for active learning strategies (*M*=3.79) and science learning value (*M*=3.84). Moreover, they have also high score for learning environments stimulation (*M*=3.48) on average, while their mean score of performance goal not that high (*M*=2.79). Students have the highest informal reasoning quality regarding SSI on average for achievement goal (*M*=4.03).

Table 4.7 *Descriptive Statistics of Middle School Students' Informal Reasoning Quality*

	Mean	Standard Deviation	Range
Relevance Institutions	3.18	0.72	3
Personal Relevance	2.97	0.74	0-4
Relevance School	2.93	0.86	0-4
Concern	2.90	0.95	0-4
Self-efficacy	2.50	0.82	3

Collective efficacy	2.30	1.35	3
Dependency on Others	2.26	0.98	4
Self-efficacy Motivation	2.19	1.08	4
Active Learning Strategies	3.79	0.91	4
Science Learning Value	3.84	0.95	4
Performance Goal	2.79	1.11	4
Achievement Goal	4.03	0.96	4
Learning Environment Stimulation	3.48	0.92	4

As can be seen in Table 4.7 the mean score of achievement goal is the highest while self-efficacy (motivation) score is the lowest.

4.1.2 Middle School Students' Attitudes Towards SSI

Research Question 2: What are the levels of middle school students' attitudes towards SSI?

Descriptive statistics were used to examine the characteristics of the sample and to assist to investigate the nature of the data. It is presented in Table 4.8 those descriptive statistics of variables of attitude toward SSI scale and students' total scores of attitudes toward SSI.

As depicted in Table 4.8 the overall average mean score of participants for relevance institution is high (M = 3.12, SD =0.96). The mean score of relevance institution indicated to what degree students believe it is important for institutions to move in the direction of resolving SSI. Students' personal relevance score is higher (M = 3.0, SD = 0.95) than their mean score of relevance school (M = 2.90, SD = 1.03). Personal relevance indicated the degree to which students think it is important that they act to solve the SSI when they are older while relevance school indicated the degree to how important it is for students learning SSI at school. As mentioned in the Methodology part, concern referred to the degree to which students find SSI worrying. The overall mean score of concern is (M = 3.1, SD = 1.8). Self-efficacy indicated the degree to which students perceive themselves to be able to participate in the SSI and self-efficacy combined with the positive feelings in the present study while collective efficacy referred to the degree to which students believe that their class can participate in the SSI. The overall mean score of students' self-efficacy was slightly higher (M = 2.5, SD = 1.0) than the mean score of collective efficacies (M = 2.3, SD = 1.23). Mean score of students' dependency on others is (M = 2.6, SD = 1.09) defined as the degree to which students' feelings about depending on others for engaging in SSI.

Table 4.8 *Descriptive Statistics for Students' Attitudes Towards SSI*

Variable	*M*	*SD*	Range
Relevance Institution	3.1	0.96	3
Personal Relevance	3	0.95	3
Relevance School	2.9	1.03	3
Concern	3.1	1.08	3
Self-efficacy	2.5	1.00	3
Collective efficacy	2.3	1.23	3
Dependency on others	2.6	1.09	3

In Table 4.8, it is showed that the concern and relevance institution have the highest mean score while collective efficacy has the lowest.

It is calculated the descriptive statistics of students' attitudes toward SSI scores.

Table 4.9 *Students' Total Score of Attitude Toward SSI*

Mean	Std. Dev.	Range
74.5	13.4	92

As can be seen in Table 4.9 Students mean score of attitudes towards SSI is (*M*=74.5, *SD*=13.4). Students' attitudes towards SSI score varies between 30 and 122.

As depicted in Table 4.10, correlation matrix is demonstrating the bivariate correlations between the variables of the attitude towards SSI variables ("relevance institution", "personal relevance", "relevance school", "concern", "self-efficacy", "collective efficacy" and "dependency on others").

Results revealed that there was significant and medium correlation between relevance institution and the other variables except for self-efficacy, collective-efficacy and dependency on others. There was a negative and not significant relationship between relevance school and collective efficacy, while there was a significant and low relationship between self-efficacy and dependency on others. Moreover, personal relevance and other variables are significantly correlated with each other, but the relationship between personal relevance and collective efficacy is not significant. Personal relevance has low and significant positive correlation with dependency on others. Hence, the relationship between relevance school and the other variables is significant and medium but, it has low and significant relationship with dependency on others. While there was a significant and medium correlation between concern and self-efficacy and dependency on others, there was no significant relationship between collective efficacy and dependency on others.

Table 4.10 *Pearson Correlations Between PASSI variables*

Variables	1	2	3	4	5	6	7
1. Relevance Institution	-						
2. Personal Relevance	.43**	-					
3. Relevance School	.40**	.35**	-				
4. Concern	.38**	.37**	.35**	-			
5. Self-efficacy	.17**	.35**	.28**	.24**	-		
6. Collective efficacy	-.042	.06	.04	.05	.21**	-	
7. Dependency on others	.09*	.11*	.15**	.25**	.13**	.06	

*Correlation is significant at the 0.01 level (2-tailed).

As can be seen in Table 4.10, the variables of the attitudes towards SSI scale are generally correlated with each other.

4.1.3 Middle School Students' Motivation to Learn Science

It is given to participants that Students' Motivation Towards Science Learning (SMTSL) questionnaire that is a Likert-type scale, and the scores varies between 0 and 5. While 0 point represents 'strongly disagree, 1 point represent agree. In the scale, 3 points represent undecided, and 4 points represent agree while 5 points

represent strongly agree. Thus, motivation towards science learning was measured. The results of motivation toward science learning included in this section.

Research Question 3: What are the levels of middle school student's motivation to learn science?

It is used descriptive statistics to examine the characteristics of the sample and to assist in investigating the nature of data. It is presented in Table 4.11 those descriptive statistics of predictor variables of motivation towards science learning scale.

As depicted in Table 4.11 the overall average mean score of participants for self-efficacy is (M = 2.31, SD =1.35). Mean score of self-efficacies indicated that students' belief in their ability to perform well in science tasks. Students' active learning strategy score is slightly lower (M = 3.82, SD = 1.21) than their mean score of science learning value (M = 3.85, SD = 1.22). Average score of active learning strategy indicated that active role taken in using variety of strategies to generate new knowledge based on students' previous understanding while science learning value indicated that experience to inquiry activity, mobilize students' own thought and to find the relevance of science in every day. As mentioned in the Methodology part, performance goal referred to students' goal in learning science are compute with other students and to attract to attention of the teacher while achievement goal referred to satisfaction of the students as they increase their competence and success during their science education. Overall mean score of achievement goal is fairly higher (M = 4.03, SD = 1.21) than the overall mean score of performance goal (M = 2.75, SD = 1.47). Learning environment stimulation indicated that students' environment such as the curriculum, teachers' teaching and students' interactions that affects students' motivation in teaching science. Overall mean score of students' learning environment stimulation is (M = 3.46, SD = 1.34).

Table 4.11 *Descriptive Statistics for Students' Motivation to Learn Science*

Variable	Mean	Std. Deviation	Range
Self-efficacy	2.31	1.35	4
Active Learning Strategy	3.82	1.21	4
Science Learning Value	3.85	1.22	4
Performance Goal	2.75	1.47	4
Achievement Goal	4.03	1.21	4
Learning Environment Stimulation	3.46	1.34	4

Table 4.11 showed that self-efficacy has the lowest mean score while achievement goal has the highest.

The descriptive statistics of the students' motivation to learn science are given in the Table 4.12.

Table 4.12 *Students' Total Score of Motivation to Learn Science*

M	*SD*	Range
77.5	11,7	87

As can be seen in Table 4.12 Students mean score of motivation to learn science is (*M*=77.5, *SD*=11.7). Students' motivation to learn science score varies between 23 and 110.

As depicted in Table 4.13, correlation matrix demonstrated the bivariate correlations between the variables of the students' motivation to learn science variables (self-

efficacy, active learning strategies, science learning value, performance goal, achievement goal and learning environment stimulation).

Results showed that there was a significant negative and medium correlation between self-efficacy and active learning strategy, science learning value, performance goal, achievement goal while there was a significant, negative and low correlation between self-efficacy and learning environment stimulation. However, a strong and positive correlation between active learning strategy and science learning value concluded while it is concluded that negative low correlation between active learning strategy and performance goal. Hence, there was a significant medium relationship between active learning strategy and, achievement goal and learning environment stimulation. Results revealed that there was no significant relationship between performance goal and achievement goal, learning environment stimulation. On the other hand, there was a significant medium relationship between achievement goal and learning environment stimulation.

Table 4.13 *Pearson Correlations Between SMTSL Variables*

Variables	1	2	3	4	5	6	7
1. Self-efficacy	-						
2. Active Learning Strategy	-.34**	-					
3. Science Learning Value	-.39**	.61**	-				
4. Performance Goal	.27**	-.09**	-.14**	-			
5. Achievement Goal	-.24**	.45**	.47**	.03	-		

6.	Learning Environment Stimulation	-.17**	.32**	.37**	.09	.37**	-

*Correlation is significant at the 0.01 level (2-tailed).

As presented in Table 4.13, the variables of the students' motivation to learn science are generally correlated with each other.

4.1.4 Middle School Students' Informal Reasoning Modes about SSI

Research Question 4: What are the middle school students' reasoning modes on SSI (Global warming, genetically modified food)?

The results revealed that 34.2% of the students could not take place in any informal reasoning mode, either by not responding or by giving non-significant answers. Students who constructed social-oriented arguments about global warming made up 18.2% of the sample. 4.2% of the students constructed economical-oriented arguments. The majority of the students (41.1%) created ecological-oriented arguments about global warming and only 2.3% of students had science and technology-oriented arguments.

Table 4.14 *Middle School Students' Frequencies of Informal Reasoning Modes about Global Warming*

	Frequency	Percent
No Modes	179	34,2
Social-Oriented	95	18,2
Economical-Oriented	22	4,2
Ecological-Oriented	215	41,1
Science and Technological-Oriented	12	2,3

As can be seen in Table 4.14, students constructed mostly ecological-oriented arguments about the global warming issue.

In Table 4.15, it is represented that some of the examples of students' arguments about global warming.

Table 4.15 *Middle School Students' Arguments about Global Warming*

Informal Reasoning Modes	Justification	Counter Argument	Rebuttal
Social-Oriented	*'If humans continue to consume fossil fuels, our world turn into a fireball.'*	*'Fossil fuels are everywhere in our lives, not using them makes our lives difficult'*	*'We can use renewable energy sources instead of using fossil fuels in daily life.'*
	'If people do not reduce their use of deodorants, we may not be able to prevent global warming.'	*'If people do not use deodorants, they smell bad, and this embarrass them in front of their friends.'*	
Economical-Oriented	*'Measures to be taken for global warming are very costly, may harm the economy of countries'*	*'Global warming is a problem that concerns all countries, so rich countries can provide financial aid to poor countries'*	*'The cost of the precautions is not more important than human life, money is regained.'*
Ecological-Oriented	*'Arctic animals are becoming extinct due to global warming.'*		

	'Global warming is causing damage to the ozone layer.'	*'Global warming is a problem that concerns the whole world. Rich countries can take precautions while poor countries cannot, and this make precautions useless'*	*'Rich countries can help poor countries financially to take precautions for global warming.'*
	'Gases from car exhausts pollute our air, which causes global warming.'	*'People cannot walk everywhere; cars provide convenience for human life.'*	*'If everyone uses public transportation instead of driving individually, less exhaust gas is released into air.'*
	'Precautions should be taken for gases coming out of factory chimneys that cause air pollution.'	*'Shutting down the factories leaves many people unemployed.'*	*'Even if factories are not shutting down, filters can be installed in their chimneys to minimize air pollution.'*
Science and Technology-Oriented	*'Technology is developing day by day and it is normal to have global warming where technology develops'.*		

The results also revealed that 43,8% of the students could not take place in any informal reasoning mode, either by not responding or by giving non-significant

answers. Students who constructed social-oriented arguments about genetically modified food made up 44.7% while 6.5% of the students constructed economical-oriented arguments. The 4.6% of the students created ecological-oriented arguments about genetically modified food and minority of the students (0.4%) constructed science and technology-oriented arguments.

Table 4.16 *Middle School Students' Frequencies of Informal Reasoning Modes About Genetically Modified Food*

	Frequency	Percent
No Modes	229	43,8
Social-Oriented	234	44,7
Economical-Oriented	34	6,5
Ecological-Oriented	24	4,6
Science and Technological-Oriented	2	0,4

As presented in Table 4.16 students constructed mostly social-oriented arguments for the genetically modified food scenario.

Some examples of the arguments about genetically modified food are shown in Table 4.17

Table 4.17 *Examples of Students' Arguments about Genetically Modified Food*

Informal Reasoning Modes	Justification	Counter Argument	Rebuttal
Social-Oriented	*'Genetically modified rice can change the lives of many children as a cure for blindness.'*	*'Even if it is a cure for blindness, it can also have harmful effects on our body.'*	

	'It is beneficial for people with vitamin A deficiency.'	*'People can also compensate for vitamin A deficiency with natural foods.'*	
	'Genetically modified foods can cause genetic disease in humans.'	*'If it is observed that genetically modified rice does not have harmful effects on other living things, human can also consume it.'*	*'People do not have the right to try something that is likely to be harmful on other living things, the also have life.'*
	'It is not a good thing to eat genetically modified food because God created everything as it should be.'		
Economical-Oriented	*'The production of these rice could stop famine in poor countries.'*	*'Rich countries can provide healthier natural food aid to poor countries that experiencing famine.'*	*'Rich countries do not have to help other countries; they have to think about their own people.'*

Ecological-Oriented	*'Genetically modified rice can bring the end of the natural rice grown in the same region.'*	*'If this rice is grown in separate regions from natural rice, there will be no harm to natural rice.'*
Science and Technology-Oriented	*'We can take vitamin A from drugs that sold in pharmacies'*	

In table 4.18 it is showed that the correlation between students' informal reasoning quality and informal reasoning mode scores for both global warming and genetically modified food scenarios.

Table 4.18 *Correlations between Informal Reasoning Quality and Informal Reasoning Mode*

Variables	IR Quality Score	IR Mode Score
Global Warming SSI	-	-
IR Quality Score	-	.674**
IR Mode Score	-	-
Genetically Modified Food	-	-
IR Quality Score	-	.695**
IR Mode Score	-	-

*Correlation is significant at the 0.01 level (2-tailed).

4.1.5 Predictors of Informal Reasoning Quality on SSI

Research Question 5: How can the students' informal reasoning quality regarding SSI be predicted by attitudes towards SSI and motivation to learn science?

In this study, multiple regression analysis was conducted to find out how well the sub-dimensions of attitude towards SSI and motivation to learn science ("relevance institution", "personal relevance", "relevance school", "concern", "self-efficacy" (attitude), "collective efficacy" and "dependency on others", "learning environment stimulation", "self-efficacy (motivation)", "achievement goal", "science learning value", "active learning strategies", "performance goal" which are independent variables) predicted the overall score of middle school students' informal reasoning qualities regarding global warming and genetically modified food (dependent variable). The results are presented in Table 4.15. Firstly, I conducted the preliminary analyses to check the assumptions of multiple regression.

1- Sample size: Stevens (1996) said that "for social science research, about 15 subjects per predictor are needed for a reliable equation'' (p.72). According

to Tabachnick and Fidell (2001), the number of independent variables to be used should be taken into account when determining the sample size (p.117). According to Tabachnick and Fidell (2001), the formula that should be used is N> 50 + 8m where 'm' represents the number of independent variables. There are 13 variables (relevance institution, personal relevance, relevance school, concern, self-efficacy (attitude), collective efficacy, dependency on others, self-efficacy (motivation), active learning strategies, science learning value, performance goal, achievement goal and learning environment stimulation) in this study and the minimum sample size required is 154. This assumption was met as the sample size of the study was 523.

2- Multicollinearity and singularity: While multicollinearity examine whether there is a high level of correlation (r=.9 and above) between independent variables; singularity reveals whether an independent variable is a combination of other independent variables (Palland, 2002). I checked this assumption by looking at the correlation coefficients and Tolerance and Variance Inflation Factor (VIF) values. The results showed that the correlations between all independent variables were less than 0.4. Moreover, the VIF values of the all the independent variables vary between 1.1 and 1.9 which are smaller than 10. Thus, all the data revealed that there was no multi-linearity, and this assumption was met.

3- Normality of Residuals: Normality explains the score distribution of the dependent variable with the independent variables (Palland,2002). I checked this assumption by examining through histogram, scatterplots and normal P-P plots of residuals. As can be presented in Appendix F, Appendix G and Appendix H.

4- Linearity of Residuals: Linearity of residuals was analyzed with partial regression plots. In order for the linearity of residuals violated, the relations of the residuals with the dependent variable must be in the form of a straight line. As seen in Appendix G, the spread of the points did not create a curved shape.

5- Homoscedasticity of Residuals: The variance of residuals associated with the predicted dependent variable scores should be the same for all predicted scores. Scatter plots checked. Since the scatter plots have a roughly rectangular shape, the homoscedasticity assumption was also validated as can be seen in Appendix I.
6- Outliers: According to Palland (2002), outliers mean extreme scores either very high or very low and should be checked for both dependent and independent variables. I checked this assumption with Cook's Distance values which should not be larger than 1. When Cook's values were examined, there was no case where the values were greater than 1, thus it is confirmed that there were no outliers.
7- Independence of Residuals: I checked the independence of residual by examining the Durbin-Watson value, which should be between 1 and 3. This assumption was also confirmed because the Durbin-Watson value was found to be 1.65.

It was deduced from the results that two of the independent variables contributed statistically differently to the estimation of the informal reasoning quality score; relevance institutions and self-efficacy (motivation). Accordingly, relevance institution predicted dependent variable informal reasoning quality positively and significantly, *ß*=.10, t (51) =2.0, $p<.001$, $pr^2=.007$. On the other hand, there was no significant relationship between, informal reasoning quality and personal relevance, *ß*=.05, t (51) =.90, $p<.001$, $pr^2=.002$. Then, the relevance school also did not make unique contribution to the prediction of informal reasoning quality score, *ß*=.06, t (51) =1.3, $p<.001$, $pr^2=.003$. There was also no significant relationship between concern and informal reasoning quality, *ß*=.09, t (51) =1.8, $p<.001$, $pr^2=.006$. Self-efficacy (attitude) also did not predict informal reasoning quality score, *ß*=-.44, t (51) =-.87, $p<.001$, $pr^2=.001$. Informal reasoning quality was not predicted by collective-efficacy *ß*=-.06, t (51) =-1.33, $p<.001$, $pr^2=.003$. Then, the contribution of dependency on other to the prediction of the informal reasoning quality score was

insignificant, *ß*=.01, t (51) =.25, *p*<.001, pr^2=.001. Self-efficacy, which is a sub-dimension of the motivation scale and one of the independent variables, significantly predicted the informal reasoning quality score, *ß*=-.11, t (51) =-2.2, *p*<.001, pr^2=.01. Informal reasoning quality score was not predicted by active learning strategies, *ß*=-.03, t (51) =-.47, *p*<.001, pr^2=.021. Apart from this, while science learning value did not contribute to the prediction of the informal reasoning quality score (*ß*=.03, t (51) =.59, *p*<.001, pr^2=.001) informal reasoning quality score was not predicted by the performance goal (*ß*=-.09, t (51) =-1.90, *p*<.001, pr^2=.007). Also, achievement goal did not predict dependent variable informal reasoning quality, *ß*=.07, t (51) =1.4, *p*<.001, pr^2=.004. According to the results, learning environment stimulation also did not predict the informal reasoning quality score, *ß*=.01, t (51) =.22, *p*<.001, pr^2=.001.

$Y = 0.352\ X1 + 0.156\ X2 + 2.558$

X1 is used for relevance institution while X2 is used for self-efficacy (motivation).

In Table 4.19, it is presented that the multiple regression analysis results of the independent variables.

Table 4.19 *Multiple Regression Analyses Results for Variables Predicting Total Informal Reasoning Quality Score* (N = 523)

	B	SE *B*	*ß*	Sig.
Relevance Institution	0.35	0.18	0.10	.045*
Personal Relevance	0.16	0.17	0.05	.367
Relevance School	0.18	0.14	0.06	.204
Concern	0.23	0.13	0.09	.078
Self-efficacy (Attitude)	-0.13	0.15	-0.04	.392
Collective efficacy	-0.11	0.08	-0.06	.184
Dependency on Others	0.03	0.11	0.01	.801

Self-efficacy (Motivation)	-0.25	0.11	-0.12	.026*
Active Learning Strategy	-0.07	0.15	-0.03	.642
Science Learning Value	0.09	0.15	0.03	.554
Performance Goal	-0.19	0.10	-0.09	.059
Achievement Goal	0.18	0.13	0.07	.176
Learning Environment Stimulation	0.03	0.13	0.01	.824
Adjusted R^2		0.07		
F		3.83		

*p<.05

As can be seen in Table 4.11 informal reasoning quality regarding SSI is predicted by relevance institution and self-efficacy (motivation).

4.2 Summary of the Results

In the present study, Informal Reasoning Quality on Socio-scientific Issues Questionnaire was used to examine the middle school students' informal reasoning quality regarding SSI, their attitudes toward SSI and their motivation to learn science.

Firstly, it is evaluated the descriptive statistics of the findings. The results revealed that the overall average score of students' informal reasoning quality on global warming (*M*=2.64, *SD*=1.86) is higher than their average score of informal reasoning quality on genetically modified food (*M*=2.16, *SD*=1.3). While more than half of the participants (51.1%) took three points from the informal reasoning quality on the global warming questionnaire, 9.9% of them took 0 points. Only 1.7% of the participants took the highest point 10 from the scenario. It is also examined the argumentation pattern about global warming issue of students. Results showed that

half of the participants (%50.9) are at the justification level. While the %9.9 of students did not argue about the issue, 25% of them constructed only claims. I also examined the students' informal reasoning modes, and it is found that many of the students (41.1%) constructed ecologically oriented arguments about the issue of global warming while 34.2% of them constructed nothing about global warming. Hence, 18.2% of the participant constructed social-oriented arguments about the global warming and 4.2% of them constructed economical-oriented arguments. On the other hand, science and technology-oriented mode is used at least.

Secondly, I conducted descriptive statistics analysis for the informal reasoning quality on global warming questionnaire. Results revealed that the mean score of students' informal reasoning quality regarding genetically modified food is (*M*=2.16, *SD*=1.83) slightly lower than the informal reasoning quality on global warming. The highest score students got from this survey was 6 (8.2%), while the lowest score was 0 (14%). While the most frequent (40.9%) score was 3, only 1.5% of the participants got three points from the informal reasoning quality regarding the genetically modified scenario. The most used informal reasoning quality pattern was justification in this scenario (40.3%). Furthermore, 31% percent of the students constructed a claim, while 13% of them constructed counter argument. Only 2.3% of the students constructed rebuttals. I also investigated the students' informal reasoning quality modes. Results also revealed that almost half of the students (44.7) used social-oriented arguments about genetically modified food. While 43.8% of them did not argue about the issue, 6.5% of them used economical-oriented arguments. Moreover, 6.5% of the sample used ecological-oriented modes, and science and technology modes used at least (0.4%) for the genetically modified food. It is also found that the relationship between students' informal reasoning quality and their informal reasoning modes in global warming SSI is slightly bigger than the relationships observed in genetically modified food.

I also analyzed the total scores of informal reasoning quality regarding global warming genetically modified foods. Students' mean score of relevance institutions is (*M*=3.18) while the mean score of personal relevance (*M*=2.97). Students' average

score of relevance school (*M*=2.93) is slightly higher than the average score of concern which is calculated as (*M*=2.90). In fact, the mean score of self-efficacies was calculated as (*M*=2.50). On the other hand, mean score of collective efficacies (*M*=2.30) is not high. The mean score of dependency on others is also low (*M*=2.26), but participants' mean score of self-efficacies for motivation is the lowest (*M*=2.19). Students have high scores for active learning strategies (*M*=3.79) and science learning value (*M*=3.84). Moreover, they have also a high score for learning environment stimulation (M=3.48), but their average score for performance goals is not that high (*M*=2.79). Students' achievement goal has the highest informal reasoning quality regarding SSI (*M*=4.03).

It is also examined in the present study that the middle school students' attitudes towards SSI. I used PASSI to examine attitudes toward SSI. Students' mean score of relevance institution is high (*M* = 3.12, *SD* =0.96. Students' personal relevance score is higher (*M* = 3.0, *SD* = 0.95) than their mean score of relevance school (*M* = 2.90, *SD* = 1.03. Overall mean score of concern is higher (*M* = 3.1, *SD* = 1.8). On the other hand, overall mean score of students' self-efficacy was slightly higher (*M* = 2.5, *SD* = 1.0) than mean score of collective efficacies (*M* = 2.3, *SD* = 1.23). Also, mean score of students' dependency on others is (*M* = 2.6, *SD* = 1.09).

After that, I examined the students' motivation to learn science by using SMTSL scale. SMTSL has six sub-dimension and students' scores for each dimension are calculated separately. The mean score of participants for self-efficacy is (*M* = 2.31, *SD* =1.35). Students' active learning strategy score is slightly lower (*M* = 3.82, *SD* = 1.21) than their mean score of science learning value (*M* = 3.85, *SD* = 1.22). Overall mean score of the achievement goal is fairly higher (*M* = 4.03, *SD* = 1.21) than the overall mean score of performance goal (M = 2.75, SD = 1.47). Overall mean score of students' learning environment stimulation is (*M* = 3.46, *SD* = 1.34).

As a result of the analysis, it was understood that the relevance institution and self-efficacy (motivation) made statistically significant contributions to the estimation of the total informal reasoning quality scores for global warming and genetically

modified food. However, as a result of multiple regression analyses, “personal relevance”, “relevance school”, “concern”, “self-efficacy” (attitude), “collective efficacy” and “dependency on others” variables did not make a significant contribution to the prediction of reasoning quality about global warming and genetically modified food. Although informal reasoning quality shows a positive and significant correlation with some of these variables, it did not present a predictive power of personal relevance, relevance school, positive feelings, concern, self-efficacy (attitude), collective efficacy, dependency on others, active learning strategies, science learning value, performance goal, achievement goal and learning environment stimulation on reasoning quality.

CHAPTER 5

DISCUSSION, CONCLUSION AND IMPLICATIONS

In this chapter, discussion of the findings were presented and implications for educational practices and recommendations for the future research were also provided.

5.1 School Students' Informal Reasoning Quality

The results of the descriptive statistics examining the informal reasoning quality of middle school students revealed that students state different argument patterns on different SSIs. In addition, the informal reasoning quality of students about different SSIs and the modes of their arguments differ (Khishfe et al., 2017). The results of the present study revealed that students' informal reasoning qualities about global warming (M=2.64, SD=1.86) were higher than those about genetically modified food (M=2.16, SD= 1.63). In fact, the frequency of the scores students get from these two scenarios also differs. While the maximum score from the global warming scenario was ten (1.7% of the students), the students got mostly six (8.2%) points from the genetically modified food scenario. The most common score in the two scenarios is three. More than half (51.1%) of the students got three points out of ten from the global warming scenario, while 40.9% of the students got from the genetically modified food scenario. Those who could not get any points from the global warming issue constitute 9.9% of the participants because they provided no answer. Also, 14% of the participants provided no answer for the genetically modified food scenario and got no points. The results examining the informal reasoning quality of the students showed that half of the participants (50.9%) in the global warming issue were at the justification level, and 40.9% of the participants were at the justification level for genetically modified food. In addition, 25% of the students constructed an argument at the claim level for the global warming scenario, and 31% of the participants were

at the claim level for the genetically modified food scenario. While 9.9% of the participants constructed counterarguments for the global warming issue, 13% of the participants created counterarguments for the genetically modified food issue. In fact, students who can construct rebuttals in the global warming scenario (4.8%) are almost twice as likely as students who can construct rebuttals in the genetically modified food scenario (2.3%). It is revealed that students have more qualified informal reasoning about global warming compared to genetically modified food. This might be because students are more familiar with global warming. In the demographic information form given to the students before the data was collected, 56.8% of the students stated that they knew about global warming, but the students who had knowledge about genetically modified food made up 50.9% of the sample. In fact, 5.9% of the students stated that they had no knowledge about global warming, while 10.3% of the students stated that they had never heard about genetically modified food. In a study conducted by Fleming (1986a, 1986b), it is investigated students' informal reasoning for different SSIs through semi-structured interviews. Fleming (1986a, 1986b) stated that many of the participants in his study used scientific terminology, but few created meaningful contexts with scientific knowledge. As a result, it has been revealed that when students lack knowledge, their reasoning about the subjects is also hindered. In fact, in a study conducted by Hogan (2002) it is compared the informal reasoning of middle school students and an ecologist in the context of environmental management dilemmas. As expected, the scientist's rich background knowledge enabled them to present more complex rationales and more explanatory explanations in the context of dilemmas. On the other hand, the limited knowledge of the students limited them to consider many factors while making their decisions. However, more studies are needed to support a positive relationship between content knowledge and informal reasoning quality. Farady et al. (1991) conducted a study on the quality of reasoning about the issues that students at different grade levels may encounter in daily life, and as a result of the study, they explained that there was no significant relationship between students' informal reasoning quality and content knowledge.

In the demographic information form given to the students, the source of their knowledge about global warming and genetically modified food was also asked. While more than half of the participants (54.3%) obtained information about global warming from school, only a few obtained information about this subject from the internet (19.3%) and media tools such as TV and radio (17.9%). On the other hand, while 19.1% of the participants obtained information about genetically modified food from school, the number of those who obtained information about this subject from the internet (48.6%) and TV and radio (18.5%) was higher. This study revealed that students' informal reasoning quality about global warming was better than their informal reasoning quality about genetically modified food. This may be because the Internet is used by students as a source of information. Stahl et al. (1996) stated that when children encounter a problem related to the environment, they have more confidence in the first information they receive, and they get this information mostly from the media. Adults, on the other hand, are more likely to get information about environmental problems from TV. Therefore, it is important to critically read and analyze the information presented by the media before deciding on SSI (Namdar et al., 2020). Media is one of the biggest factors creating misconception, misunderstanding, and confusion about SSI (Zhou et al., 2020). Zhou et al. (2020) investigated the effect of the media on misunderstandings about COVID-19, one of the recent SSIs. The results revealed that videos in the media increase the risk of spreading misunderstanding on this issue.

While evaluating informal reasoning, high-quality reasoning is proven with high-quality argumentation (Topcu, Sadler & Yılmaz-Tüzün, 2010). In this study, while examining students' informal reasoning quality, their argumentation patterns were investigated. According to the results, 31% of the students constructed claims about global warming, and 40.3% of them constructed justifications. The students who made counterarguments about this issue constituted 13% of the sample, and only 2.3% of the students created a rebuttal. 31% of the students' presented counterarguments were 13% of the participants, and only 2.3% of the participants were able to create arguments at the rebuttal level. Compared to the percentages of

argument patterns, middle school students could easily present claims and justifications, but very few of them were able to construct counterarguments and rebuttals. The findings of this study are similar to previous studies investigating students' informal reasoning quality. For example, Wu and Tsai (2011) found that students were better at creating supportive arguments than rebuttals. In addition, Dawson and Venville (2010), in their study with 10th-grade students, stated that the frequency of low-quality argument generation was higher than the frequency of creating high-quality arguments. This process is called rebuttal if the student is able to defend his claim against counterclaims and the supporting evidence of others (Öztürk et al., 2017), and some researchers call rebuttal formation the highest level of informal reasoning quality (Osborne et al., 2004; Wu & Tsai, 2007). In some studies, it has been revealed that informal reasoning quality has a positive relationship with content knowledge (Sadler, 2006). The reason why students create low-quality arguments may be that they lack argumentation in practice. In a study conducted by Dawson et al., (2010), the effect of classroom-based argumentation on students' informal reasoning, argumentation skills, and conceptual understanding of genetics was examined. Some of the students took a class argumentation course that included SSI. The complexity and quality of the arguments of the students who took the argumentation course increased significantly, and these students made more explanations showing informal reasoning. On the other hand, the reason for students' lack of argumentation in practice may be that teachers do not include argumentation in their lessons. Because many studies have shown that pre-service science teachers also have low-quality arguments about SSI (Ozturk & Yilmaz-Tuzun, 2017; Topcu et al., 2010). The fact that teachers have low-quality argumentation skills may cause them to see themselves as inadequate in this regard and therefore not to include such studies in their teaching methods. In fact, Kaya (2013) conducted a study with pre-service teachers and created an experimental and control group, and the experimental group was given argumentation practices in the lessons. At the end of the study, while there was no improvement in the argumentation skills of the control group, the ability of the experimental group to create quality arguments increased significantly.

Increasing the informal reasoning quality of students for SSI largely depends on teachers. Based on the studies carried out with pre-service teachers, the courses, practices, or instructions that novice teachers take to improve their informal reasoning quality and argumentation skills. Giving more importance to SSI in the curriculum of teacher training programs of universities will first increase the informal reasoning quality of future teachers and then students. For this reason, such instructions should be included in the education faculties of universities, and it should be emphasized to pre-service teachers how important such issues are for the future.

Multiple regression analysis results revealed that the informal reasoning quality of the participants was low. Mardin, where the study was carried out, is located in eastern Turkey and the classroom sizes are low in schools here. According to Mitchener and Anderson (1989), teachers do not feel comfortable in discussions with small groups. As a result of this study, this may be the reason why students have low informal reasoning quality about SSI. Teachers may have preferred not to use it, considering that the number of students in the classrooms is not enough to arguments about SSI. This situation may have caused the students to have low argumentation skills and therefore low informal reasoning quality due to the lack of practice in this subject. On the other hand, some of the students in that region where the study was carried out live in villages. According to the information obtained from the Demographic Information Form, only the fathers of the majority of the students contribute to the economic situation of the family by working in a job, while their mothers do not work in any job. In other words, the situation of many students is not good enough economically. Ekborg et al. (2012) conducted a study to investigate teachers' SSI experiences. As a result of the study, teachers stated that it is difficult to direct students to critical reviews and resource research, therefore it is difficult for them to use SSI in their classrooms. This may be another reason why students have low informal reasoning quality as a result of my study. Students who are economically poor may not have sufficient resources to access information, and this

may have led to their low content knowledge on SSI and therefore they have low informal reasoning quality for these issues.

In summary, it has been determined that middle school students do not have qualified reasoning qualities. This might be because students have insufficient content knowledge about SSI and do not have sufficient argumentation experience. In fact, the results of the study showed that students have different qualities of reasoning for different SSIs. The reason for this might be the level of familiarity of the students with these issues and their previous content knowledge about the issue. In addition, it was found that the reasoning skills of students on SSI differed according to SSI. Differences in the nature of SSIs and the way participants perceive these issues may have contributed to the variation in their modes of reasoning.

5.2 Informal Reasoning Modes about SSIs

In this study, students' informal reasoning modes were also investigated using the framework developed by Wu and Tsai (2007). This framework includes four different modes: social-oriented, economical-oriented, ecological-oriented, and science and technology-oriented. According to the findings of the research, while 18.2% of the students created social-oriented arguments about global warming, 4.2% presented economical-oriented arguments about this issue. While the most constructed mode was ecological-oriented (41.1%) about global warming, 2.3% of the participants constructed science and technology-oriented arguments. On the other hand, while the majority of students (44.7%) constructed social-oriented arguments about genetically modified food, 6.5% of them preferred to create economically oriented arguments about this issue. While 4.6% of the participants constructed ecological-oriented arguments about genetically modified food, only 0.4% of them put forward science and technology-oriented arguments about this subject. The results of the study conducted by Khishfe et al. (2017) agree with the results of this study. Khishfe et. al. (2017) stated that while the majority of students have environmental concerns about global warming, they are concerned about the

depletion of natural nutrients and human health related to genetically modified food. The reason why these two studies have similar results may be that global warming is defined as an environmental problem around the world. In addition, the reason why the participants use different modes on different SSIs may be that their perceptions about these issues are different. According to Khishfe (2012), people can approach SSI more personally and therefore approach the issues in terms of their harms and benefits to humans. In the present study, while students generally construct arguments about genetically modified foods' effects on humans, they approached global warming from an environmental point of view. Students generally approached the genetically modified food issue in terms of human health. Topcu et al. (2011) stated that "personal experiences", "nature of science", "conceptualizations" and "content knowledge" are factors that have a significant impact on informal reasoning. Some of the students participating in the study live in villages and grow their own natural vegetables and fruits in their gardens. In other words, considering the personal experiences of the students, they consume more natural foods in their daily lives. This may be the reason why students create mostly social-oriented arguments by considering the genetically modified food issue in terms of human health. The participants have experienced that the foods they have consumed so far have not seen any harm, but on the contrary, they have been beneficial. Therefore, they may have thought that unnatural foods, modified by humans, could be harmful to human health.

5.3 Relationship between Informal Reasoning Quality and Informal Reasoning Modes

It is conducted Pearson correlation analysis to investigate the relationship between middle school students' informal reasoning quality and informal reasoning modes. In order to reveal this relationship, I performed a Pearson correlation analysis between the scores obtained from each socio-scientific scenario and the total scores obtained that represent informal reasoning quality. The results revealed that there are

statistically significant, positive correlations with large effect sizes between informal reasoning mode scores and total scores for each SSI. This means the informal reasoning modes that students use while constructing arguments about the issues and their informal reasoning quality are significantly related to each other. In a study conducted by Wu and Tsai (2007) with high school students, the informal reasoning quality of the students about the nuclear power plant was measured and similar results were found with the results of this study. Wu and Tsai (2007) explained that the number of rebuttals constructed by students is related to the informal reasoning modes they used. That is, students with high informal reasoning qualities are more likely to use a variety of informal reasoning models (Wu & Tsai, 2007). The ability of students to argue an SSI from various perspectives enables them to produce more arguments, or the ability of students to produce more arguments about any SSI allows them to examine this issue from different perspectives. The findings of this study support the findings of the study by Wu and Tsai (2007). Thus, this study contributed to the hypothesis that there is a positive relationship between informal reasoning modes and informal reasoning quality. Therefore, teachers who apply argumentation on SSI in their classrooms should instill and encourage students not only to create counterarguments and rebuttals but also to look at the issue from different perspectives to contribute more effectively to students' informal reasoning quality.

5.4 Predictors of Informal Reasoning Quality Regarding Attitudes Towards SSI and Motivation to Learn Science

In this study, it was investigated how the informal reasoning quality of middle school students was predicted by attitude towards SSI (relevance institution, personal relevance, relevance school, concern, self-efficacy, collective efficacy, dependency on others) and motivation to learn science (active learning strategies, science learning value, self-efficacy performance goal, achievement goal, and learning environment stimulation). Multiple regression analyzes were conducted to investigate this relationship. As a result of the analysis, it was revealed that relevance

institution and self-efficacy (motivation) provide statistically significant contributions in the prediction of informal reasoning quality scores. On the other hand, personal relevance, relevance school, concern, self-efficacy (attitude), collective efficacy, dependency on others, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation did not contribute to the estimation of informal reasoning quality scores. Although it showed a positive and significant correlation with some of the independent variables, they did not contribute to the prediction of informal reasoning quality scores significantly.

Concerns about human impact on the environment such as ozone depletion, depletion of rainforests, and air pollution, have historically always worried people and continue to worry (Meinhold et al., 2005). All individuals have different interests in the environment. Today, many organizations and country managers create laws and programs to protect valuable regions in the world. According to Meinhold and Malkus (2005), the attitudes, behaviors, and concerns of adolescents towards the environment will be a major factor in how to protect and maintain natural resources in the future. In order to know the course of such situations, it is important to learn about adolescents' ideas, attitudes, concerns, and knowledge because adolescents are the decision-makers of tomorrow. Klaver et al. (2022) examined the relationship between students' attitudes towards SSI and their engagement in SSI in a study they conducted with secondary school students. According to the results of the study, many of the students stated that they did not have any knowledge about SSI, and only a few of them took part in activities related to such issues (Klaver et al., 2022). According to Klaver et al. (2022), students who are successful in using resources and have positive attitudes towards SSI are more willing to engage in SSI in lessons. In the present study, the results revealed that there is a significant relationship between students' relevance institutions between their informal reasoning quality. If students are encouraged about the positive attitude toward SSI, this also contributes to their informal reasoning quality. Based on this, we can say that teachers have a great responsibility. If teachers understand the relationship between students' engagement

with SSI and their attitudes towards SSI, they may be more willing to use SSI-based teaching in their lessons. The results of this study are similar to previous studies. Namdar et al. (2020) examined attitudes toward SSI as a predictor of informal reasoning quality in a study they conducted with pre-service science teachers. Namdar et al. (2020), stated that attitudes toward SSI did not predict the informal reasoning quality. Yerdelen et al. (2018), conducted a study to examine the effect of an SSI course on pre-service science teachers' attitudes toward SSI. The SSI course is given to pre-service science teachers. They used ASTSIS as a pre-and post-test. Yerdelen et al. (2018) found that SSI courses contributed positively to the interests of SSI, the usefulness of SSI, and PSTs' liking for these issues. According to Yerdelen et al. (2018), pre-service science teachers who have positive attitudes toward SSI will be more inclined to engage in discussion about these issues, which will encourage them to use decision-making about SSI in their future classrooms. Positive attitudes of future science teachers towards SSI may contribute to students' informal reasoning quality by encouraging students to engage in argumentations about SSI and constructing qualified arguments about the issue. In present study, seven sub-dimensions represent students' attitudes towards SSI, but among these sub-dimensions, only the relevance institution contributes to the estimation of informal reasoning quality. This might be because there is a significant but weak correlation between informal reasoning quality and attitude toward SSI. As mentioned before, some of the participants of the study stated that the sources of their content knowledge about global warming and genetically modified food are the media (TV, radio, internet). Although SSIs such as global warming and genetically modified food are frequently mentioned in the context of the media, organizations, and institutions related to these issues are also frequently mentioned. This may have made students more aware of the role of institutions in the causes and solutions of SSI (Klaver, Molen, Sins, & Guérin, 2022). On the other hand, Chang and Lee (2010) conducted a study with 16 pre-service science teachers and the results of this research revealed that pre-service science teachers' attitudes toward SSI affect their decision-making processes. However, as far as is known, no study quantitatively examines

the relationship between attitude towards SSI and informal reasoning quality regarding SSI. Therefore, more studies are needed to examine the relationship between the quality of informal reasoning and attitude toward SSI.

According to the results of the analysis, another variable that contributes significantly to the prediction of the informal reasoning quality score is self-efficacy (motivation). Bandura (1994) defined self-efficacy as individuals' confidence in solving a problem or accomplishing a task. Motivation and self-efficacy are strongly linked to each other. According to Sadler (2009), the more the students' learning environment is intertwined with their daily life, the more motivated they are to learn science. In fact, some studies have explained the positive relationship between students' motivation to learn science and SSI and their engagement with SSI (Topcu, 2014). Students are more motivated to learn the subject when the subjects taught are more relevant to their personal lives, societies, or future careers (Stukey et al., 2013). Gülacar et al. (2020) examined the effects of integrating SSI into chemistry lessons on students' motivation and self-efficacy in a study they conducted with 760 students. In the study, students completed pre- and post-motivation questionnaires. The results of the research showed that students' motivation to learn the subject of chemistry increased with SSI integration. In fact, students' self-efficacy in chemistry increased, which brought them to be successful in the chemistry course. In present study, results revealed that students' self-efficacy (motivation) has a significant power to predict students' informal reasoning quality regarding SSI. Therefore, increasing the motivation of students not only for SSI but also for learning science will be effective by ensuring that SSI is included in the lessons. Özden (2015) conducted a study with pre-service elementary school teachers and as a result of the study, the pre-service teachers stated that the inclusion of SSI in the lessons could improve students' higher-order thinking skills. Therefore, teachers should guide students while using SSI in their lessons. In fact, a study conducted by Espeja and Lagaron (2015) revealed that when pre-service teachers are taught SSI, they understand SSI better and their interest to use SSI in their teaching increases. In other words, increasing students' motivation to learn science is not just about students. Teachers should also have self-

efficacy and motivation in this regard. Some studies have shown that SSI and motivation are also linked. For example, Gülacar et al. (2020) conducted a study with 760 students using pre- and post-, and it was observed that the self-efficacy of the students in chemistry increased with the SSI applied in the chemistry course. The reason why students' self-efficacy (motivation) is explained as the predictor of informal reasoning might be that they see themselves in a position to take responsibility for the future and the environment. Because, it has been observed that students who worry about the environment and take action on this issue feel better and have an increase in their self-esteem and self-efficacy (Meinhold et al., 2005). Students who are concerned about SSI and want to take action about it can participate more willingly in arguments about the issue. On the other hand, it was revealed that active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation, which represent science learning motivation, did not make any contribution to the estimation of informal reasoning quality score. From this point of view, we can say that there may be a weak but significant relationship between students' motivation to learn science and their informal reasoning quality.

Relevance school, one of the independent variables of the research, was defined as the degree to which students think how important it is to learn SSI at school in this study. As mentioned before, Mardin is located in the east of Turkey and the majority of the teachers working here are novice teachers who are at the beginning stages of their profession and do not have much experience in teaching. Since teachers do not have sufficient experience, they may not be at a sufficient level in planning the lesson, managing the classroom or using teaching techniques, and so, they may not be confident in these matters. This may have caused them to support argumentation on SSI in the classroom. Students may not have learned enough about SSI issues and could not associate these issues with school. Therefore, the relevance school may not have contributed to the estimation of students' informal reasoning quality.

5.5 Conclusion of the Study

This study aims to investigate the informal reasoning quality regarding SSI, attitude toward SSI, motivation to learn science, and the relationship between attitude towards SSI and motivation to learn science, and informal reasoning quality.

Some studies on SSI claim that argumentations on SSI and the development of decision-making abilities will greatly contribute to raising scientifically literate individuals (Yılmaz-Tüzün et al., 2011). These studies also show that students who have advanced skills in argumentations on SSI can solve real-life problems more easily and improve themselves in decision-making based on scientific evidence, in short, they grow up as scientifically literate individuals. Socio-scientific issues, which were previously included as the science-technology-society-environment approach in the curriculum of the elementary school science and technology course, have been fully included in the program since 2013 (Ministry of National Education of Turkey [MoNE], 2013). The results of this research showed that students do not have sufficient informal reasoning quality about such issues yet. Considering the informal reasoning quality of the students, the number of students who can be considered as a high-qualified quality, that is, who can create rebuttals about SSI, is very low. While the majority of the students could easily create a claim or justification about the issue, very few of them were able to create counterarguments or rebuttals. This shows that the informal reasoning quality of middle school students is at a low level.

Informal reasoning quality and informal reasoning modes used in arguments are significantly related to each other (Wu & Tsai, 2007). In order to examine this assumption, in this study, the relationship between the informal reasoning quality of students and the scores of the informal reasoning modes they used was examined using two different SSIs, and it was revealed that there were significant relationships between informal reasoning quality and informal reasoning modes. Students with high informal reasoning quality used more diverse informal reasoning modes in their arguments. This means that considering middle school students' use of different

informal reasoning modes is an important factor in improving their informal reasoning quality.

One of the aims of this research is how attitude toward SSI and motivation to learn science predict the informal reasoning quality. The results revealed that only the relevance institutions representing attitudes towards SSI contributed significantly to the prediction of the informal reasoning quality. It was revealed that “personal relevance”, “relevance school”, “concern”, “self-efficacy” (attitude), “collective efficacy” and “dependency on others” did not predict informal reasoning quality. We can say that the prediction power of attitude towards SSI to the informal reasoning quality is low. The results of the analysis also showed that motivation to learn science has a low predictive power of informal reasoning quality. While active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation representing motivation to learn science did not contribute to predicting informal reasoning quality, it was observed that only self-efficacy (motivation) had a significant contribution.

5.6 Implications of the Study

In present study, it is investigated that middle school students' informal reasoning quality, their attitudes toward SSI, and their motivation to learn science. Based on the findings of the research, a few key implications were mentioned that science curriculum developers, teacher educators, and science teachers should consider.

In science education, students are taught SSI and encouraged to make decisions about social issues (Klaver et al., 2022). Klaver et al. (2022) stated that through SSI education, students are encouraged to argue, reflect on values from different perspectives, and make decisions about such issues. Therefore, the inclusion of SSI in science education enables future decision-makers to have an important role in such issues in the future. SSIs have been included in the curriculum of the middle school science and technology course since 2013, but when we look at the results of the

present research, the SSI education in the curriculum could not provide the expected return to the students. Although SSIs such as global warming and cloning are separately included in the curriculum, the relationship of these subjects to society, the environment, and science is not clearly explained. According to the curriculum, even if the students learned scientific knowledge about SSI such as global warming, ozone layer damage, cloning, and climate change, a learning environment could not be created to discuss such issues, to look at such issues from different perspectives, or to find alternative solutions. Synthesizing SSI in the curriculum not as scientific knowledge but as effective use of argumentation can play an important role in raising the informal reasoning quality of students on such issues. Apart from the effective use of argumentation, textbooks can provide informative additions about how SSI can be carried out with the argumentation, the relationship of argumentation with SSI, and how SSI can be handled with argumentation.

The fact that students have qualified knowledge about SSI and have a high quality of informal reasoning about these issues is related to how much their teachers can give these abilities to them. Many studies have shown that pre-service science teachers and in-service science teachers do not have qualified informal reasoning (Kortland, 1996, Öztürk et al., 2010). Therefore, it would be beneficial to include instruction involving SSI in teacher training programs, because studies are showing that such instructions increase the informal reasoning quality regarding SSI of pre-service science teachers. Robertshaw and Cambell (2013), stated that in order to develop students' scientific argumentation skills in the classroom, pre-service teachers should be prepared in this regard. Robertshaw and Cambell (2013) conducted a study with pre-service teachers and examined how the instruction in the Toulmin Argumentation Protocol (TAP) affected their ability to construct logical and scientific argumentation over a semester. The results of the study showed that the instruction in the Toulmin Argumentation Protocol has a positive relationship with the ability of pre-service teachers to produce scientific arguments

If teachers have sufficient self-efficacy to use socio-scientific topics in their lessons, and if they trust their content knowledge, they can use SSI-based teaching more in

their teaching. In order to achieve this, teachers should be supported in this regard. Policymakers should organize teacher education curricula so that teachers have sufficient skills in SSI and are motivated to use SSI. Curriculum developers should create an educational environment where pre-service teachers can practice with SSI-based instructions. This will enable future teachers to train students who are motivated to learn science and have high informal reasoning qualities for SSI.

5.7 Recommendations for the Future Research

First of all, to examine the relationship between informal reasoning quality, attitude towards SSI, and motivation to learn science, such a study can be carried out with a larger sample size and with all grade levels covering the middle school. In addition, it can be recommended that studies should be conducted on more than two SSIs such as nuclear power plants, acid rain, and genetic engineering. Apart from this, such a study can be supported not only in the form of open-ended questions but also through interviews with the participants.

It is recommended to conduct more studies examining the relationship between attitudes toward SSI and informal reasoning quality. In fact, in this study, attitude towards SSI and motivation to learn science are considered as factors that may be related to informal reasoning quality, but this framework can be expanded in future research, such as media literacy, nature of science understanding, content knowledge, etc.

Finally, as mentioned before, although SSIs are included in the science education curriculum, students have low informal reasoning quality. Studies can be conducted to test the causes of this situation and to investigate what solutions are needed. Also, more studies are needed to investigate how science teachers' attitudes toward SSI or how science teachers' motivation to learn science affects students' informal reasoning quality.

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APPENDICES

A. Permission Obtained From Mardin Provincial Directorate of National Education

T.C.
MARDİN VALİLİĞİ
İl Millî Eğitim Müdürlüğü

Sayı : E-63050228-605.01-55729816 23.08.2022
Konu : Araştırma Uygulama İzinleri

DAĞITIM YERLERİNE

İlgi : a) Birumi Üniversitesi Lisansüstü Eğitim Enstitüsü Müdürlüğünün 30/06/2022 tarihli ve E-15952939-302.14.99-29992 sayılı yazısı.
b) Orta Doğu Teknik Üniversitesi Rektörlüğü Öğrenci İşleri Daire Başkanlığının 28/07/2022 tarihli ve 54850036-044-E.314 sayılı yazısı.
c) MEB 21/01/2020 tarihli 2020/2 Numaralı Araştırma Uygulama İzinleri Genelgesi.
d) Valilik Makamının 22/08/2022 tarihli ve E-63050228-605.01-55637715 sayılı Oluru.

İlgi (a) yazıya istinaden; Lisansüstü Eğitim Enstitüsü Fizyoterapi ve Rehabilitasyon Tezli Yüksek Lisans Programı 201119015 numaralı öğrencisi Kübra ARSLAN, Doç. Dr. Buket AKINCI danışmanlığında "Obez ve Fazla Kilolu Adölesanlarda Tepe Ekspiratuar Akım, Fiziksel Aktivite Düzeyi, Antropometrik Ölçümler ve Kor Performansının İncelenmesi" başlıklı tez çalışması kapsamında Mardin ili Artuklu ilçesine bağlı Kazımiye Ortaokulunda 12/09/2022–23/09/2022 tarihleri arasında uygulama yapacağı,

İlgi (b) yazıya istinaden; Matematik ve Fen Bilimleri Eğitimi Anabilim Dalı Fen Bilimleri Eğitimi yüksek lisans programı öğrencisi Büşra Manay, Prof. Dr. Özgül Yılmaz Tüzün'ün danışmanlığında "Ortaokul Öğrencilerinin Sosyo-bilimsel Konulara Yönelik Tutumları, Akıl Yürütme Kaliteleri ve Fen Öğrenme Motivasyonları" başlıklı tez çalışması kapsamında Mardin ili Artuklu ilçesine bağlı Resmi Meslekî ve Teknik Anadolu Lisesi, Resmi İmam-Hatip Anadolu Lisesi, Resmi Ortaokullarda 19/09/2022-19/12/2022 tarihleri arasında uygulama yapacağı,

İlgi (a,b) yazılar ilgi (c) Genelgeye göre incelenmiş olup; Türkiye Cumhuriyeti Anayasası Millî Eğitim Temel Kanunu ile Türk Millî Eğitiminin genel amaçlarına uygun olarak, 6698 sayılı Kişisel Verilerin Korunması Kanununa, yürürlükteki diğer tüm düzenlemelerde belirtilen hükümlere esas ve amaçlara aykırılık teşkil etmeyecek şekilde, denetimleri ilgili ilçe millî eğitim müdürlükleri ve okul/kurum idaresinde olmak üzere, kurum faaliyetlerini aksatmadan, gönüllülük esasına dayalı olarak yapması ilgi (f) yazıda uygun görülmüştür.

Bilgilerinizi ve gereğini rica ederim.

Mehmet Halit DEMİRCAN
Vali a.
İl Millî Eğitim Müdür V.

Ek : -İlgi (a) yazı (28 Sayfa)
-İlgi (b) yazı (18 Sayfa)
-İlgi (d) Oluru (1 Sayfa)

Dağıtım :
-Artuklu Kaymakamlığına (İlçe Millî Eğitim Müdürlüğü)

Bilgi : -Birumi Üniversitesi Rektörlüğüne
-ODTÜ Rektörlüğü Öğrenci İşleri Daire Başkanlığına

B. Demographic Information Form

Kişisel Bilgi Ölçeği

1. Okulunuzun Adı:_____
2. Doğum tarihiniz (yıl): _____
3. Cinsiyetiniz: ❑ Kız ❑ Erkek
4. Kaç kardeşsiniz? (.....) (sizinle birlikte)
5. Annenizin eğitim durumu: ❑ İlkokul ❑ Ortaokul ❑ Lise ❑ Üniversite ❑ Yüksek Lisans/ Doktora ❑ Okuma-yazma bilmiyor
6. Babanızın eğitim durumu: ❑ İlkokul ❑ Ortaokul ❑ Lise ❑ Üniversite ❑ Yüksek Lisans/ Doktora ❑ Okuma-yazma bilmiyor
7. Anneniz çalışıyor mu? ❑ Evet ❑ Hayır

Yanıtınız "evet" ise çalıştığı kurum: ❑ Devlet dairesi ❑ Özel sektör ❑ Kendi işyeri ❑ Çiftçi ❑ Emekli

8. Babanız çalışıyor mu? ❑ Evet ❑ Hayır

Yanıtınız "evet" ise çalıştığı kurum: ❑ Devlet dairesi ❑ Özel sektör ❑ Kendi işyeri ❑ Çiftçi ❑ Emekli

9. Küresel ısınma ile ilgili ne kadar bilgilisiniz?

❑ Kendime Güveniyorum ❑ Az Bilgiliyim ❑ Hiç Duymadım

10. Küresel ısınma ile ilgili bilgilerinizi nereden edindiniz? (Birden fazla seçeneği işaretleyebilirsiniz.)

❑ Okul ❒ İnternet ❑ Radyo ve Televizyon ❑ Çevre

10. Genetiği değiştirilmiş gıdalar ile ilgili ne kadar bilgilisiniz?

❑ Kendime Güveniyorum ❑ Az Bilgiliyim ❑ Hiç Duymadım

11. Genetiği değiştirilmiş gıdalar ile ilgili bilgilerinizi nereden edindiniz? (Birden fazla seçeneği işaretleyebilirsiniz.)

❑ Okul ❒ İnternet ❑ Radyo ve Televizyon ❑ Çevre

C. Turkish Version of Informal Reasoning on Socio-scientific Issues Questionnaire

Sosyobilimsel Konular ile ilgili Görüşler Ölçeği

Senaryo 1: Küresel Isınma

Küresel ısınma, bütün ülkeleri ilgilendiren önemli bir çevresel durumdur. Bazı bilim insanlarına göre, insan faaliyetleri, özellikle fosil yakıtların (petrol, gaz ve kömür) yakılması, atmosferdeki karbondioksit ve diğer gaz (karbon monoksit, azot dioksit gibi) seviyelerini önemli ölçüde artırdı. Eğer bu gazlar atmosferde normal seviyede olursa güneş enerjisini hapsederek Dünya'nın sıcaklığını dengede tutar. Fakat atmosferde bu gazların seviyelerinin normalin üzerine çıkması, Dünya'nın sıcaklığını yükseltmektedir ve bu yükseliş de çevresel sorun olan küresel ısınmaya yol açar.

Karşıt görüşe sahip bilim insanlarına göre ise, küresel ısınmada insan faaliyetlerinin etkisi önemsizdir. Dünya sıcaklığındaki artışlar, Dünya ikliminin doğal bir parçasıdır. Dünya'mız geçmişte, insan etkisinin olmadığı zamanlarda, buz çağları ve aşırı sıcak dönemler yaşamıştır. Ayrıca, bu görüşe sahip bilim insanları, küresel ısınmayı engellemek için alınan önlemlerin, ülkeleri ekonomik krize sokacağından endişe duymaktadır.

Paris'te, 2015 yılında düzenlenen iklim değişikliği- küresel ısınma konferansında Paris İklim Anlaşması kabul edilerek atmosferde sıcaklığı artıran gazların miktarının azaltılması hedeflenmiştir. Bütün ülkelerin bu süreçte sorumluluk almaları; fosil yakıtların kullanımını azaltmaları ve yenilenebilir enerji tercih etmeleri kararlaştırılmıştır. Bu anlaşma kapsamında, ekonomik düzeyi iyi olan ülkeler, daha fakir ülkelere finansal destek sağlayacaktır.

1. Küresel ısınmaya karşı önlemler alınması ya da alınmaması konusunda sizin görüşünüz nedir?

2. Arkadaşlarınıza kendi görüşünüzü hangi bilgileri kullanarak savunursunuz?

3. Sizin görüşünüze karşıt görüş sahibi olan arkadaşınız hangi bilgileri kullanarak görüşünü savunabilir?

4. Arkadaşınızın görüşü ve verdiği bilgilere karşı kendi görüşünüzü (2. Soruda belirttiğiniz) hangi bilgileri kullanarak savunmaya devam edersiniz?

Senaryo 2: Genetiği Değiştirilmiş Gıdalar

İngiltere'deki bilim insanları, A vitamini eksikliğini gidermek için genetiği değiştirilmiş olan "besin değeri zenginleştirilmiş pirinç" türünü geliştirdiler.

Genetiği değiştirilmiş bu pirinç bitkileri normal pirinç bitkisinden iki fazla gen

içermektedir.

Bir grup bilim insanı, genetiği değiştirilmiş pirinci yemenin, sindirim sırasında A vitamini alımını arttırarak körlüğün önlenmesine yardımcı olabileceğine inanmaktadır. Sonuç olarak, bu pirincin tüketimi, dünya çapında,

500.000 çocuğu etkileyen çocukluk dönemi körlüğünü azaltabilir. Bu bilim insanları, genetiği değiştirilmiş gıdaların insan ve diğer canlılar için tehlikeli olduğunu belirten herhangi bir bilimsel çalışma olmadığını belirtmektedir.

Diğer bir grup bilim insanı, genetiği değiştirilmiş pirinci (veya genetiği değiştirilmiş herhangi bir yiyeceği) yemenin bizi nasıl etkileyeceğini bilmediğimizi savunmaktadır. İki genin eklenmesinin bitkiyi bir bütün olarak nasıl değiştirdiğini görmek için bu pirincin biyokimyasal analizinin gerekli olduğunu ve bunun yapılmadığını savunmaktadır. Ayrıca, yeni pirinç bitkileri ile diğer pirinçlerin aynı bölgelerde yetişmesinden dolayı diğer pirinçlerin genetik yapısının da bozulabileceğinden endişe duyulmaktadır. Bu yüzden, bu gruptaki bilim insanları, sağlıklı beslenmenin, A vitamini eksikliği ile başa çıkmak için genetiği değiştirilmiş pirinçten daha iyi bir çözüm olabileceğini savunmaktadır.

1. Genetiği değiştirilmiş pirincin üretilerek satışa sunulması ya da sunulmaması konusunda sizin görüşünüz nedir?

2. Arkadaşlarınıza kendi görüşünüzü hangi bilgileri kullanarak savunursunuz?

3. Sizin görüşünüze karşıt görüş sahibi olan arkadaşınız hangi bilgileri kullanarak görüşünü savunabilir?

4. Arkadaşınızın görüşü ve verdiği bilgilere karşı kendi görüşünüzü (2. Soruda belirttiğiniz) hangi bilgileri kullanarak savunmaya devam edersiniz?

D. Turkish Version of Pupil's Attitudes Toward SSI (PASSI)

	1	2	3	4
Ülkelerin dünyada yaşanan sorunlara çözüm üretmeyi düşünmeleri gerektiğine inanıyorum.				
Devletin dünyada yaşanan sorunlara göre hareket etmesinin çok önemli olduğunu düşünüyorum.				
Örgütlerin dünyada yaşanan sorunlara göre hareket etmelerinin çok gerekli olduğunu düşünüyorum.				
Yaşım ilerledikçe dünyada yaşanan sorunları çözmeye yardımcı olmamın kendi adıma çok önemli olduğunu düşünüyorum.				
Yaşım ilerledikçe dünyada yaşanan sorunları çözmeye yardımcı olabilmem benim için çok önemli.				
Yaşım ilerledikçe dünyada yaşanan sorunları çözmek için bir şeyler yapmamın kendi adıma çok önemli olduğuna inanıyorum.				
Yaşım ilerledikçe dünyada yaşanan sorunları çözmeye yardımcı olmamın son derece gerekli olduğunu düşünüyorum.				
Bence okulda dünyada yaşanan sorunları öğrenmeliyiz.				
Okulda dünyada yaşanan sorunları öğrenmemizin çok önemli olduğunu düşünüyorum.				
Okulda dünyada yaşanan sorunlar hakkında bilgi edinmenin çok önemli olduğuna inanıyorum.				
Okulda dünyada yaşanan sorunları öğrenmenin çok gerekli olduğunu düşünüyorum.				
Dünya yaşanan sorunları çok ilginç buluyorum.				
Dünyada yaşanan sorunları araştırmaktan gerçekten zevk alıyorum.				
Dünyada yaşanan sorunlar hakkında daha fazla şey öğrenmekten gerçekten zevk alıyorum.				

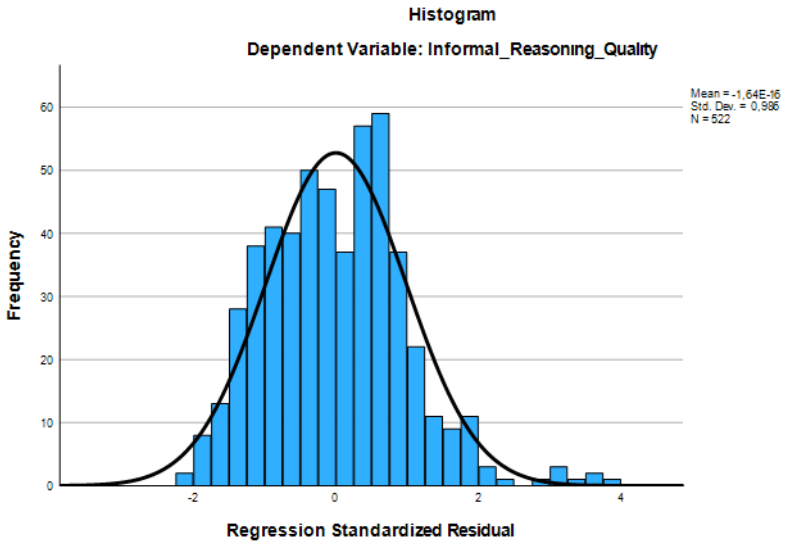
Dünyada yaşanan sorunlar hakkında düşünmeyi gerçekten çok seviyorum.				
Dünyada yaşanan sorunlardan dolayı endişeleniyorum.				
Dünyada yaşanan sorunlar beni gerçekten endişelendiriyor.				
Dünyada yaşanan sorunlar beni çok endişeleniyor.				
Dünyada yaşanan sorunlar hakkında bilgi toplamada çok iyiyim.				
Dünyada yaşanan sorunlara çözüm bulmakta çok iyiyim.				
Dünyada yaşanan sorunları hakkında araştırma yapmakta çok iyiyim				
Sınıfımın dünyada yaşanan sorunlara çözüm bulmakta çok iyi olduğunu düşünüyorum.				
Sınıfımın dünya sorunlarını tartışmakta çok iyi olduğunu düşünüyorum.				
Sınıfımın dünyada yaşanan sorunlar hakkında bilgi toplamada çok iyi olduğunu düşünüyorum.				
Sınıfımın dünyada yaşanan sorunları araştırmakta çok iyi olduğunu düşünüyorum.				
Dünyada yaşanan sorunları araştırmak için başkalarının yardımına ihtiyacım var.				
Dünyada yaşanan sorunlara çözüm bulmak için başkalarının yardımına ihtiyacım var.				

E. Students' Motivation Towards Science Learning (SMTSL)

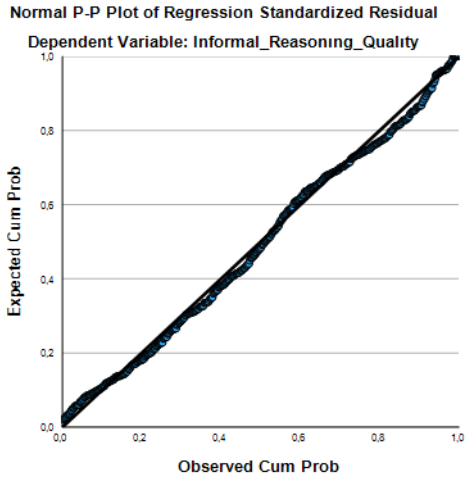
	Kesinlikle Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle Katılmıyorum
1. Fen konuları ister zor ister kolay olsun, bu konuları anlayabileceğimden eminim.					
2. Zor olan fen kavramlarını anlayabileceğimden çok emin değilim.					
3. Fen sınavlarında başarılı olacağımdan eminim.					
4. Ne kadar çabalarsam çabalayayım, fen konularını örenemiyorum.					
5. Fenle ilgili etkinlikler çok zor olduğunda, bunları yapmaktan vazgeçerim veya sadece kolay kısımlarını yaparım.					
6. Fenle ilgili etkinlikleri yaparken cevapları kendim bulmaya çalışmaktansa başkalarına sormayı tercih ederim.					
7. Fen dersinin konuları bana zor geldiğinde, bu konuları örenmek için uğraşmam.					
8. Yeni fen kavramlarını örenirken, bunları anlamak için çaba gösteririm.					
9. Yeni fen kavramlarını örenirken, bunlarla daha önceki deneyimlerim arasında bağlantılar kurarım.					
10.Bir fen kavramını anlamadığımda bana yardımcı olacak uygun kaynaklar bulurum.					
11. Bir fen kavramını anlamadığımda, bu kavramı anlayabilmek için öğretmenimle ya da diğer öğrencilerle tartışırım.					
12. Öğrenme süreci boyunca, örendiğim kavramlar arasında bağlantılar kurmaya çalışırım.					
13. Bir hata yaptığımda, niçin hata yaptığımı bulmaya çalışırım.					
14. Anlamadığım fen kavramlarıyla karşılaştığımda, yine de bunları anlamak için çaba gösteririm.					

15. Günlük hayatımda kullanabileceğim için fen örenmenin önemli olduğunu düşünüyorum.					
16. Fen beni düşünmeye yönelttiği için, fenin önemli olduğunu düşünüyorum.					
17. Fende problem çözmeyi öğrenmenin önemli olduğunu düşünüyorum.					
18. Fende araştırmaya yönelik etkinliklere katılmanın önemli olduğunu düşünüyorum.					
19. Fen konularını öğrenirken merakımı giderecek fırsatların olması önemlidir.					
20. Fen derslerine diğer öğrencilerden daha iyi olmak için katılım gösteririm.					
21. Fen derslerinde derse katkıda bulunmamım amacı, diğer öğrencilerin zeki olduğumu düşünmelerini sağlamaktır					
22. Fen derslerine öğretmenimin dikkatini çekebilmek için katılım gösteririm.					
23. Fen dersinde bir sınavdan iyi bir not aldığımda kendimi başarılı hissederim.					
24. Fen dersinin konularında kendime güvendiğimde kendimi iyi hissederim.					
25. Fen dersinde zor bir problemi çözebildiğimde kendimi başarılı hissederim.					
26. Fen dersinde, öğretmen fikirlerimi kabul ettiğinde kendimi iyi hissederim.					
27. Fen dersinde diğer öğrenciler fikirlerimi kabul ettiğinde kendimi iyi hissederim.					
28. Fen dersinin konuları heyecan verici ve çeşitli konulardan oluştuğu için fen dersine katılmaya istekliyimdir.					
29. Öretmenim farklı öğretim yöntemleri kullandığı için fen dersine katılmaya istekliyimdir.					
30. Öğretmenim üzerimde çok fazla baskı oluşturmadığı için fen dersine katılmaya istekliyimdir.					
31. Öğretmen bana ilgi gösterdiği için fen dersine katılmaya istekliyimdir.					
32. Fen dersi beni düşünmeye zorladığı için fen dersine katılmaya istekliyimdir.					
33. Öğrenciler konuları tartışabildikleri için fen dersine katılmaya istekliyimdir					

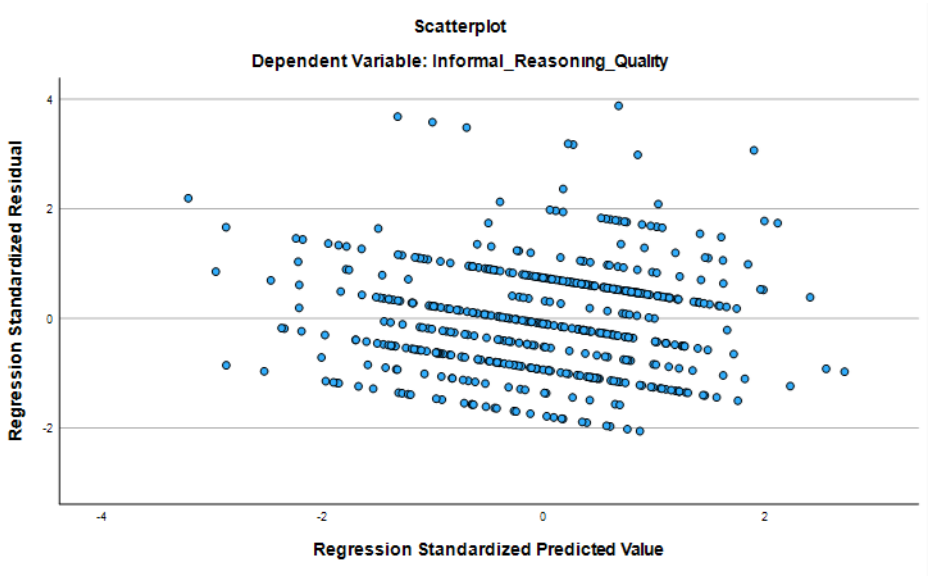
F. Histogram for Informal Reasoning Quality



G. P-P Plot for Informal Reasoning Quality



H. P-P Plot for Informal Reasoning Quality



I. Scatterplots for Informal Reasoning Quality