AN ANALYSIS OF SCIENCE TEACHERS' GENETICS LITERACY AND RELATED DECISION MAKING PROCESS

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ABSTRACT

AN ANALYSIS OF SCIENCE TEACHERS' GENETICS LITERACY AND RELATED DECISION MAKING PROCESS

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The purpose of the present study was twofold. The study, first explored the relationships among science teachers' background characteristics (gender, teaching experience, self-perceived interest in genetics and self-perceived knowledge in genetics), their genetics literacy levels, attitudes towards various issues in genetics literacy and perceptions of teaching issues in genetics literacy. Second, the present study was aimed to explore the factors that influence science teachers' decision making processes. In current study, sequential explanatory design, a type of mixed method research, was adopted. 435 science teachers working in public middle schools in Ankara participated in the quantitative part of study. Participating teachers completed Genetics Literacy Assessment Inventory, Attitudes towards Issues in Genetics Literacy Scale and Perceptions of Teaching Issues in Genetics Literacy Scale. Semi-structured interviews were conducted with 18 volunteer science teachers in the qualitative part of study. Results revealed that being female, having high level of interest in genetics and perceiving themselves as knowledgeable in genetics were associated with higher levels of knowledge in genetics literacy and favorable general attitudes as well as believing the necessity of introducing genetics literacy and holding higher self-efficacy teaching beliefs. They, however, were likely to emphasize more hinderer factors as well as holding unfavorable attitudes towards gene therapy and gene therapy applications implying that their attitudes were context dependent. Likewise, their decisions were changed based on the issues being investigated. While their decisions were influenced by a wide range of factors, the emergent factor that influenced their decisions was found as moral considerations.

Keywords: Genetics Literacy, Science Teachers, Attitude, Decision-Making

ÖZ

FEN BİLİMLERİ ÖĞRETMENLERİNİN GENETİK OKURYAZARLIK DÜZEYLERİNİN VE KARAR VERME SÜREÇLERİNİN İNCELENMESİ

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Bu çalışmanın, iki amacı bulunmaktadır: İlki, ortaokul fen bilimleri öğretmenlerinin genetik okuryazarlık düzeyleri, çeşitli genetik okuryazarlık konularına yönelik tutumları ve genetik okuryazarlık konularının öğretimine yönelik algılarını ile bu değişkenler arasındaki ilişkilere etki edebilecek faktörler (cinsiyet, mesleki deneyim, mezun olunan bölüm, genetik okuryazarlığa yönelik ilgi ve genetik okuryazarlığın öğrenildiği bilgi kaynakları) arasındaki ilişkileri incelemektir. Diğer amacı ise, fen bilimleri öğretmenlerin genetik okuryazarlık ile ilgili farklı konularda karar verme süreçlerini ve bu süreçleri etkileyen faktörleri incelemektir. Bu amaçla, Genetik Okuryazarlık Ölçme Envanteri, Genetik Okuryazarlığa Yönelik Tutum Ölçeği ve Genetik Okuryazarlık Öğretimine

Yönelik Algı Ölçekleri kullanılmıştır. Araştırmada, nitel ve nicel araştırma yöntemleri birlikte kullanılmıştır. Araştırmanın nicel kısmına, Ankara ilinde farklı okullarda görev yapan 435 fen bilimleri öğretmeni katılırken, nitel kısmına ise 18 fen bilimleri öğretmeni gönüllü olarak katılmıştır. Nicel verilerin analizinde kanonik korelasyon yöntemi kullanılmıştır. Sonuçlar, genetik konularına ilgi duyan ve kendilerini daha bilgili algılayan kadın fen bilimleri öğretmenlerinin, daha yüksek düzeyde genetik okuryazar bireyler olduklarını ortaya koymuştur. Buna ek olarak, bu öğretmenlerin genel tutumlarının daha pozitif olduğu ve öz-yeterlik algılarının yüksek olduğu sonucuna ulaşılmıştır. Bununla birlikte, aynı öğretmenlerin gen terapisi ve gen terapisi uygulamalarına yönelik olumsuz bir tutum içinde oldukları görülmüş ve bu öğretmenler, genetik okuryazarlık konularının fen sınıflarında öğretilmesinin önünde öğrencilerin ilgi ve başarıları gibi belli engeller olduğunu belirtmişlerdir. Nitel verilerin analizi sonucunda ise, öğretmenlerin karar verme süreçlerinde çeşitli faktörlerin etkili olduğu sonucuna ulaşılmıştır. Öğretmenlerin karar verme süreçlerini etkileyen en temel faktörün ahlaki faktör olduğu, bununla birlikte, bu süreçlerde birden fazla faktörün birbiri ile etkileşimde olduğu ve incelenen genetik okuryazarlık konularına göre farklılık gösterdiği bulgularına ulaşılmıştır.

Anahtar Kelimeler: Genetik Okuryazarlık, Fen Bilimleri Öğretmenleri, Tutum, Karar Verme Süreçleri

To my parents

Kezban and Ali CEBESOY

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PST	Pre-service Science Teachers
SSIs	Socio-scientific Issues
MoNE	Ministry of National Education
ATIGLS	Attitudes towards Issues in Genetics Literacy Scale
GLAI	Genetics Literacy Assessment Inventory
PTGIGLS	Perceptions of Teaching Issues in Genetics Literacy Scale
GM foods	Genetically Modified foods
Int_gen	Self-perceived Interest in genetics
Know_gen	Self-perceived knowledge in genetics
perc	Perceptions
gen_att	General attitude
use_gen	Use of genetic information
abort	Abortion
pre_IG	Pre-implementation genetic diagnosis
gene_ther	Gene therapy
g_thr_sit	Gene therapy applications

CHAPTER I

INTRODUCTION

Scientific literacy is an umbrella term that consist many different interest areas (Roberts, 2007). Despite its importance, definition of scientific literacy has long been remained "ill-defined and diffuse" (Laugksch, 2000; Dillon, 2009; Millar, 2006). Even its precise meaning is assumed to be unclear as Millar (2006) indicated, Norris and Philip (2003) clarified some core conceptions that required for scientific literacy. According to Norris and Philips (2003), scientific literacy requires conceptual understanding of basic scientific ideas, the role of science and its applications as well as nature of science. In addition, it requires the ability to use scientific knowledge in problem-solving situations and the ability to think critically as well as assessing risk and benefits arising from scientific endeavor implicit in their definition.

In addition to having contemporary knowledge regarding science, Lederman and his colleagues (2014) stated that the scientific literacy entails using this scientific knowledge in making decisions about personal and ethical situations (p. 286). Making informed decisions are also attributed to scientific literacy in numerous studies (Bingle & Gaskell, 1994; Dawson, 2011; Lee, 2007; 2008; Lewis & Leach, 2006; Roberts, 2007; Sadler, 2004a; Sadler, Amirshokoohi, Kezampouri, & Allspaw, 2006; Zeidler, Walker, Ackett, & Simmons, 2002; Tsui & Treagust, 2010). Thus, making informed decisions are elucidated as an important characteristic of scientifically literate individuals. With the rapid increase in genetic technologies, being well informed about genetics issues such as genetic testing, stem cell research, gene therapy or genetically modified foods as well as being aware of the ethical, legal and moral controversies that are emanating from technologies have become crucial (Miller, 1998; Sturgis, Cooper & Five-Schaw, 2005; Lee & Witz, 2009; Tsui & Treagust, 2010; van der Zande, Brekelmans, Vermunt & Waarlo, 2009). Since these issues are indispensable parts of scientific literacy as Tsui and Treagust (2010) mentioned, scientifically literate individuals should have accurate scientific understanding about the genetic technologies but also make informed decisions about socially and ethically controversial issues (Halverson, Freyermuth, Siegel & Clark, 2010; Sturgis et al. 2005; Tsui & Treagust, 2010). Accordingly, not only developing understanding but also participating in and making informed decisions about science-based social discussions turn out to be a requirement which have been frequently emphasized for citizens living in modern societies (Bingle & Gaskell, 1994; Eggert & Bögeholz, 2010; Kolstø, Bungum, Arnesen, Isnes et al. 2006; Lee, 2007; Lewis & Leach, 2006; Miller, 2004; Norris & Philips, 2003; Tytler, Symington, & Smith, 2011).

As public understanding of genetics has become a necessity for citizens living in 21st century (Miller, 2004), genetics is assumed to be an important and critical aspect of scientific literacy (National Research Council [NRC], 1996; Duncan, Rogat & Yarden, 2009; Duncan, Freidenreich Chinn & Baush, 2011; Kampourakis, Reydon, Patrinos & Strasser, 2014; Tsui & Treagust, 2010). The application and implications of genetics, on the other hand, require a better understanding of "genetic literacy" (Knippels, Waarlo, & Boersma, 2005). Even there is no consensus among the scholars on the definition McInerney (2000), genetics literacy has been generally described as having necessary knowledge in genetics, and using this knowledge to make informed decisions for personal well-being which in turn, resulted in effective participation of social issues (Bowling, 2007). In his article, McInerney (2002) stated that:

> Genetic(s) literacy likely does not require that the public be able to distinguish science from technology, but it is likely that genetic medicine, following the pattern of all modern health care, will confront individual patients and the public with more of the latter than the former. Already, individuals and the public encounter genetically based diagnostic and treatment technologies… Just as genetic(s) literacy requires an

> understanding of the nature of science, so it requires an understanding of the basic principles of technology. (p. 386).

As implied in McInerney's statements, it is quite clear that with the increasing influence of technological developments on society, citizens are confronted with issues related genetics in their daily lives. Thus, future generations should be raised as genetically literate in order to understand and involve in the decision-making process about the issues arising from recent developments in gene technology (Tsui & Treagust, 2010). Kampourakis and his colleagues (2014) indicated that genetic literacy has two distinct components as having basic content knowledge regarding genetics (such as knowledge about genes or DNA) and the skills to participate informed decision making situations arising from genetic technologies such as genetic testing or genetic engineering. The genetcs literacy requires not only holding sound understanding of genetics and nature of science, but also usage of this understanding in solving everyday problems. As a result, genetically literate individuals are highly demanded by modern societies. As students are future citizens in societies (Boerwinkel et al., 2014; Levinson, 2006; Molinatti, Girault & Hammond, 2010), it is important for modern societies to raise genetically literate individuals who make informed judgments and decisions about scientific and technological issues by utilizing genetics knowledge (Bowling et al. 2008; Dawson, 2007; Dawson & Schibeci, 2003; Klop & Severiens, 2007; Lanie et al. 2004; McInerney, 2002). With this respect, the inclusion of issues in genetics literacy into science classes will prepare students for their future roles as Levinson (2006) indicated.

For raising genetically literate individuals, school science will provide an appropriate context. At this point, teachers' role of implementing issues in genetics literacy is crucially important. As Kelchtermans (2009) noted; teachers are critically important in professional teaching. Teachers themselves should be genetically literate, if they want to help their students to develop informed views regarding issues in genetics literacy (Leslie & Schibeci, 2003). Despite its importance, studies from several countries indicated that besides having ethical and moral dilemmas regarding applications of genetics technologies, science teachers possessed serious conceptual difficulties in understanding and teaching of basic concepts in genetics including controversial issues (Banet & Ayuso, 2000; Boerwinkel et al., 2011; Bryce & Gray, 2004; Ozay, Ozay & Oztap, 2003; Steele & Aubusson, 2004; Tekkaya, Ozkan & Sungur, 2001). Even science teachers are assumed to be real implementers of issues in genetics literacy, research studies conducted in different countries showed teachers' unwillingness to implement these issues into their classes (e.g., Boerding, Sadler, & Koroly, 2013; Eggert & Bögeholz, 2010). This can be attributed partly to teachers' difficulty in subject matter knowledge regarding controversial issues in genetics (Steele & Aubusson, 2004; Ball, 2000), lack of their confidence in handling discussions related with controversial issues in their classes (Bryce & Gray, 2004) and partly to curricular restrictions and external examinations (Eggert & Bögeholz, 2010; Lazarowitz & Bloch, 2005), and lack of time and resources (Bryce & Gray, 2004; Kwon & Chang, 2009; Zeller, 1994). Overall, findings suggested that science teachers are not well prepared to effectively teach issues in genetics literacy to their students.

Science teachers' implementation of issues in genetics literacy in their classes are mainly influenced by their ideas, beliefs, values, philosophies and personal concerns which directly enhance their students' decision making skills, critical thinking, moral reasoning as well as attitudes towards and understanding of issues in genetics literacy (Cotton, 2006; Kolstø, 2001; Lee & Witz; 2009; Simmons & Zeidler, 2003; Zeidler, 2011). Close examination of related literature also implied that background characteristics, such as gender, self-perceived interest, religious affiliations, and cultural factors, have an impact on individuals' attitudes towards different issues in genetics literacy (Brossard, Scheufele, Kim & Lewenstein, 2008; Črne-Haladnik, Hladnik, Javornik, Košmelj, & Peklaj, 2012; Hagay, Baram-Tsabari, Ametller, Cakmakci, et al. 2013; Hagay, Peleg, Laslo & Baram-Tsabari, 2013; Sohan, Waliczek, & Briers, 2002; Rundgren, 2011; Qin & Brown, 2007; 2008). Among them are gender, self-perceived interest, religious affiliations, cultural factors such as policy conflicts, and differences in public opinions, risk perceptions and social trust were being examined and reported as influencing participants' opinions. The common finding is that since participants' knowledge as well as their attitudes tended to be influenced by one or more of these factors, it is necessary to examine and interpret participants' attitudes towards issues in genetics literacy as through the lenses of these factors.

The aforementioned literature provides some direction to this dissertation by providing insight into the factors that might influence science teachers' genetics literacy levels, as well as their attitudes towards varios issues in genetics literacy. Thus, this study aims to investigate genetics literacy with respect to knowledge level, attitude towards different issues in genetics literacy as well perceptions regarding as teaching issues in genetics literacy.

As science teachers' are assumed to develop their students' informed decision making skills regarding controversial issues in their classrooms (Dawson, 2011; Khishfe, 2012), science teachers' own decision making processes have become prominent. Henneman (2011) indicated there are many factors that may influence decision making process regarding controversial issues such as genetic screening or clinical genetics. While primary factors that influence decisions are emphasized as ethical and moral considerations (Sadler, 2004b; Sadler & Zeidler, 2005; Simmons & Zeidler, 2003; Zeidler & Keefer, 2003; Zeidler & Sadler, 2008; Wu & Tsai, 2007), a multi-perspective reasoning framework on decision making considering social, environmental, politics, economic, religious, value and risk perspectives (Bell, 1999; Bell & Lederman, 2002; Khishfe, 2012; Lee & Grace, 2012; Ratcliffe & Grace, 2002; van de Zande et al. 2011; Zohar & Nemet, 2002) is needed for exploring decision making process. Thus, the present study also focused on science teachers' decision making processes and the factors that influence their decision making processes.

1.2. Purpose of the study

The main focus of this study is to explore middle school science teachers' genetics literacy with respect to knowledge level, attitude towards different issues in genetics literacy as well as teaching perceptions regarding issues in genetics literacy and the factors that influence decision making processes. With this respect, this study, first investigated middle school science teachers' genetics literacy levels, their attitudes towards issues in genetics literacy as general attitude, use of genetic information, abortion, pre-implementation genetic diagnosis, gene therapy and gene therapy applications and their perceptions of teaching issues in genetics literacy as necessity of introducing, impeding factors and personal teaching efficacy beliefs. Second, the study examined possible relationships among science teachers' background characteristics (gender, teaching experience, self-perceived interest in genetics and self-perceived knowledge in genetics), their genetics literacy levels, their attitudes towards various issues in genetics literacy and their perceptions of teaching issues in genetics literacy. Lastly, the factors that might influence science teachers' decision making processes were addressed in present study. Research questions that are addressed in this study are presented below:

1. What are middle school science teachers' genetics literacy levels, their attitudes towards issues in genetics literacy and their perceptions of teaching issues in genetics literacy?

    1.a. What are science teachers' genetics literacy levels?

    1.b. What are the science teachers' ideas about specific issues in genetics literacy as use of genetic information, abortion, pre-implementation genetic diagnosis, gene therapy and gene therapy applications?

    1.c. What are the science teachers' perceptions regarding genetic literacy issues?

i. What are science teachers' ideas about the necessity of introducing issues in genetics literacy into science classes?

ii. What are science teachers' ideas about the factors that impede introducing issues in genetics literacy?

iii. What are science teachers' personal teaching beliefs regarding issues in genetics literacy?

2. How well do science teachers' background characteristics (gender, teaching experience, self-perceived interest in genetics and self-perceived knowledge in genetics) predict their genetics literacy levels, their attitudes towards issues in genetics literacy and their perceptions of teaching issues in genetics literacy?
3. What are the factors that influence science teachers' decision making processes while dealing with various issues in genetics literacy?

1.3. Significance of study

The overarching goal of science education has been considered as promoting scientific literacy (NRC, 1996; Sadler et al. 2006). Scientific literacy aims developing individuals' informed decision making as well as developing knowledge and understanding of scientific concepts (Bingle & Gaskell, 1994; Dawson, 2011; Lee, 2007; 2008; Lewis & Leach, 2006; NRC, 1996; Ratcliffe & Grace, 2002; Roberts, 2007; Sadler, 2004a; Sadler et al., 2006; Zeidler, et al., 2002; Tsui & Treagust, 2010). Thus, scientifically literate individuals that have sufficient knowledge and understanding of scientific concepts and make informed decisions regarding daily life problems they are encountered have long been desired by modern societies (Eggert & Bögeholz, 2010; Dougherty, 2009; Dawson, 2011; Kolstø et al. 2006; Lee, 2007; Lewis & Leach, 2006; MoNE, 2006; Norris & Philips, 2003; Tytler et al. 2011). Significance of scientific literacy and scientifically literate individuals have also been acknowledged by Turkish curriculum developers. Thus, scientific literacy as well as raising scientifically literate individuals have been in the center of reform policies in Turkish national science curriculum. The reform initiatives in Elementary Science and Technology curriculum that was disseminated starting from the year of 2005 has envisioned to raise students as “scientifically” and “technologically” literate individuals (MoNE, 2006). This goal also has shaped the current curriculum reform efforts in science curriculum beginning from 2013 (MoNE, 3013).

With the increasing impact of developing technologies, scientifically literate individuals also need to make informed decisions regarding genetics- related issues such as genetic testing, stem cell research, gene therapy or genetically modified foods (Boerwinkel et al., 2014; Choi et al., 2011; Concannon et al., 2010; Duncan et al., 2009; Freidenreich et al., 2011; Lederman et al., 2014) and be aware of the public debates such as privacy of biomedical and personal information, use of genetic databanks or potential benefits and the risks of genetics technologies as well as being able to take part in resolution of these disputes (Dawson, 2007; Miller, 1998; Norris & Philips 2003; Tytler et al. 2011). Thus, development of genetics literacy and raising genetically literate individuals who understand genetics concepts to make informed decisions related to genetics related issues by considering ethical, legal and social implications (Bowling et al. 2008; Dawson, 2007; Dawson & Schibeci, 2003; Klop & Severiens, 2007; Lanie et al. 2004; McInerney, 2002) have become prominent. As students are future citizens of modern societies, it is important to prepare students for their future roles. The inclusion of issues in genetics literacy will enable students to develop understanding regarding genetics and genetics related issues as well as preparing them to make informed decisions by considering social, ethical, legal and political concerns related with genetics (Boerwinkel & Warloo, 2011; Dawson, 2003; Dawson & Schibeci, 2003; Dawson, 2011; Klop & Severiens, 2007; Lee, 2008; Sadler et al., 2006; Venville & Dawson, 2010; Zeidler, 2011). The inclusion of issues in genetics literacy into science classes is possible with effective implementation and teaching strategies of teachers. A number of studies reported that science teachers implement issues in genetics literacy into their classes in parallel with their values, ideals, philosophies and concerns (Lee & Witz, 2009). But teachers’ limited understanding possibly will influence their ability to teach such issues effectively. Thus, for effective implementation of these issues into science classes as well as into science curriculum, first, it is needed to reveal teachers' genetics literacy levels and their attitudes towards different issues as well as their teaching perceptions regarding issues in genetics literacy. Although genetics literacy consists of combination of many issues, past studies were found to be limited by focusing on only one or two aspects of genetics literacy (Eggert & Bögeholz, 2010; Khisfee, 2012; Lee, 2008; 2009; Nielsen, 2012; Ratcliffe & Grace, 2002; Van der Zande et al., 2011). This study seeks to address this identified gap by conducting a study that investigates the possible associations between science teachers' background characteristics (gender, teaching experience, self-perceived interest in genetics and self-perceived knowledge in genetics), their genetics literacy levels, their attitudes towards various issues in genetics literacy and their perceptions of teaching issues in genetics literacy. With this study, a general overview of Turkish science teachers' attitudes towards different genetics issues as well as their genetics literacy levels and their relation to background characteristics is gained. The main contribution of this study is to elucidate Turkish science teachers' genetics literacy with respect to many aspects comprising genetics literacy. Moreover, by uncovering science teachers' levels of genetics literacy, their attitudes towards issues in genetics literacy and their perceptions of teaching these issues; this study could provide valuable clues about existing situation regarding genetics literacy to teacher educators in Turkey for promotion of raising genetics literate citizens.

Numerous studies have emphasized the necessity and the importance of developing students' informed decision making skills regarding genetics issues that consist of ethical and moral dilemmas in the context of biotechnology and socioscientific issues (Boerwinkel et al. 2009; 2012; Dawson, 2011; Dawson & Venville, 2020; Khishfe, 2012; Lee, 2007; 2008; 2012; Lee & Witz, 2009; Sadler, 2004a; Sadler et al., 2004; Sadler & Zeidler, 2005; Simmons & Zeidler, 2003; Zeidler et al., 2002; Wu & Tsai, 2007). Moreover, the role of socioscientific issues and decision making processes have also been acknowledged in the current science curriculum reform initiatives and included in the new curriculum from the beginning of 2013 (MoNE, 2013). Besides, developing students' informed decision making skills as envisioned in Turkish national science curriculum has become prominent. In order to develop students' decision making skills regarding controversial issues, teachers are assumed to address decision making regarding controversial issues in their classrooms (Khishfe, 2012). She indicated that decision making is a learned process. Thus, teachers can teach their students to be well informed and develop decision making skills about controversial issues. However, Lee and Witz (2009) pointed out that science teachers develop their own personal meaning of socio-scientific issues and teach these issues based on values, philosophies, personal concerns and experiences. Since teachers' own pedagogical beliefs influence students' development of decision making skills as well as concept learning in genetics as Zeidler (2011) highlighted, it is needed to reveal how science teachers' decisions are influenced by their viewpoints. The ethical/moral factors that influence individuals' decision making processes have been pointed out in numerous studies (e.g., Sadler, 2004a; 2004b; Sadler & Zeidler, 2005; Wu & Tsai, 2007). In addition other factors such as social, environmental, politics; economic, religious, economics and cultural as well as values and risk are reported to play important role in this decision-making process (Bell, 1999; Bell & Lederman, 2002; Khishfe, 2012; Lee & Grace, 2012; Ratcliffe & Grace, 2002; van de Zande et al. 2011; Zohar & Nemet, 2002;). Thus, it is needed to explore science teachers' decision making processes by considering multiple factors. Therefore, the current study has aimed to shed light on science teachers' decision making processes and the factors that influence their decision making processes.

1.4. Definition of important terms

Scientific literacy

Scientific literacy defined as “the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity” (NRC, 1996; p. 22).

Genetics literacy

Genetics literacy is defined by Bowling et al. (2008, p.16) as ‘sufficient knowledge and appreciation of genetics principles to allow informed decision-making for personal well-being and effective participation in social decisions on genetics issues’. Genetics literacy also referred the issues and challenges that are related to genetics and genetics technologies (Jennings, 2004).

Informed decision making

Informed decision making is defined as “decisions that is consistent, aligned and well-supported by evidence” (Khishfe, 2012; p. 69). Aside from its precise meaning, informed decision making in this study refers to be well informed about genetics related issues by considering the ethical, legal and moral controversies that are emanating from genetic technologies (Miller, 1998; Sturgis et al. 2005; Lee & Witz, 2009; Tsui & Treagust, 2010; van der Zande et al. 2009).

Issues in Genetics Literacy

Genetics related issues refers the issues that are emanated from development of technologies and can span a variety of forms such as genetic testing, stem cell research, gene therapy or genetically modified foods (Boerwinkel et al., 2014; Choi et al., 2011; Concannon et al., 2010; Duncan et al., 2009; Freidenreich et al., 2011; Lederman et al., 2014; Sadler et al. 2004).

Teachers' attitude towards issues in genetics literacy

In the present study, teachers' attitudes towards issues in genetics literacy refers to their general attitudes, attitudes towards the use of genetic information, abortion, pre-implementation genetic diagnosis, gene therapy and gene therapy applications.

Use of genetic information

Use of genetic information refers to the use of personal genetic information by third parties such as insurance companies or employers.

Pre-implementation genetic diagnosis

Pre-implementation genetic diagnosis refers to "the technique whereby embryos created by in-vitro fertilization are genetically screened prior to implantation in the womb" (Sturgis et al. 2002; 42-43).

Gene therapy

Gene therapy refers to "all types of early-intervention strategies that result in large-scale cellular modifications of the individual" (Lederman et al. 2014, p. 296).

Gene therapy applications

Gene therapy applications refers to the different types of gene therapy as somatic gene therapy, germ-line gene therapy and in-utero gene therapy. While the genes that are modified would not be inherited by any future children in *somatic gene therapy*, the modified genes would be inherited to the offspring in *germ-line gene therapy*. On the other hand, the modifications in genes are made before birth and the modified genes would not be inherited in *in-utero gene therapy* (Sturgis et al. 2002, p. 39-40).

Teachers' perceptions of teaching genetics literacy

In present study, teachers' perceptions of teaching genetics literacy explored under three dimensions as teachers' perceptions of the necessity of addressing issues in genetics literacy in their classes, their perceptions of factors that impede addressing issues in genetics literacy in their classrooms and teachers' personal teaching efficacy beliefs.

Teachers' perceptions of the necessity of addressing issues in genetics literacy

Teachers' perceptions of the necessity of addressing issues in genetics literacy refers to the teachers' ideas about the importance of genetics literacy in science curriculum.

Teachers' perceptions of factors that impede addressing issues in genetics literacy

Teachers' perceptions of the necessity of addressing issues in genetics literacy refers to the teachers' ideas about the impeding factors that burdens of addressing these issues such as maturity of students or students' learning difficulties.

Teachers' personal teaching efficacy

Teachers' personal teaching efficacy is defined as "teachers' judgments of his/her personal ability to influence students' learning" (Denzine, Cooney & Mckenzie, 2005; p. 690)

Science teachers

Science teachers refer to middle school science teachers working in public or private schools in Turkey who teach from grade 4 to 8.

CHAPTER II

LITERATURE REVIEW

The purpose of this study was to explore science teachers' genetics literacy with respect to knowledge level, attitude towards different issues in genetics literacy as well as teaching perceptions regarding genetics literacy and the factors that influence decision making processes. Therefore, an overview of genetics literacy research considering knowledge level, attitude towards different issues in genetics and studies focusing on decision making processes were reviewed in this chapter. In first part, studies focusing on genetics literacy with respect to students, pre-service and in-service science teachers were reviewed. In second part, selected studies focusing on students', pre-service and in-service science teachers' decision making processes were presented.

2.1. Genetics Literacy

"Genetics literacy" is a broad concept which has no consensus on its definition as McInerney (2000) indicated. Various researchers, however, defined genetics literacy in their research contexts (Bowling, 2007; Bowling, Acra, Wang, et al. 2008; Jennings, 2003; 2004; McInerney, 2002). For instance, Bowling and her colleagues (2008) defined genetics literacy as the having sufficient knowledge in genetics to make informed decisions for personal well-being and to effectively participated in discussion related genetics issues. According to Jennings (2003), having sufficient knowledge in genetics as well as understanding necessity of genetics was not adequate for genetics literacy. He indicated that individuals who are genetically literate also should be able to make decisions related to health related issues by using their knowledge in genetics. In his definition, McInerney (2002) stressed the importance of developing an understanding in basic principle of technology as well as in concepts in genetics. In addition, he referred the importance of dealing with ethical, legal and social issues in making decisions. From these definitions, it can be noted that critical function of genetics literacy is to develop an understanding in genetics and genetics related issues as well as in technology related issues and use these understandings in making informed decisions which have ethical, legal and social aspects. As the genetics literacy definitions clearly referred the notions "understanding in genetics", "understanding in technology" and "making informed decision", a broad literature consisting **biotechnology** and **socio-scientific issues (SSIs)** research have overlapped with genetics literacy research. While research studies conducted on biotechnology and SSIs focused on controversial issues which arise from the technological developments such as genetic modification of crops and animals, cloning, genetic testing, stem cell research (Boerwinkel, Swierstra & Waarlo, 2014; Bryce & Gray, 2004; Choi, Lee, Shin, Kim & Krajcik, 2011; Concannon, Siegel, Halverson, & Freyermuth, 2010; Dawson & Venville, 2009; Duncan, Rogat & Yarden, 2009; Freidenreich, Golan-Duncan & Shea, 2011; Sadler & Zeidler, 2004; 2005a; 2004), SSIs studies also focused on informed decision making and reasoning processes (Sadler, 2004a; Sadler & Zeidler, 2004; 2005a; Zeidler, Walker, Ackett & Simmons, 2002). Thus, while reviewing research studies in genetics literacy, studies conducted on biotechnology and socio-scientific issues with respect to various focus groups as students, undergraduate students, pre-service and in-service teachers as well as various issues in genetics such as genetic engineering, stem cell research, cloning, genetically modified foods, genetic testing and pre-implementation genetic testing were explored in present study. As genetics literacy highlighted understanding of genetics and technology, and informed-decision making, research studies focused on these aspects were specifically selected for literature review. First, empirical studies focusing on public, student, pre-service and in-service teachers' understanding and attitudes as well as the relationship between understanding and attitude were presented below:

2.1.1. Studies focusing on genetics knowledge and attitudes towards genetics

Vast variety of studies with different focus groups such as public, students, undergraduate students, pre-service and in-service teachers have long investigated participants' content knowledge in genetics as well as their attitudes towards various issues in genetics such as genetically modified foods and genetic modifications in animals in organisms (Črne-Haladnik, Haladnick, Javornik, Košmlej & Peklaj, 2012; Sohan, Waliczek, & Briers, 2002; Šorgo & Ambrožič-Dolinšek; 2009; 2010); gene therapy and specific applications of gene therapy as somatic and germ-line gene therapy (Črne-Haladnik et al., 2012; Sturgis, Cooper & Fife-Schaw 2005), use of genetic data and general attitudes towards biotechnology (Sturgis et al., 2005) and recombinant DNA (Sohan, et al., 2002). In addition, the aforementioned studies also explored the relationship between genetics content knowledge and attitudes towards various issues in genetics. These studies were reviewed under three subparts. In first part, studies conducted with students will be presented. While studies conducted with pre-service and undergraduate students, as well as teachers, will be presented in second part, last part will be devoted to public understanding of genetics and attitudes towards various issues in genetics.

2.1.1.1. Students' understanding of genetics and attitudes towards issues in genetics literacy

Under this heading, empirical studies related to students' understanding of genetic content knowledge and attitudes towards various issues in various countries were reviewed. As genetics literacy consists of issues both related to biotechnology and controversial issues, studies focusing on biotechnology issues, as well as controversial issues related to genetics, were selected for this part. In first part, the studies exploring students' understanding of genetics and their attitudes towards various genetics applications were explored. In second part, the studies seeking for relationship between content knowledge in genetics and attitudes towards issues in genetics literacy were presented.

In an earlier attempt to understand students' understanding of genetics concepts, Lewis and Wood-Robinson (2000) investigated English students' (aged 14- 16) knowledge and understanding of genetics concepts (n= 482). Findings revealed that students lacked of basic knowledge regarding genetics such as chromosomes, genes and cell structure. For instance, while a great majority (73%) were able to define characteristics of genes, only 11% correctly identified the location of genes. While half of the sample seemed to be unaware of the genetic information is found all the living things, most students were unable to distinguish meiosis from mitosis. In addition, students were also unaware of the concept of "alleles". For instance, only 3% correctly identified alleles and the role of alleles in genes and different types of genes. The study also revealed that students held alternative ideas regarding chromosomes and genes. For instance, 25% of them believed that genes were bigger than chromosomes, and only 10% of participants correctly identified the location of chromosomes. The researchers concluded that existence of confusion about terminology used in genes, uncertainty and lack of knowledge regarding genetics. They suggested the necessity of changing in secondary school biology curriculum including basic information regarding genetics and developing students' ability to evaluate scientific information or evidence through courses.

In another study, Tekkaya, Ozkan and Sungur (2001) investigated Turkish high school students' difficulties in biology concepts and whether gender difference influence their perceptions. A total of 368 high school students were surveyed. The results revealed that high school students mostly perceived the concepts in Mendelian genetics, meiosis and mitosis, and genes and chromosomes as difficult to learn. In addition, the researches revealed gender difference favoring male students that implied that male students perceived the biology concepts easier to learn when compared to female students. Moreover, the researchers interviewed with 14 biology teachers in order to get a deeper understanding of the reasons behind these difficulties. The interview results revealed that teachers were aware of their students' difficulties in learning biology concepts as the concepts that both teachers and students matched. The researchers attributed this difficulties to biology curriculum, insufficient teaching and learning strategies and laboratory conditions. Also, it was suggested that the increasing in the number of figures presenting biology concepts in textbooks might help students to develop better understanding regarding biology concepts.

In a more recent study, Topcu and Sahin-Pekmez (2009) investigated Turkish middle school students' difficulties in learning genetics concept by using qualitative approach. In first step, an open-ended questionnaire was administrated to a total of 128 students. Then, semi-structured interviews with low, moderate and high achiever students (3 students for each) who completed the questionnaire were conducted in order to get deeper insights about their difficulties. The results revealed that while majority of students correctly identified the characteristics of genetic structures as cell, nucleus, chromosome, DNA, gene; they mainly had difficulty in explaining their functions. For instance, more than half of participants correctly defined cell concepts (62.5%). However, only 14% of them correctly explained the functions of cell. Similarly, while majority of students correctly defined somatic and sex cells, more than a quarter correctly explained their functions in reproduction and growth. Overall, these findings indicated that students did not have deep understanding in genetic structures. Semi-structured interviews revealed that students were not pleased about their textbooks as they indicated that they could not get conceptual knowledge from textbooks. Moreover, students expressed that they had difficulties in mathematical expressions used in genetics such as mono-dihybrid linkages. The researchers attributed the students' difficulties to being invisible and inaccessible concepts in genetics referred as "micro-level concepts in genetics" and recommended that cell division topic which are visible and referred as "macro level" should be first taught to students which may help students to understand other genetics concepts easily.

In another study, Sesli and Kara (2012) investigated Turkish high school students' understanding of cell division and reproduction by using open-ended questions and semi-structured interviews (*n*= 403). The researchers developed a two-tier multiple-choice diagnostic test for assessing students' understanding and identifying misconceptions of cell division and reproduction concepts. The questionnaire consisted of 14 items with average item discrimination index of .46 and item difficulty index of .50. The findings revealed that students lacked of conceptual understanding regarding reproduction and cell division. In particular, students had difficulty in reproduction of sex cells, fertilization, genetic variation and genetic information. Moreover, some misconceptions regarding functions of meiosis and mitosis were revealed. In addition, some students tended to use theological explanations to the transmission and appearance of characteristics. The researchers attributed the existing students' difficulties to abstract concepts and facts as well as difficulty in making distinction between scientific and theological explanations. The researchers emphasized the importance of identifying misconceptions for meaningful learning and problem solving and recommend science teachers to use two-tier diagnostic tests before beginning of a topic or after finishing a topic which may help teacher to remedy the existing misconceptions.

While the aforementioned studies (Lewis & Wood-Robinson, 2000; Sesli & Kara, 2012; Tekkaya et al. 2001; Topcu & Sahin-Pekmez, 2009) specifically focused on exploring students difficulties, some studies focused on investigating the role of genetic knowledge in genetics applications. In a such study Lewis and Leach (2006) explored British high school students' (14-16 years) science knowledge and engagement of discussions regarding applications of gene technology such as transfer of genes between organisms of same type and different type, genetic screening, patenting, potential benefits of gene technology. The researchers used a two-phase study. In first phase, the researchers investigated students' ability to engage discussions by using small group discussions and paired discussions of written questions. The findings of first-phase indicated that students' attitudes and opinions were related to the issues identified, and these identified issues were linked to the scientific knowledge. Students demonstrated a limited understanding in both science and the contexts being discussed. And the results revealed that the ability to identify key issues required basic science understanding in a specific context. In second-phase, the researchers developed two discussion tasks about prenatal screening for cystic fibrosis and genetic engineering by using small group discussions. The results of second phase was also confirmed the findings of first phase. The students who had knowledge in basic genetics and in the scenarios presented were able to actively participate the discussions in the classrooms. The researchers acknowledged the importance of teaching basic genetics concepts to students as this enhanced students' engagement in socio-scientific issues by promoting their understanding. The researcher suggested that this basic science knowledge regarding genetics can be taught to students throughout brief and well-designed teaching interventions.

Fonseca, Costa, Lencastre and Traves (2012) explored Portuguese high school students' understanding of biotechnology who enrolled in three different curricula as science students attending biology (*n*= 225), non-biology students (*n*= 210) and non-science students (*n*= 263). Findings indicated that only 36% of students correctly answered the questions related to biotechnology implying a relatively low level of knowledge. While students were more knowledgeable in medicine and vaccine production as well as disease resistance enhancement of plants, only more than a quarter were knowledgeable in genetically modified foods and genetically modified bacteria (31% and 35% respectively). The students enrolled in biology classes were found to be more knowledgeable when compared to non-biology and non-science students. The findings regarding their attitudes towards biotechnology indicated that all three groups held favorable attitudes. Particularly, biology students held more favorable attitudes when compared to non-biology and non-science students. Overall, the researchers concluded that Portuguese high school students' knowledge regarding basic concepts in biotechnology was insufficient. Considering students' attitudes, the researchers indicated that students' attitudes differed with respect to aim and usefulness of biotechnological application. The researchers emphasized the need of updating classic science curricula which consists of classical genetics and hereditary concepts, with basic concepts of biotechnology as well as social and environmental aspects that are introduced with biotechnology.

Overall, the reviewed national and international studies showed that students had difficulties regarding concepts in genetics. While Turkish high school students perceived Mendelian genetics, meiosis and mitosis, and genes and chromosomes as difficult to learn and explain the functions of cell, nucleus, chromosome, DNA (Tekkaya et al. 2002; Topcu & Sahin-Pekmez, 2009), Sesli and Kara (2012) revealed similar difficulties in concepts of reproduction of sex cells, fertilization, genetic variation and genetic information. In fact, these findings were also consistent with Lewis and Wood-Robinson' (2000) findings. The researchers attributed these difficulties to the confusions about terminology used in genes, uncertainty and lack of knowledge regarding genetics (Lewis & Wood-Robinson, 2000) as well as mathematical expressions used in genetics such as mono-dihybrid linkages (Topcu & Sahin-Pekmez, 2009). Other studies focusing on the role of genetic knowledge in understanding of genetic applications such as genetic screening or genetic modifications revealed that holding sufficient understanding of basic knowledge in genetics enhanced the understanding of genetic applications. The researchers in general, emphasized the role updated genetic curriculum and effective classroom applications for enhancing students' understanding of genetic concepts, as well as genetic applications.

Another line of study explored the relationship among students' genetics knowledge, their attitudes towards various issues and other factors such as gender or grade level. In an earlier study investigating Australian 15-16 year old high school students' attitudes towards biotechnology issues such as genetic engineering, genetically modified foods, cloning, in-vitro fertilization, DNA finger printing, and social and ethical issues after completing a 10-week course combining genetics and biotechnology, Dawson and Schibeci (2003) indicated that high school students held a wide range of beliefs about biotechnology. More than half of the students (55%) were found to be against the use of biotechnology applications with all living organisms. Only 14% accepted using biotechnology applications with all living organisms. Overall, the students perceived genetic modifications in microorganisms and plants as acceptable and useful compared to genetic modifications in animals and humans. The researchers also compared the data gathered from the students that had completed genetics and biotechnology course with a baseline data (*n*= 116) that were collected from the students that had not taken genetics and biotechnology course. Similar patterns in both groups' attitudes towards biotechnology issues regardless they had taken genetics and biotechnology course or not. Based on this finding, the researchers concluded being more knowledgeable and well-informed about biotechnology (by taking genetics and biotechnology) course may not affect students' attitudes towards biotechnology issues as it was hoped.

In later years, Dawson (2007) explored high school students' understanding of biotechnology, genetically modified foods and cloning as well as their attitudes towards these issues. A total 465 students in year 8 (*n*= 175), year 10 (*n*= 175) and year 12 (*n*= 115) completed a written survey consisting of two parts as understanding and attitude. In addition, semi-structured interviews with six students in year 8 and year 12 were conducted for further exploration of about their understanding in specific issues such as cloning of endangered species and humans or genetic testing for diseases. Results revealed that students' definition of biotechnology, cloning and genetically modified foods and examples of each case were well constructed for year 12 students. Year eight students, however, demonstrated poor understanding about understanding of biotechnology which supported the idea of improvement in students' understanding of biotechnology, cloning and genetically modified foods as they get older. In general, students had better understanding in cloning issues when compared to biotechnology and genetically modified foods. Regarding attitudes towards biotechnology, their attitudes differed with respect to context. For instance, while students approved the use of gene technology and cloning in micro- organisms and plants, they opposed use of gene technology in human. Similarly, most students approved the use of prenatal genetic testing for determining genetic diseases. The study findings also demonstrated that students' attitudes were less favorable in year eight students when compared to year 12 students. Thus, the researchers concluded that as the understanding and knowledge in biotechnology issues enhanced, students tended to have favorable attitudes towards biotechnology issues that suggests a direct relationship.

In another study, Klop and Severiens (2007) investigated 574 Dutch secondary school students' (aged between 12-18) attitudes towards biotechnology and the factors that influence their attitudes by administrating a survey developed by using previous surveys about biotechnology. In addition, the researchers conducted six group discussions with 16 students to ensure construct validity of instrument and in-depth interviews with researchers in genetic in order to clarify the objects of instrument. The instrument consisted of 3 components as cognitive component (knowledge of biology, genetics and biotechnology applications), affective components (beliefs, basic emotional reactions, worries and unavoidable nature of biotechnology) and behavioral components (consuming intentions, medical intentions). Cluster analysis revealed four distinct groups with respect to content knowledge in biotechnology and attitudes towards biotechnology. Less than a quarter (22%) of students who highest level of content knowledge also held favorable attitudes towards biotechnology that was referred as "confident supporters of biotechnology". On the other hand, nearly half of the students were knowledgeable in biotechnology and highly positive about biotechnology issues but they were intuitively 'sceptic' about biotechnology (42%) which was denoted as "not sure". While third group students as "concerned sceptic" were knowledgeable in biotechnology, they held unfavorable attitudes and indicated their concerns about biotechnology (18%). The last group was "not for me" group whose students were little knowledgeable and held unfavorable attitudes towards biotechnology. The researchers indicated that attitude towards biotechnology is "multi-component concept" including cognitive, affective and behavioral components. Overall, the researchers concluded even the findings implied a positive relationship between content knowledge and attitudes, the relationship may seem to be complex depending on other aspect such as affective reactions, emotional reactions, considerations and worries.

In another line of study investigating the relationship between content knowledge and attitude towards various issues in genetics, the factors such as gender that may influence participants' attitudes were also explored. In such study, studying with Slovenian high school students (*n*= 469), Črne-Hladnik, Peklaj, Košmelij, Hladnik, and Javornik (2009) explored high school students' attitudes towards specific biotechnology applications as Bt corn, genetically modified salmon, somatic and germ-line gene therapy with respect to usefulness, moral acceptability and risk perception. Findings indicated that while students perceived biotechnological application in Bt corn more acceptable and less risky, they found genetically modified salmon and gene therapy applications as unacceptable and risky. In addition, gender difference with respect to some biotechnological applications was demonstrated. While, no gender difference was revealed in students' attitude towards Bt corn and somatic gene therapy, female students held unfavorable attitudes with respect to usefulness and acceptability towards germ line gene therapy when compared to male counterparts. In a more recent study, with the same sample, Črne-Hladnik, Hladnik, Javornik, Košmelij and Peklaj (2012) explored the relationship among high school students' prior knowledge regarding genetics and their attitudes towards specific biotechnology applications as Bt corn, genetically modified salmon, somatic and germ-line gene therapy which consisted of dilemmas requiring reasons for acceptance, assessing the risk factors associated with and considering the individuals to be affected by. In general, findings indicated that being knowledgeable in biotechnology applications played an important role in female students' attitudes towards biotechnology applications presented in the questionnaire. In addition, while female students who were knowledgeable in biotechnology perceived higher risk about genetically modified salmon, male students perceived higher risk in germ line gene therapy. Overall, the study indicated being knowledgeable in biotechnology issues influenced female students' attitudes towards various biotechnology applications and gender differences were revealed with respect to risk perceptions.

To conclude, the studies exploring the relationship between high school students' content knowledge in genetics/biotechnology and attitudes towards various issues in genetics/biotechnology revealed similar patterns. While Dawson (2007) stressed the existence of a positive relationship between knowledge and attitude, Dawson and Schibeci (2003) did not reveal any relationship between two constructs. Moreover, Klop and Severiens' (2007) study detected four distinct groups with respect to knowledge in biotechnology and attitudes towards biotechnology. While existence of a clear positive relationship between two knowledge and attitude can be noticed in "confident supporters" and negative relationship in "not for me" group, the other group students demonstrated sufficient understanding in biotechnology but held unfavorable attitudes towards biotechnology due to their concerns and worries about biotechnology issues. In addition, gender differences with respect to various issues in biotechnology were revealed. While, no gender difference was revealed in some issues such as Bt corn and somatic gene therapy, gender difference were found with respect some issues as germ-line gene therapy (Črne-Hladnik et al. 2009, 2012). For instance, female high school students seemed to perceive more risk and thus, held unfavorable attitudes towards germ-line gene therapy. Indeed, Klop and Severiens (2007) indicated the relationship between knowledge and attitude seemed to be complex structure including other aspects such as individuals' affective reactions, emotional reactions, considerations and worries. In following part, studies conducted with undergraduate students were reviewed.

While studies conducted with high school students' content knowledge, attitude towards various issues as well the factors influencing their attitudes revealed contradictory results, some studies conducted with undergraduate students documented similar results. In general, studies reported that undergraduate students' knowledge level in genetics were insufficient (Bowling, 2007; Bowling, Huether, Wang, et al. 2008; Sohan et al., 2002). For instance, studying with American undergraduate non-biology majors (*n*= 287), Bowling, Huether, Wang, et al. (2008) investigated undergraduate students' genetics literacy levels in an introductory biology course focusing on genetics. The Genetics

Literacy Assessment Inventory was administrated to participating students as pre- and post-test. The results showed that the participants were moderately knowledgeable in genetics literacy implying they correctly answered most questions regarding Mendelian patterns of inheritance and meiosis gene activity and genetic variation, the functions of genes in protein synthesis but failed to correctly answer the questions regarding evolution concepts like natural selection. Their difficulties in understanding current and future applications of genetics and genetics technologies, as well as the ethics, laws and public policies regarding genetics literacy, were also demonstrated.

Besides exploring undergraduate students' content knowledge, another line of research investigated the relationship among content knowledge and attitude towards various issues in genetics, the factors such as gender that may influence participants' attitudes were also explored. In such study conducted in United States with more than 3046 undergraduate students, Sohan, Waliczek and Briers (2002) investigated undergraduate students' attitudes, content knowledge and perceptions toward biotechnology issues specifically, genetic manipulation, recombinant DNA, genetically modified foods, cloning issues as well as benefits and risk factors. The results revealed a low level of awareness about biotechnology. The results indicated that participants had low level of knowledge regarding biotechnology issues and tended to accept accepts specific applications or products of biotechnology such as cloning, genetically modified foods or genetic modification as plausible. Besides, students who were knowledgeable about biotechnology also tended to have more favorable attitudes towards biotechnology. In addition, results revealed gender and department differences among participants. While undergraduate students majoring in medical, veterinary and engineering departments held more favorable attitude towards biotechnology when compared to students in education departments, the female undergraduate students were less likely to have positive attitudes towards biotechnology applications when compared to male students.

On the other hand, some studies revealed no relationship between students' knowledge and attitudes. In such study, studying with 415 undergraduate students, Acra (2006) investigated undergraduate students' genetics literacy levels and their attitudes towards genetics issues by using a genetics literacy questionnaire including 14 true/false knowledge questions, 8 multiple choice knowledge questions, 9 attitudinal questions, and 4 demographic questions. The researcher evaluated the effectiveness of different courses (Genetics & Society, General Biology, Honors Biology and Psychology) focusing on genetics by implementing a pre-course/post-course survey. The statistical analysis revealed that only two courses (General Biology and Honors Biology) significantly affected increasing participants' content knowledge in genetics. In addition, very little change in attitude scores was seen in any of the courses. The researcher concluded that the increase in participants' genetics knowledge might not affect their attitudes toward genetics as the same way of knowledge.

In Turkish context; Usak and his colleagues (2009) examined Turkish undergraduate (n= 276) and high school (n= 352) students' knowledge and attitudes towards biotechnology as well as the relationship between attitudes and knowledge. While significant relationship between knowledge and attitudes towards biotechnology issues were found, no significant difference between high school and undergraduate students' content knowledge was revealed. In addition, while participants held favorable attitudes towards agricultural biotechnology, their attitudes towards the use of genetically modified foods were less favorable implying that participants' attitudes towards different biotechnological applications were differed based on their perceptions. Multivariate analysis also revealed gender difference in favor of male in both undergraduate and high school students. Overall, the researchers concluded that both high school and university students lacked of sufficient knowledge regarding biotechnology.

Overall, the reviewed studies indicated that undergraduate students lacked of content knowledge regarding genetic/biotechnology issues (Bowling, 2007; Bowling et al. 2008; Sohan et al., 2002). In addition, while some studies indicated positive relationship between participants' knowledge and attitudes towards various issues in genetics (e.g., Usak et al. 2009; Sohan et al. 2002), some studies revealed no relationship between two constructs (Acra, 2006). With respect to participants' attitudes, differences based on the issues being investigated were observed. For instance, participants tended to have favorable attitudes towards genetically modified foods in contrast to holding unfavorable attitudes towards genetically modified foods. Besides, female students seemed to hold unfavorable attitudes towards various issues related to genetics and biotechnology.

In following section, research focusing on pre-service and in-service science teachers' understanding of genetics and attitudes towards issues in genetics literacy was reviewed.

2.1.1.2. Pre-service and in-service teachers understanding of genetics and attitudes towards issues in genetics literacy

Under this heading, empirical studies related to pre-service and in-service teachers' understanding of genetics, attitudes towards issues in genetics literacy as well as the factors that may influence their knowledge and attitudes were reviewed. The empirical studies which were chosen for review adopted a wide range of issues by using quantitate methods and qualitative methods. One of the first attempts for exploring university students' understanding of genetics was to investigate their difficulties in genetics. In such study, Bahar, Johnstone and Hansell (1999) investigated Scottish freshmen university students' difficulties in learning biology. In first step, students (*n*= 207) were surveyed about their perceptions regarding the difficult topics in biology. In second step of study, interviews were conducted with selected students from sample. The results revealed that university students mainly pointed out genetics were difficult to learn. Close examination revealed that students' difficulties reasoned from language used in genetics (they perceived the language as complex and consists of many unfamiliar terms), the mathematical expressions used in genetics, distinguishing meiosis from mitosis and insufficient time for understanding and teaching genetics. The researcher attributed students' difficulties to the complex nature of different thoughts. The students' difficulties rooted from interactions between macro, sub-micro and symbolic level of thought. For instance, while morphological characteristics of a flower includes macro level that can be understood by using senses, these characteristics lead to genes and alleles which are sub-micro level. Thus, the researchers emphasized the importance of teachers' focusing on the interactions between macro, sub-micro and symbolic level that enhance understanding in genetics.

In a more recent study, Chabalengula, Mumba and Chitiyo (2011a, 2011b) conducted a series of studies for exploring pre-service teachers' understanding of biotechnology issues and attitudes towards biotechnology. In first research, the researchers investigated American elementary education pre-service teachers' understanding of biotechnology, genetic engineering, cloning and genetically modified foods as well as exploring the relationships between background characteristics. Results revealed that a great majority of PSTs that enrolled in introductory science courses (77%) and science courses (93%) failed to define the biotechnology concepts as well as genetic engineering and genetically modified foods correctly. Moreover, they failed to give examples to biotechnology issues. The researchers attributed PSTs' insufficient knowledge in definitions and examples of biotechnology, genetic engineering and genetically modified foods to the lack of formal education related to biotechnology issues in university and highlighted the importance of PSTs being graduated having sufficient knowledge regarding biotechnology issues from teacher education institutions. The researchers also recommended that biotechnology issues should be included in elementary education content and method courses in order to equip elementary teachers with sufficient skills and understanding in biotechnology issues.

In the second research, Chabalengula et al. (2011) explored PSTs' attitudes towards biotechnology, specifically, use of microorganisms such as genetic modification of plants/foods, genetic modifications of animals and genetic modifications of human genes (n= 88). The results revealed that elementary education PSTs attitudes towards biotechnology issues were differed. While, more than half approved use of microorganisms for specific processes such as for producing beer or breakdown human sewerage (62%) the approval rate was dropped when genetic modification of animals was considered (20%). A large proportion also remained undecided with respect to modification of human genes (38%). With respect to the science education courses enrolled, the students who enrolled introductory and advanced science method courses had more approval rates. They emphasized that PSTs should develop sufficient understanding of biotechnology as well as hold favorable attitudes towards biotechnology issues as their role in introducing biotechnology issues to their students considered. Thus, they suggested that university teacher education programs should equip PSTs with sufficient understanding in biotechnology issues by developing appropriate materials for science curriculum.

Pre-service teachers' knowledge and attitudes towards various biotechnological issues were also explored by Turkish researchers (e.g., Cebesoy & Tekkaya, 2012; Ozden, Usak, Prokop, Turkoglu & Bahar, 2008; Usak, Erdogan, Prokop & Ozel, 2009; Turkmen & Darcin, 2007). Studying with 336 Turkish pre-service science and primary school teachers, Turkmen and Darcin (2007) investigated knowledge levels of pre-service teachers about various biotechnological issues (i.e., biotechnology, agro-biotechnology, human health and pharmacy issues, environment and biotechnology, and food production with biotechnology). The researchers found that even pre-service teacher had adequate knowledge in describing biotechnology and human health/pharmacy issues, their knowledge levels in other dimensions were found to be insufficient. Pre-service science teachers were found to be more knowledgeable regarding biotechnology issues when compared to primary school teachers implying a relationship between knowledge and attitude. In addition, the results did not reveal any gender difference among PSTs. The researchers inferred that Turkish PSTs' knowledge levels regarding biotechnology were insufficient and needed to be addressed in undergraduate education.

In a similar manner, Ozden and his colleagues (2008) investigated Turkish pre-service teachers' knowledge and attitudes towards use of the chemical hormone in humans, plants and ecological agriculture (*n*= 371). The researchers reported that pre-service teachers in their sample had inadequate knowledge about biotechnological issues. Besides, any difference with respect to gender or age was revealed in the study. In addition, candidate teachers' attitudes toward the applications of chemical hormones were reported to be less favorable. While candidate teachers held more favorable attitudes towards the usage of chemical hormones in plants and ecological agriculture, they were unwilling to use them in human.

Cebesoy and Tekkaya (2012) investigated Turkish senior pre-service science teachers' genetics literacy levels and their attitudes towards genetics by using Genetics Literacy Assessment Inventory (GLAI) and Genetics Attitude Scale (*n*= 183). Results revealed that Turkish PSTs had correctly responded less than half of the questions found in the GLAI. While they were found to be moderately knowledgeable in concepts related to DNA, chromosome, gene and their interactions, genetic variation, gene activity, Mendelian patterns of inheritance, meiosis and mitosis, they, on the hand, demonstrated limited understanding in understanding the relationships between genetic variation and disease, genetic variation and natural selection as well as gene regulation. With respect to their attitudes towards genetics applications, even they held quite favorable attitudes towards genetic applications, they remained uncommitted in some items. For instance, while slightly more than half of the participants believed in the importance of media in genetics research (54%), nearly a quarter remained undecided with respect to the role of media in genetics research. With respect to relationship between PSTs' genetics literacy levels and their attitudes towards genetics, no significant relationship was revealed. The researchers emphasized the role of teacher education institutions in terms of training genetically literate science teachers and recommended further to investigate teachers' as well as PSTs' genetics literacy levels by considering limitations of the study.

While aforementioned studies explored university students' difficulties in genetics as well as PSTs' understanding of genetics related issues and attitudes, some other studies explored teachers' understanding of genetics related issues and attitudes as well as the relationship between their understanding and their attitudes towards various issues in genetics literacy with respect to the some other factors such as gender or teaching experience. In such study, Boone, Gartin, Boone and Huges (2006) investigated agriculture teachers' knowledge levels and attitudes about biotechnology issues (animal reproduction, hybridization, environmental biotechnology and human genetics) as well as the relationship among the factors as teaching experience and having a master degree, their attitudes and knowledge (*n*= 62). Results indicated that while teachers perceived sufficiently knowledgeable in animal reproduction and hybridization issues, they reported lacked of knowledge in environmental biotechnology and human genetics. Teachers in their sample were found to ta have favorable attitudes towards biotechnology. For instance, vast majority of teachers expressed the importance of teaching biotechnology issues to their students as well as developing effective teaching materials. With respect to teaching experience and having a master degree, no significant relationships were detected.

In another study, Šorgo and Ambrožič-Dolinšek (2009) investigated the relationships among primary and secondary school Slovene teachers' knowledge levels in genetics and biotechnology, attitudes towards genetically modified organisms (GMO) and acceptability of using genetic modifications in microorganisms, plants and animals. Authors found that although teachers have high level of knowledge in classical genetics, they possessed poor levels of knowledge in modern issues such as stem cells, genetically modified organisms or cloning. It was also reported significant, but weak correlations between knowledge and acceptance which indicates their decisions about accepting genetic modification over variety of organisms is rarely related with scientific facts. Same researchers' replicated study with pre-service teachers also revealed similar correlation patterns between knowledge-attitude and knowledge-acceptance of GMO. While remained undecided about usage of genetically modified organisms in research studies or in medicine, prospective teachers inclined to accept usage of genetic modifications on plants and microorganisms (Šorgo & Ambrožič-Dolinšek, 2010).

To sum up, empirical studies conducted with both pre-service and in-service teachers revealed lack of content knowledge in various issues covered in genetics and biotechnology. In addition, significant but weak relationships between content knowledge and attitudes towards various issues detected. Both pre-service and in-service teachers' attitudes towards various issues differed. While both groups held favorable attitudes towards some genetics applications such as genetic modifications in plants and microorganisms or using chemicals in plants and agricultural products, they were showed unwillingness use of aforementioned issues in humans. Besides, the relationship among various factors such as gender, teaching experience or holding a master degree, knowledge and attitude were explored, and no correlation was found. Only reported difference was major factor. Turkish pre-service science teachers were reported to be more knowledgeable when compared to primary school teachers (Darcin & Turkmen, 2007). This result was an expected result as pre-service science teachers had courses such as general biology, genetics, and biotechnology when compared to primary school teachers. Another point is that studies exploring relationships between knowledge and attitude in various genetics/biotechnology issues within Turkish context were mainly conducted with pre-service teachers.

2.1.1.3. Public understanding of genetics and attitudes towards issues in genetics literacy

Study findings conducted with public in different countries reported conflicting results with respect to relationship between genetics consent knowledge and attitudes towards various issues. While some studies reported positive correlation between genetics content knowledge and attitudes towards various issues (e.g, Sturgis et al., 2005), other studies revealed no correlation between content knowledge and attitude (e.g., Ishiyama, Tanzawa, Watanebe, Maeda, et al. 2012). Regarding existence of a relationship between content knowledge and attitudes, Sturgis, Cooper and Fife-Schaw (2005) investigated British public opinion on particular applications of genetics technologies as gene therapy, use of genetic data as well as more general attitudes towards genetic research by using 2000 British Social Attitude Survey and 1999 Wellcome Consultative Panel on gene therapy. A total of 976 individuals participated in the study. The results revealed that genetics content knowledge influenced participants' attitudes towards genetic applications. Informed individuals developed more favorable attitudes towards genetics applications. This result, however, was not consistent in all attitude dimensions being explained. For instance, while informed individuals tended to favor genetics applications for treatment of disease, they showed negative appraisal for the use of genetic information.

In addition, while examining the relationship between genetics content knowledge and attitudes towards various issues, researchers also investigated some factors that might influence individuals' attitudes such as gender or educational level (Ishiyama, Nagai, Muto, Tamakoshi et al. 2008; Ishiyama, Tanzawa, Watanebe, Maeda, et al. 2012; Rundgren, 2011; Qin & Brown, 2007; 2008). For instance, Ishiyama and his colleagues (2008) aimed to examine the relationship between Japanese public attitudes towards genomic studies related to health and "genomic literacy". The researchers collected the data collected from 4000 individuals in Japan. The findings revealed that individuals who were genetically literate tended to favor genetic research related to health issues. The determined relationship between genetic knowledge and attitude was stronger in male participants when compared to females. Results also indicated that a great majority of participants (70%) approved the genetic research related to health issues. In another study, conducted with the same participants, researchers investigated the relationship among genetics content knowledge, attitudes towards health related genetics issues and gender. They, however, revealed no relationship among gender, genetics content knowledge and attitudes towards promotion of genetics research related conducted in crops (Ishiyama et al. 2012). Based on both study findings, it can be inferred that relationship between genetics knowledge and the participants' attitudes towards various issues in genetics can differ with respect to issue being investigated.

In addition to the effect of gender, other studies investigated the role of background characteristics such as education level, marital status and monthly income. In such study, studying with 501 American individuals, Qin and Brown (2008) explored participants' attitudes towards genetic engineering and genetically modified food specifically genetically modified salmon and the relationship among attitudes and the demographic characteristics such as gender, education level, marital status and monthly income. The findings only revealed gender difference with respect to attitude. Female participants held less favorable attitudes towards genetically modified salmon when compared to male counterparts. This finding is also consistent with Ishiyama et al.'s (2008) study which reported male participants had favorable attitudes towards genetics research in health context. The researchers explained the gender difference as females having concerns about health risks and the ethics/morality of this application. While female participants perceived genetically modified salmon as a potential risk to health, they also indicated that the application was morally unacceptable because of risk factors for environment and society.

To sum up empirical research conducted with public indicated conflicting results. While some studies indicated existence of a positive relationship between participants' genetics knowledge and their attitudes towards issues in genetics (e.g., Sturgis et al., 2005, Ishiyama et al., 2008), some studies revealed no correlation between two constructs (e.g., Ishiyama et al., 2012). In addition, research findings supported the idea that participants' attitudes towards various issues in genetics differ based on the issues being investigated. With respect to background characteristics, only gender seemed to influence participants' attitudes towards issues in genetics literacy (Ishiyama et al., 2012; Rundgren, 2011; Qin & Brown, 2007; 2008). Overall, the studies conducted with individuals in public implied inadequate understanding in genetics that also caused developing unfavorable attitudes towards issues in genetics literacy. As individuals actively participate in decision making processes in daily life debates (Halverson, Freyermuth, Siegel & Clark, 2010; McInerney, 2002; Miller, 1998; Sturgis et al. 2005; Tsui & Treagust, 2010), it is important to raise students with sufficient level of understanding in genetics and having favourable attitudes towards issues in genetics literacy.

Following section devoted to the studies from literature related to students', pre-service and in-service science teachers' decision making processes.

2.1.2. Studies focusing on decision making processes

Making informed decisions are assumed to be an important characteristic of both scientifically and genetically literate individuals (Bingle & Gaskell, 1994; Bowling et al. 2008; Eggert & Bögeholz, 2010; Jennings, 2004; Kolstø, Bungum, Arnesen, Isnes et al. 2006; Lee, 2007; Lewis & Leach, 2006; Miller, 2004; Norris & Philips, 2003; Tytler, Symington, & Smith, 2011). Under this heading empirical studies related to students, university students' (college and pre-service teachers) and in-service teachers' decision making and the factors that influence decision making processes in a variety of countries were presented. The empirical studies reviewed throughout current section include a wide variety of controversial issues including biotechnology and SSIs which requires making informed decisions such as biological conservation (Grace & Ratcliffe, 2002), gene therapy cloning, genetic engineering. and genetically modified foods in the context of socio-scientific issues and biotechnology (Chang & Chiu, 2008; Dawson, 2011; Khishfe, 2012; Lazarowitz & Bloch, 2005; Sadler & Zeidler, 2004, 2005a; Steele & Aubusson, 2004), pre-implementation genetic testing (Boerwinkel, Knippels & Waarlo, 2011; Ozer-Keskin, 2013), construction of power plants (Kolstø, 2006), use of nuclear power generation, climate change, and embryonic stem cell research (Lee & Witz, 2009; Lee, Chang, Choi, Kim & Zeidler, 2012; Concannon et al. 2010; Halverson et al. 2009; Halverson, Fyermuth, Siegel & Clark 2010), and pollution, global warming and endangered species (Lee & Witz, 2009). Besides, focusing on various issues, various contexts and instructional methods were adopted in reviewed studies. Due to fact that decision making in controversial issues also requires informal reasoning, studies related to informal reasoning and moral reasoning in the context of socio-scientific issues were reviewed (Dawson, 2011; Sadler & Zeidler, 2004, 2005a). In addition, studies dealing with decision making adopted a variety of instructional method such as argumentation (Dawson & Venville, 2009), classroom discourse (Lee, 2007), nature of science (Khishfe, 2012) and cooperative learning (Eggert, Ostermeyer, Hasselhorn & Bögeholz, 2013). First, studies focusing on high school students' decision making processes were presented.

2.1.2.1. Studies focusing on high school students' decision making processes

In this part, selected studies focusing on high school students' decision making processes were reviewed throughout a historical order. One strand of study focused on students' reasoning pattern used in their decisions and the factors that influence their reasoning and their decision. In such study, Grace and Ratcliffe (2002) investigated 15-16 year secondary school students' decision making and discussions on two biological conservation issues (elephants and puffins as endangered species) as well as science teachers' opinions about how students make decisions in conservation issues (n= 34). While teachers generally expected their students to use ecology concepts, genetics concepts as well as other concepts such as evolution or adaptation which require basic understanding of genetics concepts, students tended to use ecology concepts such as food web, food chain, habitat and population while making decisions. Regarding the values that were adopted in decision making process, value considerations including intrinsic values (values for life) as well as utilitarian values (i.e. values of some benefit to humans) were both used by students which were also acknowledged and stressed by teachers in teacher interviews. Students general tended to consider animals' right to live (intrinsic values) while making decisions. The researchers concluded that students' decisions were both influenced by scientific concepts and values which should be taken into consideration when dealing with ethical issues in science classes.

In another study, Kolstø (2006) investigated Norwegian students' informal reasoning on a task as local construction of new power lines and the possible increased risk of childhood leukemia which required considering possible positive and negative consequences effects on individuals. A total of 22 students were interviewed, and data analyzed by using qualitative methods. Findings revealed that all the students used different risk perceptions while dealing with scientific issues involving ethical aspects. For instance, while nine students perceived potential risk of construction of a new power line as a minor, two students perceived risk factors as negligible. Five of the students compared the pros and cons when dealing with risk factors. Only two of the students were unable to make a decision as they were unable to deal with the risk factors presented in scenario. Students were also concerned about psychological reactions of affected individuals due to uncertainty and anxiety, opinions of independent researchers and getting consensus within scientific community. Overall, Kolstø concluded that students' values are much more influential on their decisions when compare to their knowledge and thus, the aforementioned concerns of students should also be included while dealing with developing students' decision making.

In a similar manner, investigating high school students' informal reasoning and argumentation about biotechnology, Dawson and Venville (2009) conducted semi-structured interviews with year 8 students (*n*= 10), year 10 students (*n*= 14) and year 12 students (*n*= 6) in Australia. Students' informal reasoning patterns were examined under rationalistic, emotive and intuitive reasoning patterns. Results revealed that regardless grade level, students generally used intuitive reasoning which consists of participants' immediate reactions and responses to the cases (33% of total statements) and followed by emotive reasoning which consist of statements such as empathy, sympathy or care concerns (28.5% of total statements). On the other hand, only 18% of total statements included rationalistic reasoning patterns that consists of logical and scientific understanding, as well as weighting advantages and disadvantages of biotechnology. As the researcher studied with young students, use of multiple reasoning patterns was found to be less frequent.

In contrast to reasoning patterns detected in Dawson and Venville's (2009) study, Slovenian high school students, in general, tended to use rationalistic reasoning in their decisions. While investigating the relationship among Slovenian high school students' prior knowledge regarding genetics and their attitudes towards specific biotechnology applications as Bt corn, genetically modified salmon, somatic and germ-line gene therapy, Črne-Hladnik, Hladnik, Javornik, Košmelij and Peklaj (2012) further explored students' moral reasoning patterns. Regarding students' decision making and reasoning patterns, majority of students adopted rationalistic reasoning in their decisions. They indicated some concerns as inferring with nature, benefits, unknown consequences, possible abuse of applications, progress of science. They also expressed some concerns regarding adverse effect on animal heath that was categorized under emotive reasoning pattern.

On the other hand, investigating investigated 80 Swedish upper secondary school (aged 18-19) students' informal reasoning patterns with respect to different SSIs as global warming, genetically modified organisms, nuclear power and consumption issues, Christenson, Chang-Rundgren and Höglund (2012) used another model consisting of six areas as environment, economy, science, ethics/morality and policy with respect to value, personal experience and knowledge. They proposed that students' decisions are influenced by the interplay between these factors. The researchers analyzed students' reasons by using the proposed model. Data were collected from students' written expressions about their reasoning about one of the different SSIs as global warming, genetically modified organisms, nuclear power and consumption issues. Among issues, global warming and consumption (the effect of consumption on environment both local and global level) were the most preferred ones (33% and 31% respectively). Results revealed that students in the study used different reasoning patterns considering different issues. Regardless the issues, majority of students used value aspect while supporting their reasons (67%). Only a quarter, on the other hand, used scientific knowledge to support their reasons. Researchers concluded that, selection of SSIs in science teaching is crucial part of curriculum if teachers aim to engage their students to take active part in informal argumentation. For example, while environmental courses are more appropriate for covering issues like global warming or nuclear power plants, science courses may be more appropriate for including issues such as genetically modified foods. In addition, some alternative conceptions that students had were identified implying that students did not have a deep understanding about SSIs being discussed. Lastly, researchers indicated that the students in their study did not used all the perspectives. Thus it was not possible to adopt a holistic approach in analyzing students' argumentation patterns, as well as argumentation skills. They suggested that teachers studying with different subject areas on SSIs may be helpful in engaging students to actively participate in this issues as well as developing multidisciplinary viewpoints.

In parallel with Christenson and her colleagues study (2012); Lee (2012) proposed another framework that explained how decisions are framed. In his study, Lee explored how various factors interact while making decision regarding SSIs in health context. He used a collective case study method and examined the case studies that are related with health. He addressed that while making decisions, many factors such as psychological state of individuals, science and sociocultural values interact each other which deeply effect participants' decisions. He proposed a tentative framework that demonstrated how various factors interact while making decisions. According to this framework, while scientific knowledge from everyday life and sociocultural background that individuals are raised in serve as background in making decisions. As individuals are dealt with a specific case, individuals also face with the uncertainties, risk factors, locality of issues, the stakeholder that are involved in societal values and cultural aspects. So the researcher concluded that aside from rationalistic, emotive and intuitive reasoning while making decisions, it is also necessary to address societal values, cultural values, politic and economic aspects in decision making framework. Thus, decision making framework should be considered within a wider perspective including multiple frameworks.

In another study conducted with 1142 high school students in Turkey, Ozer-Keskin (2013) investigated students' ethical decision making process in hypothetical cases as genetic screening, prenatal genetic testing, abortion, reproductive technologies and euthanasia by using an inventory constructed by multiple-choice items. Results, in general, indicated that students opposed the applications presented in the cases. For instance, a great majority of students opposed abortion (79%) and indicated that "we should not deny the right to life of other organisms even it is disabled". Likewise, 86.5% of participants were against the use of prenatal testing for the purpose of sex determination and stressed the importance of having a healthy child is more important than determining its gender. Similar patterns were observed in genetic screening and Euthanasia scenarios. With respect to different scenarios, students made different ethical decisions. For example, students expressed the importance of individuals' choices and right as well as the role of religious values in prenatal genetic testing, abortion and euthanasia scenarios. Overall, the research findings indicated that students' ethical decisions are influenced by their perceptions about personal choices, individual rights and values as well as the theological worldviews that they are holding.

Another study investigating secondary school students' decision makings and the factors that affect their decision in the context of pre-symptomatic genetic testing, Boerwinkel, Knippels and Waarlo (2011) used four real life cases focusing on genetic testing in elite sport. Participated students (*n*= 120) reported their decisions on student worksheet after each case. Results revealed that students changed their decisions about conducting a genetic test after each case. At the end of lesson, a great majority (71%) changed their decisions. While 7% of students indicated multiple factors associated with genetic testing at the beginning of course, 75% of students indicated multiple factors at the end of course. At the end of course, students recognized the advantages and disadvantages of genetic testing for different stakeholders (for instance, advantages and disadvantages for both athlete and sport organization), the uncertainty of genetics testing as well as the conflicting values that genetics testing has entailed. Overall, students realized that controversial issues like genetic testing required consideration of different perspectives while making decisions.

Another line of research investigated the how various methods influence development of students' decision making. For instance, Khishfe (2012) investigated the relationship between nature of science (NOS) teaching and students' decision making skills in controversial socioscientific issues as cloning and genetically modified foods. 9^{th} grade students in 4 intact groups taught by the same teacher (the two groups referred as experimental, and the other two groups referred as control group) participated in the study. A 4-week unit focusing on genetic engineering was designed consisting of how to apply NOS aspects when formulating arguments and making decisions when encountered with a controversial issues. Views of Nature of Science Questionnaire and open-ended scenario on decision making were used for data collection. The results indicated that treatment group students developed better understanding of NOS aspects when compared to control group. No statistical difference was revealed between control and treatment groups' pre- and post-decisions but students in treatment group used more factors as health, moral/ethical, religious, and economic factors when making decisions and explaining the rationale of their decisions. Based on the findings, the researcher concluded that the instruction focusing on NOS aspects is useful for facilitating students' decision making skills.

In a similar manner, studying with 360 senior high school students, Eggert, Ostermeyer, Hasselhorn and Bögeholz (2013) investigated how students' socio-scientific decision making strategies including description of SSI and developing and evaluating solutions to SSI could be developed. The researcher developed two training programs as a cooperative learning setting and a cooperative learning setting assisted with metacognitive guidance. Both programs used methods as jigsaw and fishbowl as well as think-pair-share processes. In addition in metacognitive assisted group, metacognitive guidance to students was provided. The training focused on controversial issues as the issue of palm oil production in Indonesia and two measures as metacognition, and socio-scientific decision making were used as pre-and post-test. The findings indicated that both training programs facilitated the process of students' decision making when compared to control group. Even students get higher scores in cooperative learning setting than the cooperative learning embedded in metacognitive setting; no significance difference between two experimental groups was revealed. It was concluded cooperative learning setting as well as metacognitive guidance may help students' to enhance decision making skills regarding controversial issues.

Aside from the studies that investigated informal reasoning and moral reasoning while making decisions and during development of instructional methods for exploring and enhancing students' decision making, some researchers attempted to develop instruments for assessing decision making competence. For instance, Eggert and Bögeholz (2010) developed a test instrument in order to measure students' decision making skills with respect to sustainable development issues. In first phase of study, an open ended questionnaire focusing on sustainable development issues considering national standards and state curricula developed. Then, a group of experienced science teachers in decision making competence (*n*= 10) examined the developed questionnaire in terms of the quality of decision making competence. The reviewed questionnaire was pre-piloted with junior high school students (*n*= 25) and university undergraduates (*n*= 20). The finalized form consisting two decision making tasks as overfishing of codfish in the Baltic Sea and neophyte invasion that causes landslides along river banks was piloted with 291 students and was reported as valid and reliable instrument for measuring students' use of decision making strategies. The main study was conducted with 370 secondary school students from Grades 6 (*n*= 105), grade 8 (*n*= 100), grade 10 (*n*= 82), and grade 12 (*n*= 83) and 78 second-year biology university undergraduates and the data was analyzed by using Rash partial credit model. Results identified that years of education has a strong effect on decision making competence as decision making competence increased with respect to years of education. Based on this finding, the researchers concluded that the first two years in secondary school have critical importance in developing students' decision making competence.

The literature reviewed above provided empirical evidence that students' decision making processes are influenced by the interaction of multiple factors. The researchers explored these factors within various issues in the context of *genetics*, *biotechnology* and *socioscientific issues*. The reviewed studies unveiled various factors such as political, cultural and social factors (Lee, 2007); risk factors (Kolstø, 2006; Lee, 2012); sociocultural and psychological factors and uncertainty (Boerwinkel et al. 2011; Lee, 2012; Kolstø, 2006); rationalistic, emotive and intuitive factors (Črne-Halanick et al. 2012; Dawson & Venville, 2009); religious factors (Khishfe, 2012; Ozer-Keskin, 2013); value factors (Boerwinkel et al. 2011; Christenson et al. 2012; Grace & Ratcliffe, 2002; Kolstø, 2006; Lee, 2012), personal choice (Ozer-Keskin, 2013) and economic factors (Lee, 2012; Khishfe, 2012). Thus, it can be concluded that students' decisions are influenced by the interaction of multiple factors. In addition, some studies explored how various methods enhance development of students' decision making (Dawson & Venville, 2009; Khishfe, 2012; Eggert et al; 2013) and NOS, cooperative learning as well as argumentation and discourse were reported to enhance students' reasoning which in turn influence their decision making process. Lastly, Eggert and Bögeholz (2010) developed an instrument for assessing students' decision making competence and revealed students' decision making competence increased with respect to level of education implying that as the students get older, they develop more comprehensive decision making skills which was also supported by a previous study conducted by Dawson and Venville (2009).

In following part, studies focusing on undergraduate students' decision making process were presented.

2.1.2.2. Studies focusing on undergraduate students' decision making processes

In this part, selected studies in biotechnology and socioscientific issues contexts focusing on undergraduate students' decision making processes by using different frameworks were reviewed throughout a historical order. In such study, exploring college students' informal reasoning patterns (*n*= 30), Sadler and Zeidler (2005a) conducted two semi-structured interviews in genetic engineering scenarios as gene therapy on Huntington Disease, on near sightedness and on intelligence, cloning, reproductive cloning, deceased child cloning and therapeutic cloning. The researchers tried to explain participants' socio-scientific informal reasoning by using a socio-scientific informal reasoning framework by considering multiple perspectives as personal experiences, emotive factors, social consideration, moral and ethical considerations. Results indicated that all the participants used rationalistic reasoning in their decisions and considered a wide range of issues in their decisions such as patient rights, parental responsibilities, availability of treatment options, side effects and the accessibility of treatments. Some of the students used emotive informal reasoning and had concerns how individuals would be affected, thus indicated feelings such as sympathy or empathy to fictious characters in the scenarios. Some of the participants used their "intuitions" while making decisions. They made decisions but they did not clearly explain the main reason for their decision. Besides, distinct patterns of informal reasoning, students also frequently used multiple reasoning patterns in their decisions. For instance, while they considered the individuals' situations in the scenarios by showing empathy towards characters in the scenarios, they also considered the availability of treatment options in their decisions. Another significant finding revealed was that participants' reasoning patterns differed with respect to scenarios. The researchers concluded that decision making is a complex process that are not only influenced by informal reasoning patterns, but also morality, personal experiences, social considerations as well as emotive factors influence decision making of individuals. Studying with 20 college students, the same researchers (2004) also explored the role of morality on college students' decision making in the same genetic engineering issues. Results revealed that students mainly used consequalistic moral reasoning and principle based moral reasoning patterns indicating that students made decision by considering either the consequences of issues presented in the scenarios or principles such as taking human life or using embryos as a tool. Besides, participants used moral intuitions and emotions while considering these issues. Researchers also indicated that students' decisions were influenced by other factors such as religion, personal experience, additional information and pop culture besides moral reasoning. They proposed that decision making process should be dealt with considering multiple perspectives.

In another study conducted by Sadler and Zeidler (2005b), the role of content knowledge in influencing college students' informal reasoning regarding controversial genetic engineering scenarios focusing on gene therapy and cloning were investigated. Two groups of students (*n*= 15 for each group) representing high and low knowledge levels in genetics who were selected among 258 college students that completed a questionnaire assessing genetics knowledge were interviewed by using genetic engineering scenarios. Findings indicated that participants in high knowledge group expressed clear positions, rationales, counter-positions and rebuttals by using their extensive knowledge in genetics. On the other hand, no patterns in informal reasoning (rationalistic, emotive, and intuitive) were revealed about between two groups. Even the participants' knowledge levels in genetics differed, any observable differences in their informal reasoning while making discussion and during decision making about controversial issues were detected.

While Sadler and Zeidler (2004; 2005a, 2005b) used rationalistic, emotive and intuitive informal reasoning pattern for explaining undergraduate students' decision making in the context of socioscientific issues processes focusing on genetic engineering issues and cloning issues, Chang and Chiu (2008) used another framework to explore Taiwanese undergraduate students' decision making in a different context. The researchers investigated science majors' (*n*= 40) and non-science majors' (*n*= 30) informal argumentation skills with respect to four scenarios with respect to genetically modified food, organic food, DDT and malaria and dispute about dioxins. Based on students' written reports about each scenario, researchers determined five sources to support their reasons as general beliefs, scientific belief (participants' beliefs about the value of scientific research, uncertainty and temporary nature of science) authority (reasons from textbooks, expert opinions, teachers' instructions, parents' thoughts), personal experience and analogy (using examples of knowledge regarding other field while making a decision). Participants in both groups frequently used their personal experiences and scientific beliefs while supporting their reasons. In addition, while science majors use analogies such as giving examples development of medical products and their clinical trials, non-science majors used authority such as approval of governments for supporting their reasons. Based on the findings, researchers concluded that individuals' background knowledge such as majoring in science or non-science braches such as psychology influence their reasons and the way how they supported their reasons.

In stem cell research context, Halverson, Siegel, and Freyermuth (2009) examined 132 college students' papers in a biotechnology course in order to investigate students' decision making strategies about stem cell research including embryonic and adult stem cells, in-vitro fertilization, and therapeutic and reproductive cloning. They reported that college students' decisions were rooted from eight different perspectives as medical application, ethical, rights, economic, religious, personal anecdotes, political, and scientific. Even, the most common perspective among students was found as medical applications, most of students used multiple viewpoints while making decisions. The researchers also concluded that the influencing perspectives were unequally valued, and students' decisions, in general, relied on ethical perspectives.

In another study, studying with 96 undergraduate students; Concannon, Siegel, Halverson and Freyermuth (2010) investigated undergraduate students' understanding related to stem cell, stem cell research and cloning. The researchers developed a course including interactive lectures, case discussions, hands-on activities, and independent projects in order to develop students' scientific understanding as well as enhance their reasoning about these controversial issues and make decisions regarding these issues. The data was collected as pre-posttest administration of 23 question instrument with multiple item format including true/false with justification, multiple choice with justification, and open-ended responses that focused on knowledge of stem cells, stem-cell research, and cloning. Findings indicated that there were a significant decrease in students' misconceptions about stem cells, stem cell research and cloning from pre- to posttest implying that participants developed more accurate understanding about stem cells, stem cell research and cloning issues which in turn will be resulted in making informed decisions.

To conclude, the reviewed studies conducted with undergraduate students also revealed similar results with respect to decision making. The researchers used different frameworks for explaining participants' reasoning in decision making process both biotechnology related issues and socioscientific issues. For instance, while Sadler and Zeidler (2004; 2005) used informal reasoning as rationalistic, emotive and intuitive reasoning, Chang and Chiu (2008) identified five sources that undergraduate students supported their reasons as general beliefs, scientific belief (participants' beliefs about the value of scientific research, uncertainty and temporary nature of science) authority (reasons from textbooks, expert opinions, teachers' instructions, parents' thoughts), personal experience and analogy (using examples of knowledge regarding other field while making a decision). The reviewed studies unveiled various factors such as rationalistic, emotive and intuitive reasoning patterns, personal experiences, social considerations, pop culture, religion (Sadler & Zeidler, 2004, 2005a, 2005b); general beliefs, scientific belief, authority, personal experience and analogy (Chang & Chiu, 2008) and medical application, ethical, rights, economic, religious, personal anecdotes, political, and scientific (Halverson et al. 2009). In addition, Sadler and Zeidler's (2005b) study revealed that participants' knowledge levels influenced making clear positions, indicating rationales, counter positions and rebuttals but not their informal reasoning patterns. Besides, Concannon and her colleagues' study (2010) uncovered that participants' understanding about controversial issues could be enhanced by courses consisting of interactive lectures, case discussions, hands-on activities, and independent projects and this may help students to develop scientific understanding as well as making informed decisions.

2.1.2.3. Studies focusing on pre-service and in-service science teachers' decision making processes

Under this heading, two strands of study were investigated. In one strand, studies exploring pre-service and in-service science teachers' decision making processes and the factors that influence their reasoning in various contexts ranging from nuclear power to stem cell research were reviewed. In another strand, studies investigating science teachers' teaching perceptions and difficulties while teaching controversial issues in genetics/biotechnology contexts as well as some possible factors such as gender, teaching experience or self-perceived importance that influence their teaching were reviewed.

In first strand, the studies exploring pre-service and in-service teachers' decision making processes and the factors that influence their reasoning in various contexts ranging from nuclear power to stem cell research were reviewed. In an earlier study, Sadler, Amirshokoohi, Kazempour and Allspaw (2006) explored 20 middle and high school science teachers' perspectives on using socio-scientific and ethical issues in their classes by conducting semi-structured interviews. Based on the data analysis, the researchers described five different profile explaining their views and practices while dealing with socio-scientific and ethical issues in their classes. While Profile A stressed the importance of including SSIs into science classes and gave specific examples in classes, Profile B emphasized existence of constraint that prevent them implementing SSIs into science classes. On the other hand, Profile C remained undecided about the implementation of SSIs. Profile D indicated that science education should be value free. Both Profile C and D indicated that science education should not focus on controversial issues. Lastly, Profile E stressed that all the science education should include ethical issues. The results revealed that teachers held a wide range of perspectives considering their own values.

In another study, H. Lee and Witz (2009) recruited four science teachers' implementation of SSIs in their classrooms and explored their motivations to teach SSIs by conducting a series of semi-structured interviews (changing 4 to 6) with each teacher and by classroom observations. They explored how teachers were dealt with SSIs such as their interest in SSIs, their personal concerns and implementation strategies of SSI into their classes. The recruited issues that were specified during interviews and observations included environmental problems as pollution, global warming, endangered species; biotechnology related issues as cloning, stem cell research and genetically modified foods; and power plant issue. They reported that all the teachers' implementations were deeply influenced by their ideas, values, philosophies and personal concerns. Teachers' inspiration to teach SSIs to students differed based on teacher. While two of teachers' inspiration were rooted from their personal concerns and experiences, the rest of teachers' inspirations were rooted from their moral and spiritual-religious concerns. As a conclusion, Lee and Witz (2009) indicated that teacher in their study developed their own teaching goals, and this influenced their students' decision making skills and attitudes towards SSIs.

While Lee and Witz (2009) explored science teachers' implementation of SSIs and the factors that influence their implementation, in later years, Dawson (2011) investigated an experienced science teacher's teaching strategies on reproduction unit focusing on SSIs as genetic diseases, embryo testing and genetic engineering as well as Mendelian patterns of inheritance. In addition, the researcher also explored how the adopted learning activities affected students' attitudes towards science. Multiple data collection tools as participant observation, interviews with teacher, questionnaires and personal reflection journals were used in the study. The teacher used group work, whole group discussion; cooperative learning and student centered learning while dealing with SSIs. The findings indicted that teacher's perceptions about SSI may influence students' attitudes. The researcher concluded that the teacher's beliefs about the purpose of SSI are important. The teachers who explicitly explained the importance of SSIs in genetics lead greater improvement in their students' reasoning and argumentation skills. She addressed that teachers' beliefs; understanding and skills are important in developing students' decision making abilities.

In another study conducted by H. Lee and her colleagues (2012) investigated how Korean pre-service science teachers dealt with socio-scientific issues and the role of character and values in this process. 18 PSTs were participated the program focusing on SSIs as use of nuclear power generation, climate change, and embryonic stem cell research. Audiotyping of small group discussions of each scenario and self-reflections of pre-service teachers were gathered and analyzed with respect to PSTs' characters and values. The researchers reported that participants' reactions to different SSIs were influenced by their character and value considerations. The effect of moral consideration was most evident in stem cell research scenario. The participants experienced dilemmas rooted from their personal beliefs and religious beliefs when dealing with stem cell research scenario. Another important finding was that even PSTs were influenced by value and moral considerations; they tended to possess a high degree of faith in science and technology. The researchers suggested that a pre-service teachers' reasoning and decision making competence can be enhanced via programs focusing on socio-scientific issues (H. Lee, Chang, Choi, Kim & Zeidler, 2012).

As abovementioned studies stressed the importance of the factors such as teachers' ideas, beliefs, values, philosophies and personal concerns, moral and religious perspectives influence their decisions, some researchers investigated the role of content knowledge in making informed decisions. In such study, van der Zande, Waarlo, Brekelmans, Akkermant and Vermut (2011) investigated the content knowledge that is required for teaching genetic testing. For this purpose, the researchers conducted interviews with 9 experienced science teachers (average teaching experience of 20.7 years) and 12 stakeholders (four clients, two physicians, one clinical geneticist, one genetic counselor and medical ethicists). Three instruments were used for data gathering as semi structured interviews with teachers, semi-structured interviews with different stakeholders and the referents regarding ethical, legal, and social aspects of genetics testing. Overall, the result revealed that content knowledge was a necessity for effective teaching of genetic testing. However, researchers indicated that, some additional concepts such as multifactorial and Polygenic disorder were needed in addition to the concepts that are found current curriculum. Moreover, ethical, legal and social aspects and characteristics as uncertainty, complexity, probability, and morality were reported to be important factors for effective teaching. The researchers also added some additional characteristics as informed consent, solidarity, legal issues concerning insurance, and social implications for relatives or future children to the framework.

In another strand, studies investigating science teachers' teaching perceptions and difficulties while teaching controversial issues in genetics/biotechnology contexts as well as some possible factors such as gender, teaching experience or self-perceived importance that influence their teaching were reviewed. In an earlier study, Australian secondary science teachers' difficulties while teaching two specific biotechnology units which focused on DNA, proteins, mutations, genetic manipulations and the role of biotechnology in daily life including ethical issues were investigated by Steele and Aubusson (2004). Data was collected by using multiple methods as interviews, document analysis and observation (field notes) during two case studies of teachers while teaching biotechnology unit. Prior to case studies, the researchers collected data from 59 teachers from 100 schools by using questionnaires in order to provide some insights about teaching biotechnology in their courses. In addition, eleven teachers were interviewed for probing their experiences regarding teaching biotechnology. The quantitative analyses revealed that teaching experience in general, as well as teaching experience in biology, were not related with the amount of biotechnology taught in their classes. Qualitative analyses of interviews with teachers revealed that, teachers, in their study, reported lacking both enough knowledge and practical work to teach these units effectively. They attributed this finding to presence of external exams and students' difficulties in understanding concepts in biotechnology.

In the same year within a different cultural context, Byrce and Gray (2004) investigated Scottish biology teachers' opinions about the new biotechnology curriculum consisting of biotechnological issues such as genetic modification or cloning. They interviewed with ten biology teachers who were previously attended a summer school for implementing new curriculum and their students. The findings revealed that biology teachers' lacked of confidence in handling discussions about social and ethical applications of biotechnology such as genetic modification and cloning. Even both teachers and high school students in their study stressed the importance of including ethical and social dimensions into science classes, the results revealed that teachers lacked of confidence in handling discussions. They explained main reasons of this lacked confidence in handling discussions as lack of knowledge in science content, unfamiliarity with the issue presented and being unsure about students' interests.

The difficulties that Australian and Scottish science teachers faced with were also supported with other studies. For instance, Lazarowitz and Bloch (2005) investigated 30 Israeli high school biology teachers' awareness of societal issues including values, moral, ethical and legal issues when teaching genetics, genetic engineering and molecular genetics by conducting interviews. The researchers analyzed data based on teaching experience, gender and religion. Majority of teachers tended to include Mendelian Genetics as Mendel principles, sex determination, genetic disease and blood types while teaching genetics. Only three teachers included societal issues into their classes while teaching. Overall, the results demonstrated biology teachers' low levels of awareness about societal issues, including bioethical, social and political aspects of molecular biology and genetic engineering. While biology teachers' opinions were not differed based on religious faith and gender, experienced teachers were more eager to teach societal issues to their students. The researchers reported that teachers preferred not to include societal issues in their classes; instead they preferred to prepare their students for the matriculation exams which is a similar finding to Steele and Aubusson's study (2004).

While Lazarowitz and Bloch (2005) did not reveal any difference with respect to gender or religion, Sadler and his colleagues (2006) found differences between male and female teachers' opinions and implementation of controversial issues. While all the female teachers supported the idea of implementation SSIs into science classes, half of them implemented these issues into classes. Whereas five of eight participating male teachers were undecided and showed unwillingness about the importance as well as implementation of these issues implying that females were more eager to implement these issues when compared to male counterparts. In addition, all the teachers in the study expressed the importance of including ethical issues into science classes and raising students as being aware of ethical issues. Even science teachers acknowledged the importance of controversial issues in science classes; they failed to implement these issues into their classes. Moreover, high school and middle school teachers had different opinions regarding implementation of SSIs. For instance, high school teachers preferred to focus on the content knowledge in the curriculum for preparing their students for entrance exams. Likewise, the importance of introducing controversial issues into science classes, have been referred by H. Lee, Abd-El-Khalick and Choi (2006). Studying with 86 Korean science teachers, H. Lee, and her colleagues (2006) investigated science teachers' perceptions about the necessity of introducing SSIs, the impeding factors that prevent them to implement SSIs to science classes and their self-efficacy beliefs regarding teaching SSIs in their classrooms. They used a Likert-type scale to explore science teachers' perceptions about SSI and conducted follow-up interviews with 12 selected teachers for further investigation. Quantitate data analysis revealed that while majority of science teachers strongly believed that SSIs worth to address in their classes, they identified some factors that prevent them to address SSIs in their classes such as lack of time, student maturity, student interest in SSIs or unavailability of materials for classrooms. As they perceived the existence of factors that prevent them from addressing SSIs, they demonstrated low self-efficacy beliefs regarding teaching of these issues. They expressed inadequacy in their content knowledge as well as pedagogical expertise and low confidence in developing materials for teaching these issues. The interview analysis provided supporting evidence for the quantitative data. While teachers most frequently emphasized that SSIs will help their students to make informed decision, more than a quarter perceived addressing SSIs as time consuming.

While H. Lee and colleagues identified some hinderer factors as lack of time, student maturity, student interest, van der Zande, Brekelmans, Vermunt and Warloo (2009) identified another difficulty as making distinction between emotive and rationalistic reasoning for science teachers. The researchers designed a 2-stage study in order to investigate students' reasoning and teachers' considerations while dealing with controversial issues. In Study 1, they interviewed with 15 students (14-15 years) about their reasoning patterns while dealing with controversial issues by using a dilemma. In Study 2, the researchers also interviewed with eight experienced biology teachers about teachers' approaches to moral education and students' moral reasoning. The results of Study 1 indicated that while more than half of the students made decisions based on emotive considerations (53%), 20% of participants used rational considerations and 26% of them used both emotive and rationalistic considerations while dealing with dilemma in the interview. The results of Study 2 revealed that even experienced science teachers noticed the existence of different reasoning skills, they failed to make a distinction between reasoning skills and to choose appropriate skills for addressing different reasoning skills in their classes. They also used different approaches for promoting moral reasoning, but they had difficulty in recognizing and making distinction between emotive and rationalistic reasoning is difficult for both students and teachers.

A more recent study also investigated high school life teachers' concerns and opinions about biotechnology issues which have undeniable effects on issues such as health, food, environment, as well as energy. Borgerding, Sadler and Koroly (2013) conducted semi-structured interviews with 20 high school life science teachers that had attained a two-week summer programmed focusing on biotechnology. Findings revealed a wide range of approaches about biotechnology considering teacher' teaching perceptions, difficulties as well as students' difficulties. One of the major point that was revealed is that even teacher did not teach or include biotechnology issues in their classes (7 teachers indicated that they did not cover biotechnology issues in their classes), all teachers were aware about the importance of biotechnology issues. They were aware of how implementing these issues into their classes will affect their students in terms of career choice, and understanding science and scientific knowledge. They also demonstrated some obstacles that prevent effective implementation of biotechnology issues such as lack of time and materials to be used in classes, and curriculum overload. Also, some teachers were concerned about lack of content knowledge (*n*= 6) that in turn resulted in feeling of inadequacy and anxiety towards biotechnology issues. With respect to teaching experience, novice teachers that they did not prefer to teach biotechnology issues and expressed that they were ill-prepared for effective teaching. On the other hand, experienced teachers felt well-prepared for teaching biotechnology issues. In fact, this finding is also support van der Zande and his colleagues' (2012) findings. Exploring Dutch biology teachers' expertise and needs for teaching genetics focusing on genetic tests, van der Zande et al. (2012) interviewed nine biology teachers about how to teach genetic testing considering pedagogical content (concerning learning process of students), subject matter (entailing knowledge of curriculum) moral (considering controversial issues and their ethical aspects) and interpersonal (contains the ability of teacher's creating a good relationship with students) expertise and they observed lessons of five teachers among them. Results revealed that science teachers held a variety of learning and teaching activities while teaching genetic testing in pedagogical content area. Experienced teachers used more problem based on activities in their lessons.

The literature reviewed above were conducted in various countries as well as in various contexts from stem cell research to cloning. The reviewed studies unveiled various factors such as religious, factors, values and personal factors (Lee & Witz, 2009; Lee et al. 2012), beliefs (Dawson, 2011), content knowledge (van der Zande et al. 2011), ethical, legal and social factors (van der Zande et al. 2012). Overall, the reviewed studies provided empirical evidence that teachers' decision making processes are influenced by multiple factors. In addition, the studies explored how science teachers dealt with various issues in classroom contexts. While several studies indicated that science teachers acknowledged the importance of these issues (Lee et al. 2006; Sadler et al. 2006; van der Zande et al. 2009), other studies reported that they also identified some issues that prevent effective implementation of these issues (Bryce & Gray, 2004; Borgerding et al., 2013; Lazarowitz & Bloch, 2005; Lee et al. 2006; Steele &Aubusson, 2004). Among them, low self-efficacy

(Lee et al., 2006), lack of content knowledge (Bryce & Gray, 2004; Borgerding et al. 2013; Lee et al. 2006; Steele & Aubusson, 2004; van der Zande et al., 2012), external examinations such as state or university entrance exams (Lazarowitz & Bloch, 2005; Steele & Aubusson, 2004), lack of material and time and curriculum overload (Lee et al., 2006; Borgerding et al. 2013) and student difficulties and maturity (Lee et al., 2006; Steele & Aubusson, 2004); and low self-efficacy beliefs about effective teaching of controversial issues (Lee et al. 2006) were reported. Among these issues, content knowledge were frequently examined in different contexts and reported as an important factor for effective implementation of controversial issues into science classes (e.g., van der Zande et al., 2012). Besides, the effect of some background characteristics such as gender, teaching experience and religion were explored. The effects of these characteristics, however, yielded conflicting results. While Lazarowitz and Bloch (2005) revealed no gender difference with respect to teaching societal issues, Sadler and her colleagues (2006) indicated male teacher were more eager to teach these issues in their classes when compared to female teachers. Likewise, there was no consensus in research findings with respect to teaching experience. While studies indicated that experienced teachers tended to teach controversial issues in their classes when compared to their novice counterparts (Borgerding et al., 2013, van der Zande et al., 2009; 2012) some studies revealed that teaching experience in general as well as teaching experience in biology was not related with teachers' implantation of controversial issues (Lazarowitz & Bloch, 2005; Steele & Aubusson, 2004). Lastly, high school teachers tended to acknowledge and try to implement these issues into science classes when compared to middle school teachers (Sadler et al., 2006).

Overall, the reviewed research studies highlighted the importance of investigating multiple factors that influence teachers' decision making processes as well as some background characteristics that might influence science teachers' implementation in many contexts. Therefore, it is needed to conduct a study that investigated both the factors that influence science teachers' decision making as well as the relationship among science teachers' background characteristics, genetics literacy level, attitudes in genetics literacy issues and teaching perceptions. With this respect, this study investigated multiple the effect of background characteristics as gender, teaching experience, content knowledge, self-perceived interest and self-perceived importance in genetics and tried to explain the relationship among background characteristics, genetics literacy levels and attitudes in genetics literacy as well as teaching perceptions. Moreover, it is tried to explain the factors that influence participants' decision making processes that identified in previous studies and investigated the role of these factors by adopting a multi-layer perspective.

2.1.3. Studies focusing on teachers' perceptions of teaching issues in genetics literacy and self-efficacy beliefs regarding genetics literacy

As present study investigated the relationship among science teachers' genetics literacy levels, their attitudes towards various issues in genetics literacy and their teaching perceptions regarding genetics literacy, this part is devoted to the studies focusing on pre-service teachers and in-service teachers' perceptions of teaching about issues in genetics literacy and their self-efficacy teaching beliefs regarding genetics literacy.

In an earlier study, Czerniak and Schriver (1994) explored pre-service teachers' self-efficacy beliefs by using a Likert scale instrument and compared their pedagogical teaching strategies to their self-efficacy scores over two-year period. In first year of study, data collected from a total of 25 pre-service teachers by open-ended and journal type questionnaire. After determining the most and least efficacious teachers, in second year, the most and least efficacious 14 PSTs were interviewed for revealing their teaching strategies. Results revealed that both group of teachers used a variety of teaching strategies such as discussions, experiments, games or hands-on activities. On the other hand, while most efficacious teachers, in general, used student centered activities like simulations, small group discussions, low efficacious teachers preferred teaching from textbooks and using lecturing and demonstrations while teaching. Overall the high efficacious teachers were more eager to help their students to learn science, acknowledged their strengths and weakness. In addition, they were eager to use student centered activities and selected teaching strategies that may help their students while learning science. On the other hand, low efficacious teachers felt uneasy about their teaching abilities to teach science effectively. They frequently stressed other factors for their failure. As a conclusion, the researchers emphasized the importance of self-efficacy in terms of enhancing students' learning in science as self-efficient teachers were frequently used appropriate teaching strategies for enhancing their students' leaning science concepts. The researchers indicated that science educators should aware of self-efficacy construct as it affects students' beliefs and behaviors regarding science.

Schoon and Boone (1998) investigated the relationship between pre-service elementary teachers' teaching efficacy beliefs and the number of alternative conceptions. A total of 619 pre-service teachers were surveyed throughout a survey that measured both science teaching efficacy beliefs and alternative conceptions. The results revealed that the high efficacious PSTs were more knowledgeable in science concepts being assessed by the inventory, and no relationship was revealed between number of alternative conceptions and science teaching efficacy beliefs. Some certain misconceptions such as "planets can be seen only by using a telescope" or "the dinosaurs lived at the same time with cave-man" were found to be associated with low science teaching efficacy beliefs regarding science. The researchers attributed this to the barriers that alternative concepts create in learning process and the students with these alternative misconceptions tended to struggle in understanding scientific knowledge that in turn resulted in developing low self-efficacy beliefs. The researchers suggested the need of focusing pre-service science teachers' alternative conceptions as well as students' misconceptions that may also help developing their self-efficacy beliefs regarding teaching science.

In another study, Roberts, Henson, Tharp and Morena (2001) investigated the role of different length of in-service teacher training programs (2-week, 3-week, 4-week and 6-week) in enhancing teachers' self-efficacy. The results revealed that 2-week and 3-week programs were more successful in terms of increasing self-efficacy scores of teachers who had scored below average. On the other hand, the length of professional training did not seem to influence the teachers' self-efficacy who scored over average. The researchers concluded that in-service training programs were more successful in increasing low efficacious teachers' efficacy scores. As the researchers expected that teachers' efficacy are closely related with students' outcomes, they emphasized the role of in-service training programs for enhancing teachers' self-efficacy beliefs.

In an earlier study, Tekkaya, Cakiroglu and Ozkan (2002) investigated Turkish senior pre-service science teachers' understanding of science concepts and their teaching self-efficacy beliefs regarding science by using science concept test and Science Teaching Efficacy Beliefs (STEBI) form B (*n*= 299). Results revealed that less than half the questions were correctly answered by PSTs implying that PSTs held low level of understanding in science concepts. In addition, misconceptions regarding fundamental concepts in science were revealed. For instance, a great majority reported that "plants respire only at nights" (83%) and "respiration in plants occurs in the leaves (89%). With respect to PSTs' self-efficacy beliefs and outcome expectancies, PSTs gained high scores in STEBI. For instance, a great majority reported they had confidence in effectively teaching science concepts to their students (81%), and that welcomed students' questions during their teaching (86%). The researchers also sought for the relationship among self-efficacy beliefs, number of courses completed and conceptual understanding in science. The results implied that the number of courses completed and having sufficient conceptual understanding in science increased PSTs' personal teaching efficacy beliefs regarding science positively. On the other hand, no difference in outcome expectancy scores were reported with respect to number of courses completed and conceptual understanding in science. The researchers concluded that even science teachers were highly confident in their ability to teach science effectively; they possessed insufficient understanding in science. The researchers suggested that rather than including additional courses to science teacher education programs in universities, the existing courses should focus on alternative conceptions that PSTs held and the ways for remedying them before PSTs start their professions.

In another study, Cantrell, Young and Moore (2003) explored the factors such as gender or extracurricular science activities in high school that affect undergraduate students' efficacy beliefs in science teaching. Different groups [seminar group that enrolled nine semester-hours of science content (*n*= 154), methods group that enrolled six-semester-hour advanced methods course in science, mathematics and technology (*n*= 84), and student teacher group that completed their semester of student teaching experience period (*n*= 54)] were surveyed by using Science Teaching Efficacy Belief Instrument Form B. Result revealed that male seminar group students had higher self-efficacy beliefs in teaching science when compared to females. In addition, the number of extracurricular activities and the years of being involved influenced their self-efficacy beliefs. For instance, the undergraduates who reported they had extracurricular activities over five years had greater self-efficacy beliefs when compared to the students who has 2-4 years of high school experience. Similar pattern was found among method group students as students who reported they had extracurricular activities in high school tended to have higher self-efficacy beliefs in teaching science. On the other hand, no gender difference was revealed among method group students. No difference with respect to gender and number of activities in high school were revealed for pre-service teachers group. The researchers concluded that being involved in extracurricular activities like being a judge in science fairs, giving assistance to students in Science Olympiads or being a volunteer in a science related club lead an increase in participants' self-efficacy teaching beliefs in science teaching. In addition, the time for teaching science to the students also was found to be an influencing factor. The participants who reported have teaching experience tended to have higher self-efficacy beliefs. The researcher concluded that undergraduate courses that provides effective strategies and teaching experiences of undergraduate students are important for improving students' personal teaching efficacy beliefs regarding science.

In a more recent study, Sahin, Isiksal and Ertepinar (2010) explored Turkish elementary school teachers' self-efficacy beliefs in science teaching and the factors that influence their self-efficacy beliefs (*n*= 197). Results revealed that elementary teachers held favorable self-efficacy beliefs in science teaching. For instance, a great majority indicated that they understood science concepts well enough to teach science effectively (90%) and indicated their confidence in both understanding and teaching science concepts to their students (89%). With respect to gender and school type (private or public school), only school type was found to be a significant factor affecting elementary teachers' self-efficacy beliefs. Teachers working in private schools seemed to have higher self-efficacy beliefs when compared to teachers working in public schools. The researchers attributed the difference in school type to the opportunities provided to private school teachers such as instructional materials and technological support. They, on the other hand, suggested that the reasons why teachers working in public schools had lower self-efficacy beliefs should be further investigated.

While Sahin and her colleagues (2010) explored the role gender and school type on PSTs' self-efficacy beliefs, Aydin and Boz (2010) explored PSTs' sources of their science teaching efficacy beliefs in addition to self-efficacy beliefs. The statistical analysis indicated that there was difference with respect to grade level in self-efficacy scores and outcome expectancy scores. While seniors had highest personal self-teaching efficacy beliefs mean scores, juniors had the lowest scores. Pre-service teachers' self-efficacy sources were explores by semi-structured interviews. While mastery experience (teaching in school experience course, giving private lessons or teaching to peers/students/siblings) was most common source reported by PSTs (*n*= 14), vicarious experience (referring their teachers who had taught them in past or observations of other peers in school experience) was the second important source (*n*= 8) followed by social persuasion (*n*= 1). The researchers attributed the increase in self-efficacy and outcome expectancy scores as senior students had highest scores to the number of courses completed. As senior students completed a number of courses that might help to gain more experience with respect to teaching, they might develop higher self-efficacy beliefs. The interviews also supported their conclusion as the most referred source for self-efficacy was mastery experience reported by PSTs. The researchers emphasized the importance of method course that provides effective activities and the possibility for gaining teaching experience for helping PSTs to develop effective teaching efficacy beliefs regarding science.

While Sahin et al.'s (2010) and Aydin and Boz's (2010) studies focused on PSTs' general science efficacy beliefs, Sonmez and Kilinc (2012) specifically focused on PSTs' self-efficacy beliefs about teaching genetically modified foods. They investigated Turkish pre-service science teachers' knowledge, risk perceptions and attitudes about genetically modified foods (GM foods) as well as their self-efficacy beliefs about teaching GM foods (n= 161). Results revealed that pre-service science teachers were well-informed about GM foods. In terms of self-efficacy beliefs about teaching GM foods, even they seemed to have moderate self-efficacy beliefs about teaching GM food, they acknowledged the existence of some hinderers. For further analysis, the researchers explored the factors (knowledge, risk perceptions and attitudes about GM foods, age, gender, preparing project and joining science Olympiads) that affect PSTs' self-efficacy beliefs by using step-wise regression model. The statistical analysis revealed that only knowledge in GM foods and joining science Olympiads influenced PSTs' self-efficacy beliefs. While knowledge explained 8% variance in PSTs' self-efficacy beliefs, joining a joining science Olympiad explained only 4% of variance. The researchers concluded that educating PSTs about GM foods as well as SSI will enhance students' ability to discuss controversial issues in their classroom environment. They also suggested that even risk perceptions and attitudes about GM food did not found to be influencing factors for self-efficacy beliefs of PSTs, these factors need to be further explored as they influence teachers' positions while dealing with GM foods.

In a more recent study, Fonseca, Costa, Lencastre and Tavares (2012) explored Portuguese secondary biology teachers' beliefs about teaching biotechnology issues and the relationship between their beliefs and biotechnology teaching (n= 97) by administrating a quantitative survey consisting of four biotechnology issues as classical applications, genetically modified organisms, gene therapy and human. The statistical analysis revealed that biology teachers perceived biotechnology as interesting and important to teach. With respect to their competence of teaching biotechnology, teachers showed interest in attaining workshop related to biotechnology for equipping themselves and updating their knowledge regarding biotechnology issues. Even teachers acknowledged the students' interest in biotechnology, the highlighted the curriculum restrictions that limits their teaching of biotechnology issues. The researchers highlighted the importance of teacher training programs for both pre-service and in-service teachers for improving teachers' teachers' beliefs about biotechnology.

To sum up, the studies focusing on PSTs' and science teachers' teaching perceptions and self-efficacy beliefs focused on many issues. While earlier studies identified the characteristics of high and low efficacious teachers' characteristics (Czerniak & Schriver, 1994), they revealed that high efficacious teachers were tended to adopt a wide range of student centered activities like simulations or small group discussions in order to enhance their students' learning in science. In addition, Schoon and Boon's (1998) study determined that low efficacious teachers tended to hold more alternative misconceptions. This finding was also supported by Tekkaya et al.'s (2002) study in Turkish context. Moreover, while some studies reported that extracurricular activities and school type (public or private) were found to be enhancing teachers' self-efficacy beliefs (Cantrell et al. 2003; Sahin et al. 2010; Sonmez & Kilinc, 2012), gender was not found to be associated with teachers' self-efficacy beliefs. As a common finding, all the studies emphasized the role of undergraduate courses such as method courses and in-service training programs in enhancing pre-service teachers' self-efficacy beliefs.

CHAPTER III

METHOD

In this chapter, method of the present study was explained in detail. The chapter is divided into six sections as general research design, participants, instrumentation, data collection procedure, data analysis, trustworthiness and finally, assumptions and limitations of the study. The chapter begins with general description of the research design used in present study design and its rationale. Then, in participant section, sampling procedure of quantitative part study and participant selection of qualitative part of study was explained followed by instrumentation. In this section, instruments used in present study, namely, teacher demographic information scale, Genetics Literacy Assessment Scale, Attitudes towards Issues in genetics literacy Scale, Perceptions of Teaching Issues in genetics literacy Scales and lastly, Decision-Making Interview were explained in detail. In data collection part, the procedures utilized during data collection was described. This section was followed by data analysis section. In this section, quantitative and qualitative data analyses procedures were elucidated. In addition, description of codes, categories in code book and sample quotations illustrating codes and categories used in present study were described in qualitative data analysis part. In following part, trustworthiness of study was explained under validity of study, reliability of study and ethical issues headings. Lastly, the assumptions and limitations of current study was presented.

3.1. General Research Design and Rationale

The main purpose of this study was to investigate middle school science teachers' (a) genetics literacy levels, (b) attitudes towards issues in genetics literacy and (c) perceptions of teaching issues in genetics literacy. Possible relationships among science teachers' genetics literacy levels, attitudes, teaching perceptions and various demographic characteristics were also explored. Moreover, factors that influence science teachers' decision making processes were examined.

Based on these purposes, the current study was designed as mixed method design which consists of both quantitative and qualitative data collection methods in a single study in order to obtain deeper understanding phenomenon (Creswell & Plano-Clark, 2011; Fraenkel, Wallen, & Hyun, 2011). In present study, *sequential explanatory design*, a type of sequential design was adopted. In *sequential explanatory design*, only quantitative data is collected and analyzed in first stage and qualitative data was collected and analyzed in second stage for the purpose of exploring and elaborating the quantitative results (Creswell, Plano-Clark, Gutmann & Hanson., 2003; Creswell, 2009; Creswell, 2012; Fraenkel et al., 2011). While quantitative data and results derived from quantitative data present a general picture of the research problem, qualitative data analysis is used for explaining the general picture in a more detailed way (Creswell, 2012; p. 542).

As this study was designed as *sequential explanatory design*, the data were collected in two stages: In first stage, quantitative data were collected by administration of instruments namely Genetics Literacy Assessment Inventory (GLAI), Attitudes towards Issues in Genetics Literacy Scale (ATIGLS) and Perceptions of Teaching Issues In Genetics Literacy Scale (PTIGLS) to a sample of middle school science teachers for exploring relationships among science teachers' genetics literacy levels, their attitudes towards issues in genetics literacy and their perceptions of teaching issues in genetics literacy. In second stage, qualitative data were collected from selected middle school science teachers through semi-structured interviews to support the data collected quantitatively to explore the factors that influence science teachers' decision making processes in a detailed way.

The visual model of research design, outlining each stage of the research process and the methods used to collect data and to analyze data is presented 3.1.

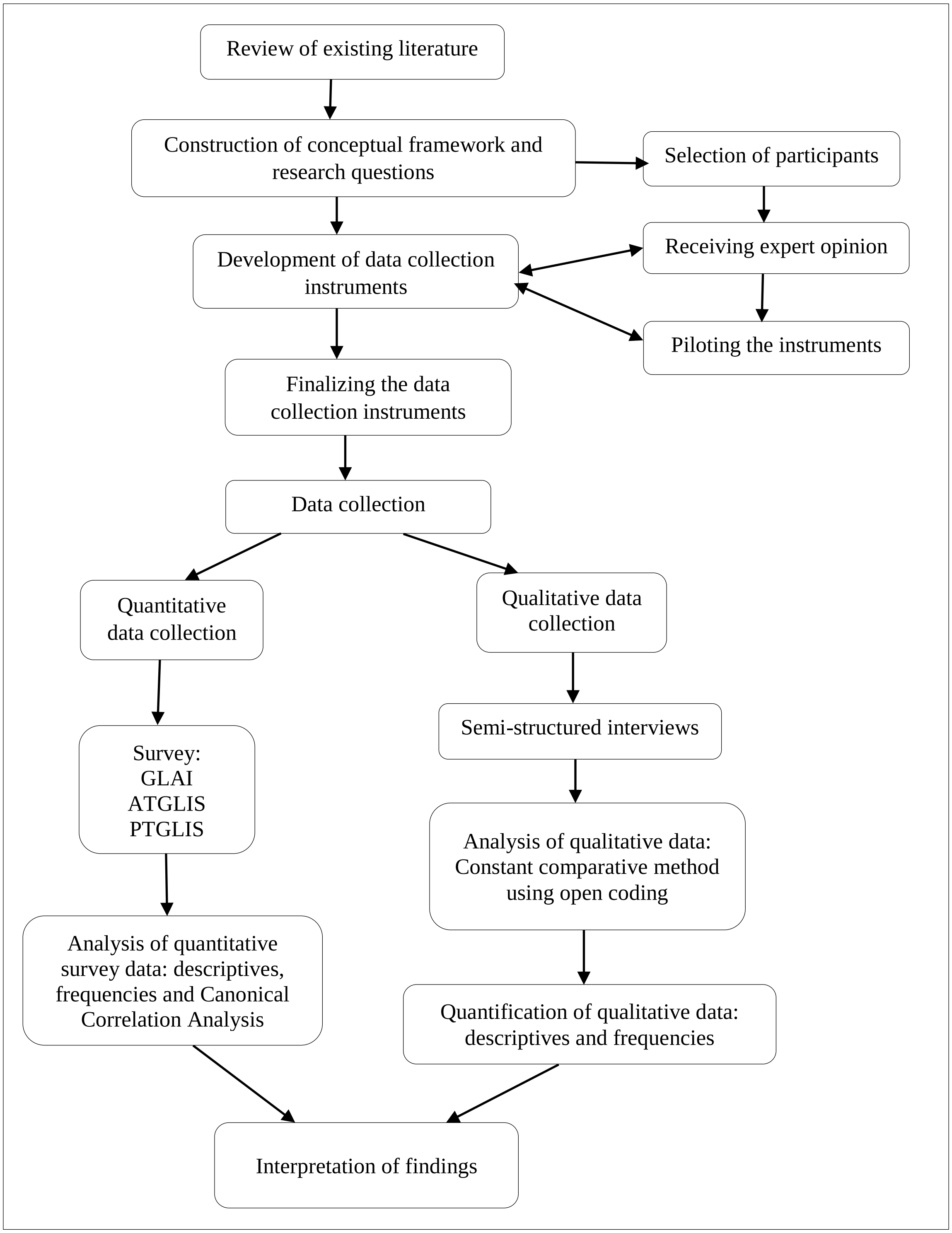

Figure 3.1 Visual model of research design, outlining each stage of research process

As seen in Figure 3.1, the present study started with the review of the related literature regarding genetics and issues in genetics literacy. Based on the review, conceptual framework of the study and research design was constructed. After the determining participants of the study, the data collection tools including questionnaires and interview protocols were developed. Then, the expert opinions were received, and necessary changes were made. The data collection instruments were finalized subsequent to pilot analysis. The data collection procedure was carried out in two phases. In the first phase, quantitative data collected throughout the administration of the Genetics Literacy Assessment Inventory (GLAI), Attitudes towards Issues in Genetics Literacy Scale (ATIGLS) and Perceptions of Teaching Issues in Genetics Literacy Scale (PTIGLS). Later, the data was analyzed by using descriptive statistics (i.e., frequencies) and inferential statistics (i.e., Canonical Correlation Analysis). In the second phase, qualitative data were gathered by semi- structured interviews. The aim of conducting interviews was to explore the factors that influence science teachers' decision making processes in order to support quantitative results of present study. The qualitative data were analyzed by using open coding, and then findings were quantified and presented by using descriptive statistics and frequencies. Lastly, the data obtained from both qualitative and quantitative data analyses were interpreted together.

3.2. Participants

In accordance with the nature of *sequential explanatory design*, two sampling procedures were unitized in this study. First, sampling procedure included for quantitative part of the study was explained. Then, selection of participants for qualitative part was described.

3. 2. 1. Sampling procedure of quantitative part of study

In present study, cluster random sampling procedure was utilized. In this sampling procedure, schools were randomly selected as clusters. Thus, the teachers in selected schools constituted the sample of current study. The target population of this study was all middle school science teachers in Ankara. There are a total of 515 public middle schools in 25 districts of Ankara according to the 2012-2013 Education Statistics report (Education Statistics of Ankara for 2012-2013). Out of 25 districts, six districts were accepted as the accessible population of present study. 272 middle schools were found in 6 districts (Education Statistics of Ankara for 2012-2013). 200 schools were reached by the researcher due to time and accessibility constraints (see Table 3.1).

Table 3.1

Number of Middle Schools and Teachers in Each School

Districts	Total Number of Middle Schools	Number of Middle Schools	Total number of teachers
Sincan	43	39	106
Etimesgut	29	26	38
Kecioren	52	43	97
Mamak	51	36	83
Cankaya	56	33	60
Altindag	41	23	51
Total	272	200	435

Of 200 schools visited, 435 science teachers participated voluntarily in the quantitative part of the study. Characteristics of teachers who participated in the study are presented in Table 3.2. Briefly, majority of teachers were reported to be female (74.5%), and the rest were male (25.5%). In terms of teaching experience, nearly a quarter reported to have a teaching experience of 1 to 5 years (24.4%). A close percentage had a teaching experience of 6-10 years (20.9%). While 15.9% of science teachers had 11-15 years teaching experience, nearly 10% had less than 1 years of experience. Moreover, 14.7% of teachers who had 16-20 years teaching experience and 14.2% of then had more than 20 years teaching experience. As far as their education background was considered, majority of science teachers were graduated from Education Faculties (69%). A quarter reported to graduate from Faculties of Arts and Sciences (25.1%) and declared they had teaching certificate. Only 5.5% were graduated from Institutes of Education. Lastly, less than 1% of participants declared that they were graduated from faculties of engineering. These teachers also reported to have a teaching certificate. Regarding science teachers' majors, majority of science teachers (75.2%) have possessed a college degree in science education. 14.5% of teachers have a college degree in biology education. While 7.3% of teachers have a college degree in chemistry education degree, only 3% have physics education degree.

Table 3.2

Science Teachers' Demographic Characteristics

Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	111	25.5
Female	324	74.5
Teaching experience		
Less than 1 year	43	9.9
1-5 years	106	24.4
6-10 years	91	20.9
11-15 years	69	15.9
16-20 years	64	14.7
More than 20 years	60	14.2

Table 3.2 (Continued)

Characteristics	Frequency (n)	Percentage (%)
Graduated program		
Faculty of Education	300	69.0
Faculty of Arts and Sciences	109	25.1
Institutes of Education	24	5.5
Faculty of Engineering	2	0.4
Major		
Science education	327	75.2
Biology education	63	14.5
Physics education	13	3.0
Chemistry education	32	7.3

3.2.2. Selection of participants for qualitative part of study

Stratified purposive sampling method was utilized in qualitative part of this study. In this sampling strategy, researcher identifies subgroups within a population and select cases from subgroups in a purposive manner (Teddlie & Tashakkori, 2009; p. 186). In present study, groups were constructed based on science teachers' teaching experience in order to reach diverse groups of teachers. Three groups were constructed as Group 1, Group 2 and Group 3. Teachers with 2-5 year teaching experience were grouped as Group 1, teachers with 6-10 year teaching experience were grouped as Group 2 and lastly, teacher with more than 10 year teaching experience were grouped as Group 3. Based on the created groups, the science teachers who completed the instruments were invited to participate the interviews. The researcher tried to reach equal number of teachers in each group. She, however, was able to reach more teachers in Group-2 when compared two other two groups because of voluntary participation of teacher. Accordingly, semi-structured interviews were conducted with 18 science teachers. The number of teachers in each group was presented in Table 3.3.

Table 3.3

The number of teachers in each group

Groups	Number of participants (N)
Group 1 (2-5 years)	5
Group 2 (6-10 years)	8
Group 3 (more than 10 years)	5
Total	18

Out of 18 science teachers, 13 (72.3%) were female and five (27.7%) were male science teachers. Their teaching experience ranged from two years to 15 years. While majority of science teachers (66.7%) have possessed a degree in science education, 33.3% of teachers have a college degree in biology education. The length of interviews ranged from 45 minutes to 75 minutes. The characteristics of participating science teachers in each group are given in Table 3.4.

Table 3. 4

The Characteristics of Science Teachers and Duration of Interviews

Participant	Gender	Teaching Experience	Major	Duration of interview
P1	Male	12 years	Science teacher	55 minutes
P2	Female	11 years	Biology teacher	62 minutes
P3	Female	8 years	Science teacher	50 minutes
P4	Female	15 years	Biology teacher	60 minutes
P5	Male	9 years	Science teacher	45 minutes
P6	Female	14 years	Biology teacher	30 minutes
P7	Female	15 years	Biology teacher	45 minutes
P8	Female	7 years	Science teacher	45 minutes
P9	Male	8 years	Science teacher	60 minutes

Table 3. 4 (Continued)

Participant	Gender	Teaching Experience	Major	Duration of interview
P10	Female	4 years	Science teacher	45 minutes
P11	Female	2 years	Science teacher	59 minutes
P12	Male	2 years	Science teacher	48 minutes
P13	Male	7 years	Science teacher	75 minutes
P14	Female	6 years	Science teacher	55 minutes
P15	Female	5 years	Biology teacher	60 minutes
P16	Female	8 years	Science teacher	46 minutes
P17	Female	3 years	Biology teacher	45 minutes
P18	Female	7 years	Science teacher	60 minutes

3.3. Instrumentation

In this section, quantitative and qualitative data collection tools were explained in detail. In first part, quantitative data collection tools as Teacher Demographic Information Scale, Genetics Literacy Assessment Inventory (GLAI), Attitudes towards Issues in Genetics Literacy Scale (ATIGLS) and Perceptions of Teaching Issues in Genetics Literacy Scale (PTIGLS) were elucidated. In second part, qualitative data collection tools, namely, Decision-Making Interview (DMI) were elucidated.

3.3.1. Quantitative Data Collection Tools

3.3.1.1. Teacher demographic information scale

Teacher demographic information scale consists of eight items regarding science teachers' background characteristics as gender, major, graduated program type, earning teaching certificate (only for teachers graduated from a non-teacher education program), years of experience in teaching profession, self-perceived knowledge in genetics, self-perceived interest in genetics and source of information where they learn about issues in genetics literacy (See Appendix E).

3.3.1.2. Genetics Literacy Assessment Inventory (GLAI)

This section consisted of three parts. In the first part, information regarding the dimensions, reliability and validity issues of the original version of Genetic Literacy Assessment Inventory was presented. Second part included translation and adaptation process of the instrument, followed by statistical procedures utilized in pilot study and later in main study were explained in detail for ensuring validity and reality of Turkish version of the Genetic Literacy Assessment Inventory.

3.3.1.2.1. Original version of Genetics Literacy Assessment Inventory

The Genetics Literacy Assessment Inventory is a self-report questionnaire developed by Bowling and her colleagues (2008) to assess undergraduate non-biology majors' genetics literacy levels. It originally consisted of 31 multiple-choice items under six dimensions. Dimensions and the subconcepts being assessed in each dimension and number of questions in dimensions is presented in Table 3.5.

Table 3.5

Dimensions of Original Version of Genetics Literacy Assessment Inventory (Bowling et al. 2008)

Dimensions	Subconcepts	Number of Questions
Nature of Genetic Material	Properties of DNA, DNA-gene-chromosome interactions, gene activity and description of genetic variation	8
Transmission	Mendelian patterns of inheritance and meiosis	4
Gene Expression	Functions of genes in protein synthesis, multiple genes, and disorders related with multiple genes	6
Gene Regulation	Genetic variations that result in diseases such as Huntington disease and turn on and turn of genes in gene regulation	4

Table 3.5 (Continued)

Dimensions	Subconcepts	Number of Questions
Evolution	Genetic variation as the basis of evolution, genetic variations in the human ethnic groups and natural selection	3
Genetics-Society	Science-ethic-genetics concerns and current-future applications of genetics and genetics technologies	6

Bowling et al. (2008) explored the content and discriminant validity evidences for the original form of the instrument. For ensuring content validity, the items of the GLAI were reviewed by genetic professionals in terms of understandability and suitability. Their feedback was used in revising items in the GLAI and finalizing the instrument. For ensuring discriminant validity of instrument, they compared the GLAI scores of 395 undergraduate students enrolled in introductory genetics courses, 113 students in a psychology course, and 23 graduate students from specialized fields of genetics by using an analysis of variance test with a Games–Howell post hoc analysis and reported that the instrument was able to distinguish among the groups that it that it theoretically should be able to distinguish. In addition, researchers also explored internal validity evidences by using a test-retest procedure and reported a Pearson correlation as 0.68 (Bowling et al., 2008).

3.3.1.2.2. Turkish version of Genetics Literacy Assessment Inventory

This section is divided into two parts. In the first part, translation and adaptation process of the GLAI was described. Second part consisted of detailed information about ITEMAN analysis results with pilot study data and confirmatory factor analysis results with main study data.

For translation and adaptation of the GLAI, required permissions were taken from the developers via e-mail (See Appendix A). As Hambleton (2005) indicated when adapting an instrument from one language into another language, basic translation procedures may not provide equivalence between original and translated version of test. Instead of basic translation from one language to another language, *test adaptation* considering cultural, psychological and linguistic equivalence in a second language is needed (Hambleton, 2005; 1993). Thus, during translation process, Turkish cultural context was taken into consideration. During this process, *forward translation* that requires adaptation the test from source language to another language by a translator was used (Hambleton, 2005; p.12). The GLAI was translated from English language into Turkish by researcher and a science education professor. There were two items reflecting American regulations in original instrument. These two items were not suitable for Turkish culture and were replaced with two questions reflecting Turkish legal regulations according to Human Rights and Biomedical legislation that was enacted in 2003. As there were only three questions in evolution dimension of original instrument, additional four items from *Evolution Content Knowledge Test* (Rutledge & Warden, 2000) were added to the inventory for ensuring content validity of this dimension (item number 33 to 36). Accordingly, the modified version of GLAI consisted of 36 multiple choice items. After the translation process had completed, the original and translated versions along with the attitude and perception scales utilized in present study were checked by English language experts at Middle East Technical University Academic Writing Center. Then, another researcher who has expertise in biology education, as well as science education checked for the equivalence of the original and translated versions of the instrument. Necessary revisions were made in the light of their suggestions. Finally, a third researcher who has expertise in biology, specifically in genetics, reviewed the items in the instrument. In accordance with the comments from third researcher, the necessary revisions were made in items, and the instrument became ready for pilot study.

The instrument was initially was pilot tested with 95 science teachers. For pilot study, Turkish version of GLAI was administrated 95 science teachers. Of the sample, 63 (66.32%) were females, and 32 (33.68%) were males. Majority of science teachers (72.6%) have possessed a college degree in science education, and 14.5% of teachers have possessed a college degree in biology education. In terms of teaching experience, majority of the teachers (45.3%) had 2-5 years of teaching experience followed by 1 year teaching experience (26.3%). About 14.7% of participants reported having 6-10 years teaching experience, and only a small percentage had more than 10 years teaching experience (13.7%).

In following sections, results obtained from ITEMAN analysis were presented.

3.3.1.2.2.1. ITEMAN analyses results for GLAI with pilot study data

The data obtained from pilot study were examined by using ITEMAN item analysis program for determining item discrimination and item difficulty indexes of each item in order to investigate the contribution of each item to the reliability of instrument. ITEMAN analysis provides item analysis statistics (e.g., item discrimination index, item difficulty index) for each item as well as statistical indicators (e.g., mean, standard deviation, reliability) of a test as a whole (ITEMAN User Manual, ND). Item discrimination index (D) is a parameter that is used for dichotomously scored items for the purpose of discriminating the examinees who know the subject from those who do not (Crocker & Algina, 1986, p. 314). Based on the Ebel (1965)'s criterion, the items that have discrimination indexes lower than 0.19 should be eliminated from the test. According to ITEMAN analysis results, four items had discrimination indexes less than 0.19 ($D1= 0.10$, $D3=0.11$, $D4=0.04$, $D21=0.11$ and $D34=0.13$). Thus, these four items were removed from the instrument (See Table F.1 in Appendix F for item discrimination and item difficulty indexes of each item). The rest of items had discrimination indexes ranging from 0.21 to 0.53 with an average of 0.33 indicating the inventory was constructed by reasonably good questions (Ebel & Frisbie, 1986). In next step, item difficulty indexes of each item were examined. Item difficulty index is a parameter that refers to proportions of examines who answered the item correctly. It may take a value ranging from 0.00 (any of students answered the item correctly) to 1.00 (all students answered the item correctly) (Crocker & Algina, 1986, p. 311-312; Oosterhof, 2001; p. 176). The items in the GLAI had item difficulty indexes ranging from 0.25 to 0.86 with an average of 0.55 indicating a medium difficulty. As stated by Oosterhof (2001), a test with a medium difficulty and had a discrimination index higher than 20% is considered as a good test. Accordingly, the final form of the GLAI included 31 items. The reliability coefficient computed by Kuder Richardson-20 (KR-20) was found to be .75. The reliability coefficients higher than .70 are recommended as a rule of thumb by Fraenkel, Wallen and Hyun (2011; p.157). Thus, the reliability coefficient obtained from pilot study is considered as good.

After ITEMAN analyses in the pilot study, the 31-item Genetics Literacy Assessment Inventory (See Appendix F) was administrated to 435 middle school science teachers. Confirmatory factor analysis was performed in order to test hypothesized factor structures. Firstly, data were screened through descriptive statistics. Then, confirmatory factor analysis was performed for each dimension of the instrument to test the model fit to the data.

3.3.2.2.2. Confirmatory factor analyses for Genetics Literacy Assessment Inventory with main study data

In this section, the confirmatory factor analyses results with main study data were explained. Specifically, data screening with main study data, the statistical procures utilized in Confirmatory Factor Analysis were described. Furthermore, confirmatory factor analyses results with each dimension as well as with the overall instrument were elucidated.

3.3.2.2.2.1. Data screening with main study data

The minimum and maximum values, standard deviations, skewness and kurtosis values and range for the items in the instrument that will be subjected to confirmatory factor analysis were inspected through descriptive statistics. The minimum and maximum values, means and standard deviations of each item were reasonable. Skewness values ranged from -2.320 to 1.948 and kurtosis values ranged from -2.008 to 2.399 that are lower than the supposed value of 3.00 indicating there is no violation of univariate normality (Pallant, 2007). There were no missing cases in data. Thus, any replacement methods were used in analysis. Descriptive statistics of each item were presented in Table F.2 in Appendix F.

3.3.2.2.2.2. Confirmatory factor analyses results for Genetics Literacy Assessment Inventory

The GLAI was composed of dichotomously scored items and thus, the data obtained from administration of GLAI was ordinal. Therefore, when performing confirmatory factor analysis, an appropriate estimation method for ordinal data should be used. There are various estimation methods such as instrumental variables method (IV), two stage least squares (TSLS), Unweighted Least Squares (ULS), Generalized Least Squares (GLS), Maximum Likelihood (ML), weighted least squares (WLS), and diagonal weighted least squares (DWLS) (Byrne, 2012; Tabachnick & Fidell, 2013). Among them, the Diagonally Weighted Least Squares (DWLS) estimation method is used when the multivariate normality assumption is violated and/or the data are ordinal. It provides more accurate parameter estimates and uses polychoric correlation matrix of variables (Mindrila, 2010; Schumacker & Beyerlin, 2000). As the data obtained in present study is composed of ordinal items, the DWLS estimation procedure was used in confirmatory factor analysis.

In order to investigate how well the items in the GLAI fit to proposed 6 dimensions as nature of genetic material, transmission, gene expression, gene regulation, evolution and genetics and society confirmatory factor analyses with Diagonally Weighted Least Squares (DWLS) were conducted by using LISREL 8.8 (Jöreskog & Sörbom, 2007). It has been recommended to investigate the identification of individual constructs which might cause a problem for overall model fit (Hair, Black, Babin, & Anderson, 2010). Thus, before assessing overall model fit, confirmatory factor analysis for each individual construct was conducted.

3.3.2.2.2.2.1. Confirmatory factor analyses with nature of genetic material dimension

According to confirmatory factor analyses results, the chi-square test was found to be significant ($\chi^2_{(14)}$= 30.02, *p*< .05). However, as chi-square test is sensitive to sample size (Jöreskog & Sörbom, 2007; Kline, 2005; Tabacnick & Fidell, 2013; p. 700), relative/normed chi-square (χ^2/df) were suggested for decreasing the impact of sample size on chi-square. Although there is no consensus on the acceptable ratio for normed chi square as Hooper, Coughlan and Mullen (2008) indicated, the recommendations of this ratio range from 2 to 5 as an indicator of reasonable fit (Marsh & Hocevar, 1985; Tabacnick & Fidell, 2013; p. 720). This value was computed as 2.14 in this study indicating a reasonable fit. Besides, various fit indices were used for assessing model fit. Fit indices (RMSEA= .054, CFI= .94, SRMR= .80, and GFI= .98) suggested a good fit. All items loaded on intended factor namely nature of genetic material. Completely standardized solutions (Lambda-x estimates) for latent factor of nature of genetic material were presented in Table 3.6.

Table 3.6

Lambda-x estimates for nature of genetic material dimension

Dimension	Indicator	Lambda-X
	It_2	0.33
	It_5	0.25
	It_6	0.36
Nature of genetic material	It_10	0.31
	It_12	0.50
	It_13	0.49
	It_18	0.43

Note: “It_2” represents the 2nd item in the GLAI

3.3.2.2.2.2.2. Confirmatory factor analyses with transmission dimension

Based on confirmatory factor analyses results, the chi-square test was not found to be significant ($\chi^2_{(2)}$= 2.86, *p*> .05). Rest of fit indices (RMSEA= .031, CFI= 1.00, SRMR= .03, and GFI= 1.00) suggested a good fit. All the items loaded on intended factor as transmission. Completely standardized solutions (Lambda-x estimates) for latent factor of transmission were presented in Table 3.7.

Table 3.7

Lambda-x estimates for transmission dimension

Dimension	Indicator	Lambda-X
	It_3	0.77
	It_4	0.73
Transmission	It_24	0.60
	It_26	0.67

Note: "It_3" represents the 3rd item in the GLAI

3.3.2.2.2.2.3. Confirmatory factor analyses with gene expression dimension

Based on confirmatory factor analyses results, the chi-square test was not found to be significant ($\chi^2_{(2)}$= 4.74, *p*> .05). Fit indices (RMSEA= .056, CFI=.96, SRMR= .05, and GFI= 1.00) suggested a good fit. All the items loaded on intended factor namely gene expression. Completely standardized solutions (Lambda-x estimates) for latent factor of gene expression were presented in Table 3.8.

Table 3.8

Lambda-x estimates for gene expression dimension

Dimension	Indicator	Lambda-X
	It_1	0.30
	It_15	0.69
Gene expression	It_19	0.70
	It_21	0.33

Note: "It_1" represents the 1st item in the GLAI

3.3.2.2.2.2.4. Confirmatory factor analyses with gene regulation dimension

Confirmatory factor analyses results indicated that the chi-square test was not significant ($\chi^2_{(2)}$= 2.09, p> .05). Fit indices (RMSEA= .01, CFI=1.00, SRMR= .03, and GFI= 1.00) suggested a good fit. All the items loaded on intended factor namely gene regulation. Completely standardized solutions (Lambda-x estimates) for latent factor of gene regulation were presented in Table 3.9.

Table 3.9

Lambda-x estimates for gene expression dimension

Dimension	Indicator	Lambda-X
	It_7	0.58
	It_9	0.57
Gene regulation	It_16	0.27
	It_17	0.61

Note: "It_7" represents the 7th item in the GLAI

3.3.2.2.2.2.5. Confirmatory factor analyses with evolution dimension

According to the confirmatory factor analyses results, the chi-square test was not found to be significant ($\chi^2_{(9)}$= 9.91, *p*> .05). Even fit indices (RMSEA= .015, CFI=.99, SRMR= .056, and GFI= .99) suggested a good fit, all the items did not load on evolution. The completely standard solution of item 30 and item 31 were found to be very low indicating that these two items did not explain the dimension well (See Table 3.10 for Lambda-x estimates). Thus, these two items were removed from the dimension.

Table 3.10

Lambda-x estimates for evolution dimension (6 items)

Dimension	Indicator	Lambda-X
	It_11	0.47
	It_20	0.38
Evolution	It_22	0.54
	It_29	0.28
	It_30	0.04
	It_31	0.04

Note: "It_11" represents the 11^{th} item in the GLAI

After the removal of two item (item 30 and item 31), confirmatory factor analysis was repeated with rest of items. Confirmatory factor analyses results indicated that the chi-square test was not significant ($\chi^2_{(2)}$= 1.07, *p*> .05). Fit indices (RMSEA= .00, CFI=1.00, SRMR= .25, and GFI= 1.00) suggested a good fit. All the items loaded on evolution dimension. Completely standardized solutions (Lambda-x estimates) for latent factor of evolution were presented in Table 3.11.

Table 3.11 Lambda-x estimates for evolution dimension (4 items)

Lambda-x estimates for evolution dimension (4 items)

Dimension	Indicator	Lambda-X
	It_11	0.48
	It_20	0.36
Evolution	It_22	0.55
	It_29	0.21

Note: “It_11” represents the 11th item in the GLAI

3.*3.2.2.2.2.6. Confirmatory factor analyses with genetics and society dimension*

Confirmatory factor analyses results indicated that the chi-square test was not significant ($\chi^2_{(9)}$= 11.18, *p*> .05). Fit indices (RMSEA= .024, CFI=.99, SRMR= .059, and GFI=.99) suggested a good fit. All the items loaded on genetics and society dimension. Completely standardized solutions (Lambda-x estimates) for latent factor of genetics and society were presented in Table 3.12.

Table 3.12

Lambda-x estimates for genetics and society dimension (6 items)

Dimension	Indicator	Lambda-X
	It_8	0.24
	It_14	0.37
Genetics and society	It_23	0.36
	It_25	0.77
	It_27	0.67
	It_28	0.23

Note: “It_8” represents the 8th item in the GLAI

In the following part, confirmatory factor analyses results with overall Genetics Literacy Assessment Inventory were described and a model fit for the Inventory was provided.

3.3.2.2.2.2.7. Confirmatory factor analyses with Genetics Literacy Assessment Inventory

After elimination of two items from evolution dimension, the 29-item GLAI (See Appendix X) was subjected to confirmatory factor analysis to hypothesize overall factor structures. The chi-square test was found to be significant ($\chi^2_{(362)}$= 502.97, p< .05). Instead of using chi-square statistics, normed chi-square (χ^2/df) was used for assessing overall model fit. Normed chi-square value was computed as 1.38. This value is below the suggested normed chi-square value of 2 as an indicator of a good fit that is proposed by Tabanchnik and Fidell (2013; p. 720). Besides, various fit indices were used for assessing model fit. Besides, other fit indices (RMSEA= .03, CFI= .98, SRMR= .80, and GFI= .95) suggested a good fit. All the items loaded on hypothesized factors namely nature of genetic material, transmission, gene expression, gene regulation evolution, and genetics and society. The model fit of the genetics literacy assessment inventory was presented in Figure 3.3.

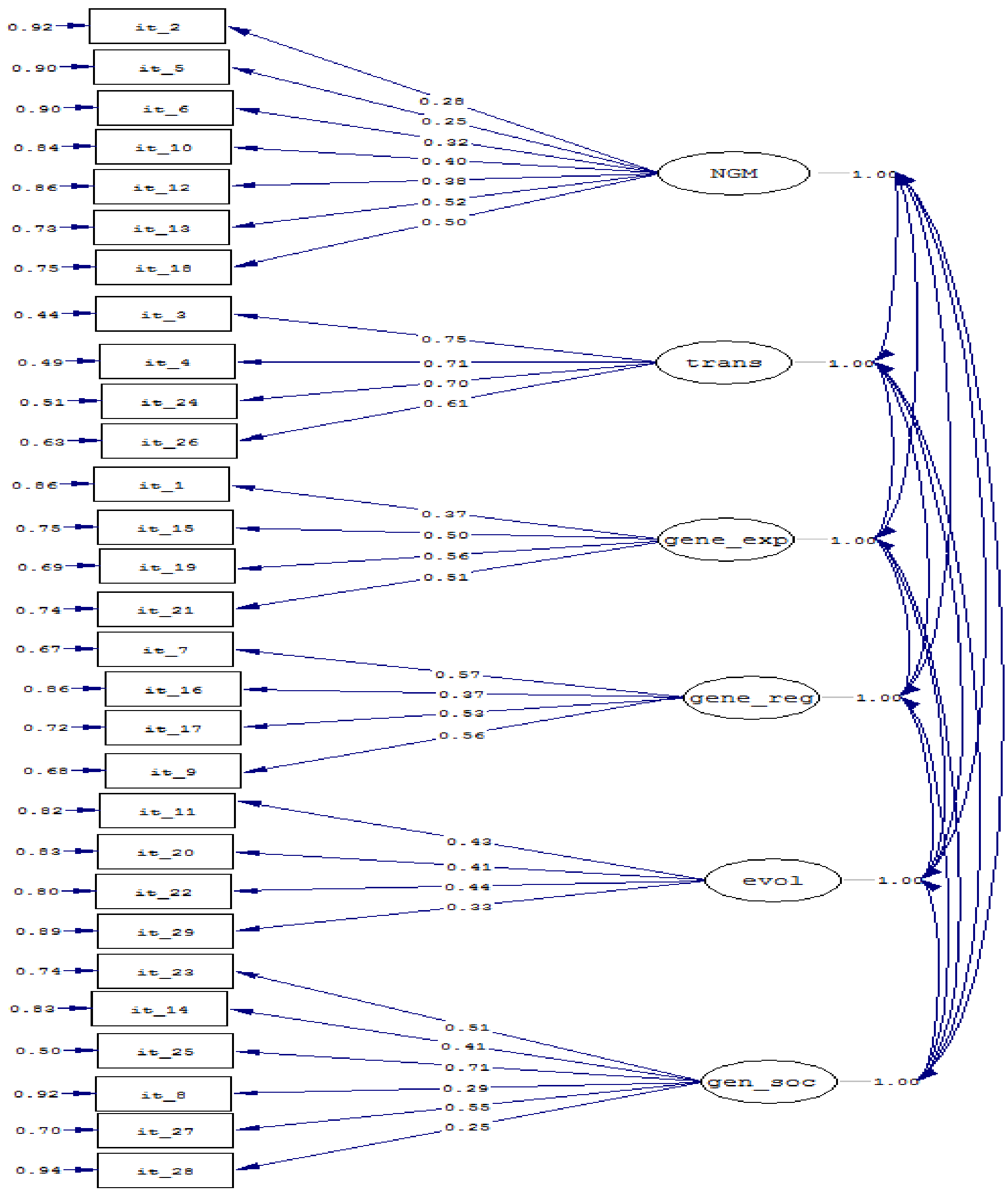

Figure 3.2 The model fit of Genetics Literacy Assessment Inventory

Note: "it_1" represents item 1 in the GLAI, "NGM" represents nature of genetic material dimension, "trans" represents transmission dimension, "gene_exp" represents gene expression dimension, "gene_reg" represents gene regulation dimension, "evol" represents evolution dimension and "gene_soc" represents genetics and society dimension

3.3.2. Attitudes towards Issues in Genetics Literacy Scale (ATIGLS)

Attitudes towards issues in genetics literacy scale is a self-report instrument designed to assess individuals' attitudes on particular applications of genetic technologies including gene therapy, use of genetic information, abortion and Pre-Implementation genetic diagnosis as well as more general attitudes towards genetics research *which* was adapted from British Social Attitude Survey (2000) and Wellcome Trust Consultive Panel on Gene Therapy (1999). The scale has six subscales as *general attitudes, use of genetic information*, *abortion*, *Pre-Implementation Genetic Diagnosis*, *gene therapy* and *gene therapy applications* as *somatic gene therapy, germ-line gene therapy* and *in-utero gene therapy.* The scale was constructed in a multiple Likert Scale format and consisted of 50 items. While *general attitude* items and *use of genetic information* items is a 5-point Likert-type scale ranging from 1 "strongly disagree" to 5 "strongly agree", items in *abortion* and *Pre-implementation genetic diagnosis* subscales were scored on a 3-point Likert-type scale with 1 being "always right" and 3 being "never right". *The gene therapy* items responded on a 4-point Likert-type scale from 1 "definitely allowed" to 4 "never allowed". On the other hand, a 5-point Likert scale was used in *gene therapy applications* dimension where 1 indicates "definitely allowed" and 4 indicates "never allowed" and 5 indicates "it depends/needs more information" (see Table 3.13).

Table 3.13

The Dimensions of Attitudes towards Issues in genetics literacy Scale

Dimension	Number of Item	Likert Scale format	Adapted from
General Attitude	19	5 point	British Social Attitude Survey Wellcome Trust Consultive Panel on Gene Therapy
Use of genetic information	4	5 point	British Social Attitude Survey

Table 3.13 (Cont.)

Dimension	Number of Item	Likert Scale format	Adapted from
Abortion	4	3 point	British Social Attitude Survey
Pre-Implementation Genetic Diagnosis	4	3 point	British Social Attitude Survey
Gene Therapy	10	4 point	British Social Attitude Survey
Gene Therapy Applications	9	5 point	Wellcome Trust Consultive Panel on Gene Therapy

After the translation and adaptation procedures as explained earlier Genetics Literacy Assessment Inventory section, the scale was pilot tested.

In the following part, reliability and validity issues of the Attitudes towards Issues in Genetics Literacy Scale with the pilot study data was explained.

3.3.2.1. Validity Evidences for Attitudes towards Issues in Genetics Literacy Scale with pilot study data

As attitude scale was constructed from Likert-type items ranging from 3-point to 5-point. For pilot study, attitudes towards issues in genetics literacy scale was administrated 95 science teachers. Firstly, the data screening for exploring missing data patterns was performed, and the descriptive statistics were examined. For validating scale structure, various validity evidences should be presented as Crocker and Algina (1986) noted. Thus, various validity evidences were investigated for validating the Attitude towards Issues in genetics literacy Scale. Content validity, convergent validity and discriminant validity evidences, as well as reliability coefficients, were examined.

3.3.2.1.1. Data screening with pilot study data

The minimum and maximum values, standard deviations, skewness and kurtosis values and range for the items in the scale that will be subjected to confirmatory factor analysis were inspected through descriptive statistics. The minimum and maximum values, means and standard deviations of each item were found to be reasonable. Skewness values ranged from -1.153 to 1.125 and kurtosis values ranged from -1.546 to 2.03 that are lower than the supposed value of 3.00 indicating there is no violation of univariate normality (Pallant, 2007). Percent of missing cases ranged from 1.1% to 5.3%. The percent of missing cases and descriptive statistics of each item were presented in Table G.1 and Table G.2 in Appendix G, respectively. As Tabachnick and Fidell (2013) indicated if missing data is about 5% or less of actual data, almost any procedure can be used for handling missing data (p. 63). In this study, missing values are found around 5%. Thus, missing data were replaced by using regression procedure. After imputation, skewness values ranged from -1.257 to 1.594 and kurtosis values ranged from -1.507 to 2.188 (See Table G. 3 in Appendix G for descriptive statistics of pilot study data after imputation).

3.3.2.1.2. Content validity of attitude towards issues in genetics literacy scale

Croker and Algina (1988) indicated that, a typical procedure should be followed in content validity is the examination of items in terms of adequacy to the domain by a group of experts (p. 218). Content validity of attitudes towards issues in genetics literacy scale was ensured by examination of items in the scale by two researchers. First researcher has expertise in biology education as well as science education checked for the equivalence of the original and translated versions of the instrument, second researcher has expertise in biology, specifically in genetics, reviewed the items in the instrument. Thus, the content validity of scale was ensured. But it is recommended to use other validity evidences for ensuring validity of a test (Crocker & Algina, 1988, p. 219).

3.3.2.1. 3. Convergent validity of attitudes towards issues in genetics literacy scale

Convergent validity refers to correlations between measures of same construct, and it is recommended to be high (Crocker & Algina, 1988, p. 233). So, the correlations among the dimensions of attitude scale should be high for ensuring convergent validity. For ensuring convergent validity of attitude scale, correlation coefficents among the dimensions of attitude scale were calculated. As shown in Table 3.14, all the attitude dimensions were correlated. The magnitude of correlations was ranged from small to large (Cohen 1977, 79-80). Any significant correlation between use of genetic information and abortion were demonstrated ($p > .05$).

Table 3.14

Zero order correlations among the dimensions of attitude scale

Dimension	1	2	3	4	5	6
1. General attitude	-	.36**	.33**	-.42**	-.33**	-.40**
2. Use of genetic information		-	-.15	-.27**	-.42**	-.26*
3. Abortion			-	0.48**	.29**	.38**
4. Pre-Implementation Genetic Diagnosis				-	.44**	.51**
5. Gene therapy					-	.68**
6. Gene therapy applications						-

**$p < .01$
* $p < .05$

3.3.2.1. 4. Discriminant validity of attitudes towards issues in genetics literacy scale

Croker and Algina (1988) defined discriminant validity as correlations between different constructs. It is recommended to be substantially lower than reliability or convergent validity coefficents (p. 233). Thus, correlations between different measures should be lower for ensuring discriminant validity. For this purpose, the reliability coefficents among the subscales of two different scales (attitudes towards issues in genetics literacy scale and perceptions of teaching issues in genetics literacy scale) were examined. As shown in Table 3.15, in general, dimensions of attitude scale were not correlated with dimensions of perception scale. However, Pre-implementation genetic diagnosis was significantly correlated with impeding factors ($r = .21$, $p < .01$) and negatively correlated with personal teaching efficacy beliefs ($r = -0.23$, $p < .01$) though small in magnitude. As most of attitude dimensions were not significantly associated with dimensions of perception scale and the found correlations among Pre-implementation genetic diagnosis, impeding factors and personal teaching efficacy beliefs are small in magnitude and lower than the inter-correlations among the scales themselves, the discriminant validity of attitude scale was ensured.

Table 3.15

Zero order correlations among the dimensions of attitude scale and perception scale

Dimension	1	2	3	4	5	6	7	8	9
1. General Attitude	-	-.36**	.33**	-.42**	-.33**	-.40**	.08	-.18	.09
2. Use of Genetic Information		-	-.15	-.27**	-.42**	-.26*	.14	-.09	.12
3. Abortion			-	0.48**	.29**	.38**	-.08	.05	-.07
4. Pre-Implementation Genetic Diagnosis				-	.44**	.51**	-.11	.21*	-.23*
5. Gene Therapy					-	.68**	-.07	.03	-.08
6. Gene Therapy Applications						-	.03	.12	-.08
7. Necessity of issues in genetics literacy							-	.44*	.53*
8. Impeding factors								-	.44*
9. Personal teaching efficacy beliefs									-

** $p < 0.01$
* $p < 0.05$

3.3.2.2. Reliability of subscales of attitudes towards issues in genetics literacy scale in pilot study

Last validity evidence used for this study is to calculate reliability coefficents as Croker and Algina (1988) suggested. Cronbach alpha reliability values of subscales ranged from .77 to .95. Reliability values of subscales were presented in Table 3.16.

Table 3. 16

Reliability values of subscales of attitudes towards genetics literacy scale

Dimension	Cronbach Alpha
General Attitude	.77
Use of genetic information	.75
Abortion	.84
Pre-Implementation Genetic Diagnosis	.86
Gene Therapy	.89
Gene Therapy Applications	.95

Confirmatory factor analyses conducted with main study findings are presented in following section.

3.2.2.3. Confirmatory factor analyses for Attitudes towards Issues in Genetics Literacy Scale with main study data

After pilot study, the Attitudes towards Issues in genetics literacy Scale (See, Appendix G) was administrated to 435 middle school science teachers in Ankara. Confirmatory factor analysis was performed in order to test hypothesized factor structures. Firstly, preliminary analyses as data screening and missing data analysis were conducted. Then, confirmatory factor analysis was performed for each dimension of the instrument to test the model fit to the data.

3.3.2.1.1. Data screening with main study data

The minimum and maximum values, standard deviations, skewness and kurtosis values and range for the items in the scale that will be subjected to confirmatory factor analysis were inspected through descriptive statistics. The minimum and maximum values, means and standard deviations of each item were found to be reasonable. Skewness values ranged from -1.348 to 2.029 and kurtosis values ranged from -1.424 to 2.927 that are lower than the supposed value of 3.00 indicating there is no violation of univariate normality (Pallant, 2007). Percent of missing cases ranged from 0% to 1.4%. The percent of missing cases and descriptive statistics of each item were presented in Table G.4 and Table G.5 in Appendix G, respectively. As Tabachnick and Fidell (2013) indicated if missing data is about 5% or less of actual data, almost any procedure can be used for handling missing data (p. 63). In this study, missing values are found less than 5%. Thus, missing data were replaced by using regression procedure. After imputation, skewness values ranged from -1.348 to 2.026 and kurtosis values ranged from -1.426 to 2.960 (See Appendix G.6 in Appendix G for descriptive statistics of main study data after imputation).

3.3.2.1.2. Confirmatory factor analyses results for Attitudes towards Issues in genetics literacy Scale

The attitudes towards issues in genetics literacy scale is composed of multiple Likert-scale format ranging from 3-point to 5-point. The variables with 5 or more categories are considered as continuous and the variables with less than 5 categories are considered as ordinal (Johnson & Creech, 1983; Hutchinson & Olmos, 1998; Lehmann & Hulbert, 1972). Thus, the dimensions with 5-point Likert scale format (general attitude, use of genetic information and gene therapy application) were treated as continuous variables and while conducting confirmatory factor analysis, Maximum Likelihood (ML) was used as method of estimation. When non-normality is more pronounced, Maximum Likelihood (ML) estimation can cause inflated model χ^2 values which is related to overrejection of solutions. The two most commonly used estimators for non-normal continuous data is Robust Maximum Likelihood (MLM) and Weighted Least Squares (WLS). As WLS estimation requires extremely large sample, it is not recommended (Brown, 2006; p.379).

Thus, Robust maximum likelihood (MLM) estimation was used when dealing non-normal data obtained in this study. MLM estimation provides a ML parameter estimates with standard errors and a mean-adjusted χ^2 which is known Satorra- Bentler scaled χ^2 test statistic that are robust to non-normality (Brown, 2006; p. 379; Satorra & Bentler, 1994; Tabachnik & Fidell, 2013; p. 718). Multivariate non-normality was checked by examining LISREL output. According to multivariate analyses results, the variables in general attitude scale were multivariately peaked (p <.05) implying that the data were comprised of non-normal continuous variables. Thus, robust maximum likelihood estimation method was used in estimation.

The items in abortion and Pre-implementation genetic diagnosis were composed of 3-point Likert scale format and the items in gene therapy were composed of 4-point Likert scale format. The items in these dimensions were considered as ordinal. Thus, while conducting confirmatory factor analysis with these dimensions, the Diagonally Weighted Least Squares (DWLS) was used as method of estimation.

In following part, confirmatory factor analysis results for each dimension of the instrument was described.

3.3.2.1.2.1. Confirmatory factor analyses with general attitude dimension

According to confirmatory factor analysis results, the hypothesized model Satorra–Bentler χ^2 (152, N= 435) = 817.36, p< .05, Robust CFI = .75, RMSEA = .10 indicating poor fit. In an attempt to develop a better fitting model, the items which had lowest standardized coeffecients (item 14= .02, item 8= .10, item 3= .15 and item 7 = .19 respectively) were removed from general attitude dimension and fit indices were examined. The model improved after elimination of these items. Even the chi-square test of final model was found statistically significant, the normed chi-square (χ^2/df) value was found as 4.04 indicating acceptable fit. The final model was found as acceptable, Satorra–Bentler χ^2 (90, N= 435) = 364, p< .05, Robust CFI = .87, RMSEA = .084. The 15-item general attitude scale with standardized coefficents is presented in Table 3.17.

Table 3. 17

Lambda-x estimates for general attitude dimension

Dimension	Indicator	Lambda-X
	gen_att1	.22
	gen_att2	.47
	gen_att4	.53
	gen_att5	.48
	gen_att6	.25
	gen_att9	.21
	gen_att10	.39
General attitude	gen_att11	.35
	gen_att12	.25
	gen_att13	.64
	gen_att15	.72
	gen_att16	.57
	gen_att17	.77
	gen_att18	.36
	gen_att19	.22

Note: "gen_att1" represents the 1^{st} item in general attitude dimension

3.3.2.1.2. 2. Confirmatory factor analyses with use of genetic information

Based on confirmatory factor analyses results, the chi-square test was not found to be significant ($\chi^2_{(2)}$= 5.34, p> .05). Fit indices (RMSEA= .06, SRMR= .04, CFI=1.00 and GFI= 1.00) suggested a good fit. All the items loaded on intended factor namely use of genetic information. Completely standardized solutions (Lambda-x estimates) for latent factor of use of genetic information were presented in Table 3.18.

Table 3.18

Lambda-x estimates for use of genetic information dimension

Dimension	Indicator	Lambda-X
	use_gen_1	0.58
	use_gen_2	0.95
Use of genetic information	use_gen_3	0.92
	use_gen_4	0.30

Note: "use_gen_1" represents the 1st item in use of genetic information dimension

3.3.2.1.2.3. Confirmatory factor analyses results with abortion

Based on confirmatory factor analyses results, the chi-square test was not found to be significant ($\chi^2_{(2)}$= 1.38, *p*> .05). Fit indices (RMSEA= .03, SRMR= .08, CFI=1.00 and GFI= 1.00) suggested a good fit. All the items loaded on intended factor namely use of genetic information. Completely standardized solutions (Lambda-x estimates) for latent factor of abortion dimension were presented in Table 3.19.

Table 3.19

Lambda-x estimates for abortion dimension

Dimension	Indicator	Lambda-X
	abort_1	0.77
	abort_2	0.84
Abortion	abort_3	0.95
	abor_4	0.85

Note: "abort_1" represents the 1st item in abortion dimension

3.3.2.1.2.3. Confirmatory factor analyses results with pre-implementation genetic diagnosis

Confirmatory factor analyses results indicated that the chi-square test was not significant ($\chi^2_{(2)}$= 1.06, *p*> .05). Fit indices (RMSEA= .01, CFI=1.00, SRMR= .01, and GFI= 1.00) suggested a good fit. All the items loaded on intended factor namely pre-implementation genetic diagnosis. Completely standardized solutions (Lambda-x estimates) for latent factor of pre-implementation genetic diagnosis were presented in Table 3.20.

Table 3.20

Lambda-x estimates for pre-implementation genetic diagnosis dimension

Dimension	Indicator	Lambda-X
Pre-implementation genetic diagnosis	pre_IG_1	0.84
	pre_IG_2	0.86
	pre_IG_3	0.95
	pre_IG_4	0.89

Note: “pre_IG__1” represents the 1st item in pre implementation genetic diagnosis dimension

3.3.2.1.2.3. Confirmatory factor analyses results with gene therapy

According to confirmatory factor analyses results, the chi-square test was found to be significant ($\chi^2_{(35)}$= 165.24, *p*< .05). The relative/normed chi-square (χ^2/df) value was calculated as 4.72 which was considered as an indicator of reasonable fit (Marsh & Hocevar, 1985; Tabacnick & Fidell, 2013; p. 720). Besides, various fit indices were used for assessing model fit. Fit indices (RMSEA= .094, CFI= .98, GFI= .97 and SRMR= .80) suggested a reasonable fit. All the items loaded on intended factor namely gene therapy. Completely standardized solutions (Lambda-x estimates) for latent factor of gene therapy dimension were presented in Table 3.21.

Table 3.21

Lambda-x estimates for gene therapy dimension

Dimension	Indicator	Lambda-X
	gene_ther_1	0.79
	gene_ther_2	0.75
	gene_ther_3	0.74
	gene_ther_4	0.94
Gene therapy	gene_ther_5	0.96
	gene_ther_6	0.96
	gene_ther_7	0.50
	gene_ther_8	0.85
	gene_ther_9	0.92
	gene_ther_10	0.81

Note: “gene_ther_1” represents the 1st item in use of genetic information dimension

3.3.2.1.2.3. Confirmatory factor analyses results with gene therapy applications

Confirmatory factor analysis results indicated that According to confirmatory factor analyses results, the chi-square test was found to be significant ($\chi^2_{(23)}$= 122.15, $p<$ .05). The relative/normed chi-square (χ^2/df) value was calculated as 5.3 which was considered as an indicator of reasonable fit (Marsh & Hocevar, 1985; Tabacnick & Fidell, 2013; p. 720). Besides, various fit indices were used for assessing model fit. Fit indices (RMSEA= .098, CFI= 1.00, GFI= 1.00 and SRMR= .08) suggested a reasonable fit. The RMSEA and SRMR values are advised to be lower than .05 for a good fit. Though, values less than 0.10 are indicates acceptable fit (Kline, 1998; Schermelleh-Engel, Moosbrugger, & Müller, 2003). Thus, the obtained RMSEA and SRMR values in this study suggested acceptable fit. All the items loaded on intended factor namely gene therapy applications. Completely standardized solutions (Lambda-x estimates) for latent factor of gene therapy applications were presented in Table 3.22.

Table 3. 22

Lambda-x estimates for gene therapy applications dimension

Dimension	Indicator	Lambda-X
Somatic gene therapy	g_thr_sit_1_1	0.83
	g_thr_sit_1_2	0.74
	g_thr_sit_1_3	0.89
Germ-line gene therapy	g_thr_sit_2_1	0.85
	g_thr_sit_2_2	0.79
	g_thr_sit_2_3	0.86
In-utero gene therapy	g_thr_sit_3_1	0.89
	g_thr_sit_3_2	0.80
	g_thr_sit_3_3	0.92

Note: "g_thr_sit_1_1" represents 1^{st} item in somatic gene therapy dimension, "g_thr_sit_2_1" represents the 1^{st} item in germ-line gene therapy dimension and "g_thr_sit_3_1" represents 1^{st} item in in-utero gene therapy dimension

In following part, reliability values of each dimension in Attitudes towards Issues in genetics literacy were presented.

3.3.2.2. Reliability of subscales of Attitudes towards Issues in genetics literacy Scale in main study

Cronbach alpha reliability values of subscales ranged from .70 to .90 in main study. Reliability values of subscales were presented in Table 3.23.

Table 3. 23

Reliability values of subscales of attitudes towards genetics literacy scale

Dimension	Cronbach Alpha
General Attitude	.70
Use of genetic information	.72
Abortion	.86
Pre-Implementation Genetic Diagnosis	.90
Gene Therapy	.87
Gene Therapy Applications	.90

3.3.3. Perceptions of Teaching Issues in Genetics Literacy Scale (PTIGLS)

Teachers' Perceptions of Teaching Issues in genetics literacy Scale is a self-report questionnaire for assessing in-service science teachers' perceptions of teaching issues in genetics literacy in their classes. This scale was prepared by adapting items which were used by previous studies (Lee, Abd-El-Khalick, & Choi, 2006; Pedretti, Bencze, Hewitt, Romkey, & Jivraj (2008); Riggs & Enochs, 1990). The Scale is composed of 20 Likert type items which are scored on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). After the translation and adaptation procedures as explained earlier Genetics Literacy Assessment Inventory section, the scale was pilot tested.

In following part, the statistical procedures for ensuring validity and reliability of Teachers' Perceptions of Teaching Issues in genetics literacy Scale was explained. Firstly, explanatory factors analyses results and reliability values with pilot study data was presented. Then, confirmatory factor analyses results with main study data were described in details.

3.3.3.1. Exploratory factor analyses for Teachers' Perceptions of Teaching Issues in genetics literacy Scale in pilot study

The scale was pilot tested with 95 science teachers. In order to validate factor structure of teachers' perceptions of teaching issues in genetics literacy scale, the data obtained from pilot study was subjected to exploratory factor analysis which is a technique used for explaining underlying factor structures (Hair, Black, Babin, & Anderson, 2010). While performing explanatory factor analysis, principal component analysis and direct oblimin was used.

Tabachnick and Fidell (2013) suggested that the impact of sample size is reduced when the communality values are higher than .6. In such cases, sample size below 100 is acceptable (p. 618). In this study, the communality values are generally found higher than .6. Only three items (item 3, item 5 and item 19) had communality values lower than .6 (.395, .378 and .238 respectively) indicating that these items do not fit well with the other items in its component. Pallant (2007) recommended eliminating the items with low communality values which will be resulted in increasing the total variance explained (p. 196). Thus, three items were removed from the scale, and communality values are examined again. The communality values of 17-item scale were found higher than .6 indicating that the data obtained in pilot study is appropriate for explanatory factor analysis. The Keiser Meyer-Olkin (KMO) measure of sampling adequacy was .816 and Barlett's test of sphericity was statistically significant $\chi^2(190)= 691.244$, $p< .05$, indicating existence of relationships between variables and the data is suitable for factor analysis. According to the Keiser's criterion (Pallant, 2007; p. 182) there were three factors with eigen values greater than 1. Inspection of scree pilot also supported a three-factor model. The first factor accounted for 35.50% of the variance in correlation matrix and included 8 items related to *teachers' perceptions of the necessity of addressing issues in genetics literacy in their classes* (e.g., I want to develop teaching and learning materials on issues in genetics literacy for my science class). Factor loadings ranged from .466 to .840 (see Table 3.15). The second factor explained 12.15% of the variance in the correlation matrix. This factor included 5 items related to *teachers' perceptions of the factors that impede* *addressing issues in genetics literacy in their classrooms* (e.g., limited class time makes me feel burdened when dealing with issues in genetics literacy during class). The items factor loadings ranged from .534 to .784. The third factor explained 9.23% of the variance in the correlation matrix. This factor included four items related to *teachers' personal teaching efficacy beliefs regarding issues in genetics literacy* (e.g., I sufficiently understand what issues in genetics literacy). The item factor loadings of this dimension ranged from .442 to .820 (See Table 3.24).

Table 3.24

Factor loadings of items in teachers' perceptions of teaching issues in genetics literacy scale

Item	Factor 1	Factor 2	Factor 3
I want to develop teaching and learning materials on issues in genetics literacy for my science class (per_1)	.831		
If I can get materials on genetics literacy, I am willing to use them in class (per_3)	.840		
I am willing to participate in a program that helps teachers deal with issues in genetics literacy (per_4)	.813		
The inadequacy of students' background regarding issues in genetics literacy needs to be addressed (per_7)	.466		
Introducing issues in genetics literacy into science classes will increase students' interest in science (per_9)	.694		
Issues in genetics literacy is not as important as the rest of the science curriculum (per_15)	.657		
Teaching issues in genetics literacy is not worth the effort and time (per_16)	.508		
Introducing issues in genetics literacy into science classes is definitely necessary (per_17)	.615		

Table 3.24 (Continued)

Item	Factor 1	Factor 2	Factor 3
I believe that students are not mature enough to be interested in and understand issues in genetics literacy (per_5)		.750	
I believe that students are barely interested in issues in genetics literacy (per_6)		.722	
Classes dealing with issues in genetics literacy are most likely to be classes for high achieving students (per_8)		.676	
Addressing issues in genetics literacy in science classes could confuse students about their own values (per_12)		.534	
Dealing with issues in genetics literacy using various teaching strategies (role plays and group activities) is hardly possible in a "real" classroom situation (per_13)		.784	
Even when I try very hard, I do not teach issues in genetics literacy as well as I do most subjects (per_2)			.442
I sufficiently understand what issues in genetics literacy is (per_10)			.599
I have confidence in developing teaching and learning materials about issues in genetics literacy (per_11)			.778
I have the knowledge necessary to effectively teach about issues in genetics literacy to my students (per_14)			.820

Note: "per_1" represents 1st question in the PTIGLS

Cronbach's alpha internal consistency coefficient was calculated for each factor. The Cronbach's alpha coefficient ranged from .77 to .85 (See Table 3.25). In addition, corrected item-total correlations were examined, and high correlations among items were revealed (See Table H.1, Table H.2 and Table H.3 in Appendix H). Moreover, the mean inter-item correlations for necessity of addressing issues in genetics literacy, impeding factors and self-efficacy beliefs dimension were 4.42, 2.87 and 3.58 respectively (See Table H.4 in Appendix H). Overall, the findings indicated high internal consistency for subscales of teachers' perceptions of teaching issues in genetics literacy scale.

Table 3.25

Reliability values of subscales of teachers' perceptions of teaching issues in genetics literacy scale

Dimension	Total number of item	Cronbach Alpha
Necessity of addressing issues in genetics literacy	8	.85
The factors that impede addressing issues in genetics literacy	5	.78
Teachers' personal teaching efficacy beliefs	4	.77

In following part, confirmatory factor analyses results for each dimension of Teachers' Perceptions of Teaching Issues in genetics literacy Scale as well as overall instruments were elucidated.

3.3.3.2. Confirmatory factor analyses for Teachers' Perceptions of Teaching Issues in genetics literacy Scale with main study data

After conducting exploratory factor analyses and reliability analyses in the pilot study, the 17-item perception scale was administrated to 435 science teachers. The confirmatory factor analyses were used for exploring hypothesized factor structure. As the data was constructed with 5-point Likert scale items, Maximum Likelihood (ML) was used. In addition, Robust Maximum Likelihood (MLM) was used as method of estimation when non-normality is pronounced in data. Firstly, preliminary data analyses were conducted: the data screening for exploring missing data patterns was performed and descriptive statistics were examined. In addition, univariate and multivariate normality was checked. Then, confirmatory factor analyses for each subscale as well as overall instrument was performed to test model fit.

3.3.2.1.1. Data screening with main study data

The minimum and maximum values, standard deviations, skewness and kurtosis values and range for the items in the scale which will be subjected to confirmatory factor analysis were inspected through descriptive statistics. The minimum and maximum values, means and standard deviations of each item were found to be reasonable. Skewness values ranged from -1.176 to 1.337 and kurtosis values ranged from -1.138 to 2.144 that are lower than the supposed value of 3.00 indicating there is no violation of univariate normality (Pallant, 2007). Percent of missing cases ranged from 0.5% to 1.1%. The percent of missing cases and descriptive statistics of each item were presented in Table H.5 and Table H.6 in Appendix H, respectively. As Tabachnick and Fidell (2013) indicated if missing data is about 5% or less of actual data, almost any procedure can be used for handling missing data (p. 63). In this study, missing values are found around less than 2%. Thus, missing data were replaced by using regression procedure. After imputation, skewness values ranged from -1.122 to 1.327 and kurtosis values ranged from -1.145 to 2.666 (See, Table H.7 in Appendix H for descriptive statistics of pilot study data after imputation). Multivariate non-normality was checked by examining LISREL output. According to multivariate analyses results, the variables in *necessity of addressing issues in genetics literacy* scale were multivariately skewed and peaked ($p <.05$) implying that the data were comprised of non-normal continuous variables. Thus, robust maximum likelihood estimation method was used in estimation in this dimension.

3.3.2.1.2. Confirmatory factor analyses results for Teachers' Perceptions of Teaching Issues in genetics literacy Scale

In this part, confirmatory factor analyses results for each dimension of Teachers' Perceptions of Teaching Issues in genetics literacy Scale were presented. Confirmatory factor analysis with maximum likelihood (ML) estimation was performed by using Lisrel 8.8 (Jöreskog & Sörbom, 2007) in order to investigate how well the items in the perception scale fit to proposed 3 dimensions.

3.3.2.2.2.1. Confirmatory factor analyses with necessity of addressing issues in genetics literacy

Confirmatory factor analysis results revealed that the hypothesized model yielded an acceptable fit, Satorra–Bentler χ^2 (20, N= 435) = 142.39, $p< .05$, Robust CFI = .90, RMSEA = .09. All the items loaded on intended factor namely necessity of addressing issues in genetics literacy. Completely standardized solutions (Lambda-x estimates) for latent factor of necessity of addressing issues in genetics literacy were presented in Table 3.26.

Table 3.26

Lambda-x estimates for necessity of addressing issues in genetics literacy

Dimension	Indicator	Lambda-X
	perc_1	.49
	perc_3	.50
	perc_4	.58
Necessity of addressing	perc_7	.48
issues in genetics literacy	perc_9	.58
	perc_15	.69
	perc_16	.72
	perc_17	.39

Note: "perc_1" represents item 1 in necessity of addressing issues in genetics literacy dimension

3.3.2.2.2.2. Confirmatory factor analyses with the factors that impede addressing issues in genetics literacy

According to confirmatory factor analyses results, the chi-square test was not found to be significant ($\chi^2_{(5)}$= 3.72, $p> .05$) and other fit indices (RMSEA= .01, CFI= 1.00, SRMR= .018, and GFI= 1.00) suggested a good fit. All the items loaded on intended factor namely the factors that impede addressing issues in genetics literacy. Completely standardized solutions (Lambda-x estimates) for latent factor were presented in Table 3.27.

Table 3.27

Lambda-x estimates for the factors that impede addressing issues in genetics literacy

Dimension	Indicator	Lambda-X
	perc_5	.43
The factors that impede	perc_6	.61
addressing issues in	perc_8	.51
genetics literacy	perc_12	.37
	perc_13	.57

Note: "perc_5" represents item 5 in the factors that impede addressing issues in genetics literacy dimension

3.3.2.2.2.3. Confirmatory factor analyses with teachers' personal teaching efficacy beliefs

Confirmatory factor analyses results, the chi-square test was not found to be significant ($\chi^2_{(2)}$= 5.94, p> .05) and other fit indices (RMSEA= .064, CFI=.99, SRMR= .025, and GFI=.99) suggested a good fit. All the items loaded on intended factor namely teachers' personal teaching efficacy beliefs. Completely standardized solutions (Lambda-x estimates) for latent factor were presented in Table 3.28.

Table 3.28

Lambda-x estimates for the factors teachers' personal teaching efficacy beliefs

Dimension	Indicator	Lambda-X
	perc_2	.41
Teachers' personal	perc_10	.66
teaching efficacy beliefs	perc_11	.68
	perc_14	.63

Note: "perc_2" represents item 2 in Teachers' personal teaching efficacy beliefs dimension

After conducting confirmatory factor analyses for each dimension of PTGLIS, whole instrument was subjected to confirmatory factor analysis. In following part, confirmatory factor analyses results for overall instrument was presented.

3.3.2.2.2.4. Confirmatory factor analyses with teachers' perceptions of teaching issues in genetics literacy scale with main study data

After examination of items in each dimension through standardized solutions (Lambda-x estimates) was completed and any problems with items were encountered, the 17-item teachers' perceptions of teaching issues in genetics literacy scale (See Appendix H) was subjected to confirmatory factor analysis for investigating overall factor structures. The chi-square test was found to be significant ($\chi^2_{(116)}$= 424.36, p< .05). However, as chi-square test is sensitive to sample size (Jöreskog & Sörbom, 2007; Kline, 2005; Tabacnick & Fidell, 2013; p. 700), relative/normed chi-square (χ^2/df) were suggested for decreasing the impact of sample size on chi-square. Instead of using chi-square statistics, normed chi-square (χ^2/df) was used for assessing overall model fit. Normed chi-square value was computed as 3.65. This value is below the suggested normed chi-square range of 2 to 5 which is an indicator of acceptable fit (Tabanchnik & Fidell, 2013; p. 720). Besides, various fit indices were used for assessing model fit. Other fit indices (RMSEA= .078, CFI= .90, SRMR= .64, and GFI= .90) suggested acceptable fit. All the items loaded on hypothesized factors namely necessity of addressing issues in genetics literacy, the factors that impede addressing issues in genetics literacy and teachers' personal teaching efficacy beliefs. The model fit of teachers' perceptions of teaching issues in genetics literacy scale was presented in Figure 3.4.

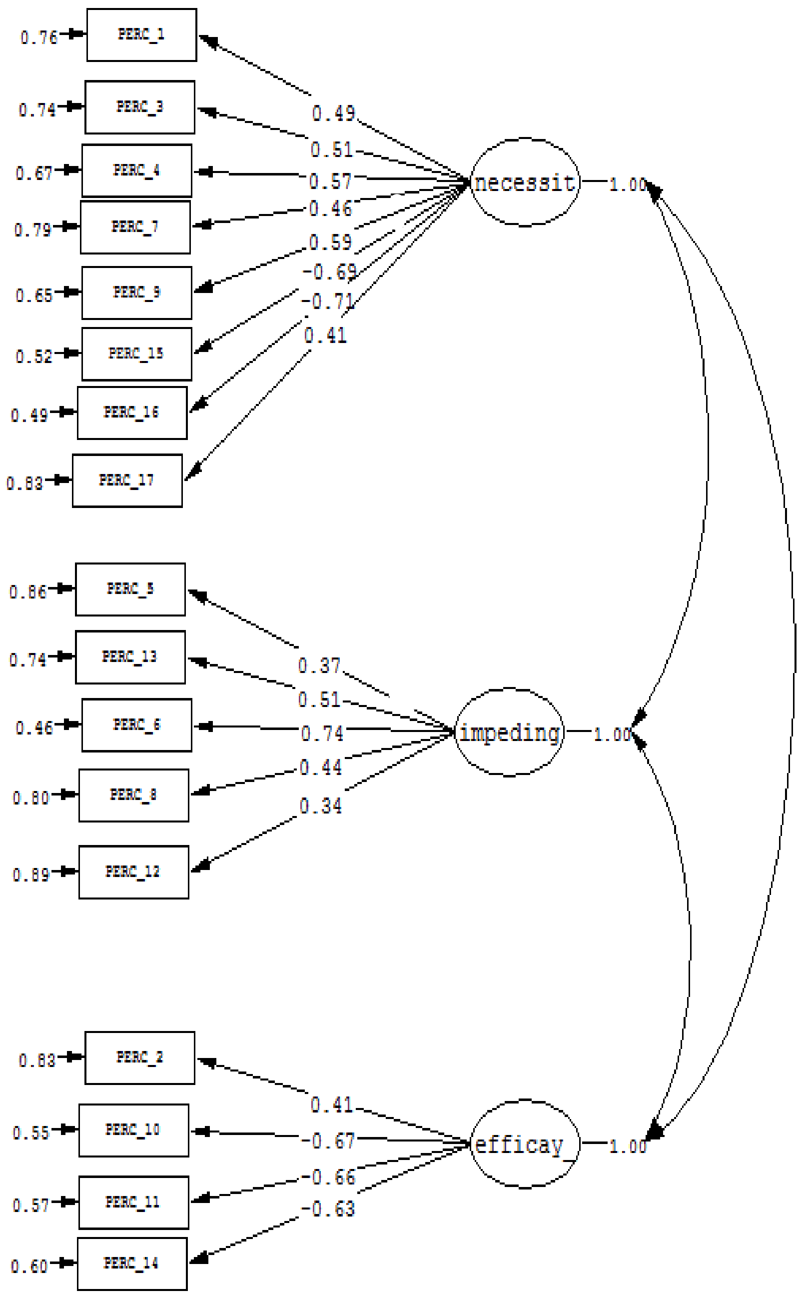

Figure 3.3 The model fit of Teachers' Perceptions of Teaching Issues in Genetics Literacy Scale

Note: "PERC_1" represents item 1 in the PTGLIS, "necessit" represents necessity of addressing issues in genetics literacy dimension, "impeding" represents the factors that impede addressing issues in genetics literacy and " efficacy_" represent teachers' personal teaching efficacy beliefs

3.3.2.1.3. Reliability of subscales of teachers' perceptions of teaching issues in genetics literacy scale in main study

Cronbach alpha reliability coefficents of subscales ranged from .70 to .78 in main study which is above the recommended value of .70 (Fraenkel et al. 2011). Reliability coefficents of subscales were presented in Table 3.29.

Table 3.29

Reliability values of subscales of teachers' perceptions of teaching issues in genetics literacy scale

Subscale	Cronbach Alpha
Necessity of addressing issues in genetics literacy	.78
The factors that impede addressing issues in genetics literacy	.71
Teachers' personal teaching efficacy beliefs	.70

In following part, the instruments used for qualitative part of study, namely, Decision Making Interviews were explained.

3.3.2. Qualitative Data Collection Tools

3.3.2.1. Decision-Making Interview (DMI)

For qualitative part of study, decision making interview protocol (DMI) was used in order to investigate the influencing factors that affect participants' decision making processes. This protocol consisted of four scenarios regarding issues in genetics literacy as fetal tissue transplantation, Cystic Fibrosis, use of gene therapy for Huntington Disease and Intelligence. The scenarios in qualitative part of study were determined based on the relevance to the scenarios used in Attitudes towards Issues in genetics literacy Scale. The scenarios were developed by using previous studies and focused on a series of genetic issues that consist of ethical dilemmas (Bell, 1999; Bell & Lederman, 2003; Sadler & Zeidler, 2004a, Sadler & Zeidler, 2004; Zohar and Nemet, 2002).

The scenarios was translated and adapted into Turkish by researcher. Another researcher who has expertise in biology education as well as science education checked for the equivalence of the original and translated versions of the scenarios. The original and translated versions were checked by English language experts at Middle East Technical University Academic Writing Center. Lastly, the adapted scenarios were examined by two members of experts committee who has expertise in the fields of science and biology education. After finalizing the scenarios, a pilot interview was conducted with an experienced science teacher in order to see the relevance to the aim of the study, appropriateness of the language, and sufficiency of the given information about each issues in genetics literacy. More detailed information regarding each scenario was presented under following headings:

3.3.2.1.1. Fetal Tissue Transplantation Scenario

This scenario consisted of an imaginary experimental procedure involving the use of fetal tissue implantation for the treatment of Parkinson's disease. This procedure consisted of ethical and moral components (Bell & Lederman, 2003). In this scenario, Ahmet and Suzan was a married couple who had two grown-up children. They did not think to have another child but Suzan finds out that she is pregnant. Meanwhile, the couple learnt that Suzan's father has Parkinson disease. They found out that Suzan's father disease can be slowed and possibly reversed by implanting fetal brain cells. Five questions related to experimental nature of procedure, donation of fetal tissue for transplantation, using fetus in terms of providing a source of tissue for transplantation and whether doctor be allowed to continue his work on fetal brain tissue transplantation were asked to participants. The Fetal Tissue Transplantation Scenario was presented in Appendix I.1.

3.3.2.1.2. Cystic Fibrosis Scenario

This scenario consisted of short description of Cystic Fibrosis disease and presents information about symptoms of disease as being autosomal recessive trait and being fatal at a certain age. Then, two possible gene therapy methods for treatment of disease were briefly explained. After this brief description and possible gene therapy methods, a vignette was presented regarding an imaginary couple whose brothers with Cystic Fibrosis disease found out that they would have a baby (Zohar & Nemet, 2002). Participants were asked to answer a series of questions based on the information presented in the scenario. The questions were related to whether to abort or not abort the fetus without having a genetic test to determine the disease and whether to abort or not abort the fetus after learning genetic testing results. The Cystic Fibrosis scenario was presented in Appendix I.2.

3.3.3.4.3. Huntington Disease Scenario

This case consisted of short description of Huntington disease and presents information about disease as being dominant trait and symptoms of disease which are not seen until adulthood. Unlike previous scenario, any possible gene therapy methods for treatment of disease were presented. After this brief information, a vignette about a pregnant woman named Lale whose father was diagnosed with Huntington disease was presented (Zohar & Nemet, 2002). Participants were asked to answer a series of questions based on the information presented in the scenario. The questions were related to whether to abort or not abort the fetus, the difference between the Huntington diseases and other diseases whish the symptoms begin at birth, and the sufferings that patients will face. The Huntington disease scenario was presented in Appendix I.3.

3.3.4.4. Gene Therapy Scenario

This scenario consisted of two vignettes related to germ-line gene therapy as a specific application of gene therapy. The first vignette was related with Huntington disease and use of germ-line therapy for the treatment of this fatal disease. The second vignette was related to the use of germ-line gene therapy for increasing intelligence of human offspring. Both vignettes were developed by Sadler and Zeidler (2004). Participants were asked whether they approve or not use of gene therapy in each context. Then, a series of follow up questions were asked to elicit participants' positions and rationales while making decisions regarding issue presented. In addition, participants' opinions about whether the gene therapy in each vignette is subject to any kind of moral rules and principles were asked. Lastly, two more follow up questions about participants' concerns regarding gene therapy and technological issues. The Gene Therapy Scenario was presented in Appendix I.4.

3.4. Data Collection

Data collection procedure comprised of quantitative and qualitative part of study for examining middle school science teachers' genetics literacy levels, their attitudes towards issues in genetics literacy and their perceptions of teaching issues in genetics literacy as well as the factors that influence science teachers' decision making process. Before data collection procedure, required permission from Ethical Committee of Middle East Technical University and from Ministry of National Education were obtained in order to administer the instruments and interview protocols (see Appendix B and C for approvals of Ethical Committee of Middle East Technical University and Ministry of National Education). Both quantitative and qualitative data were collected throughout two semesters (2012-2013 Fall and Spring). In following part, quantitative and qualitative data collection stages will be explained respectively.

For quantitative part of study, the schools were selected randomly from 6 districts of Ankara. A total of 200 middle schools in Ankara were visited, and the aim of study was briefly explained to the school administrator and science teachers by researcher. It was also, noted that the participants' names and responses would be kept concealed. Then, the instruments namely Genetics Literacy Assessment Inventory, Attitudes towards Issues in genetics literacy Scale and Personal Teaching Issues in genetics literacy Scale were administrated to the 435 voluntary participating science teachers. Each participant signed a consent form before completing instruments and participating semi-structured interviews confirming voluntary participation in the study. The informed consent form was given in Appendix D. During the administration of the instruments; no specific problems were encountered.

For qualitative of study, the semi-structured interviews were conducted with each participant who completed the instruments by researcher. The teachers being interviewed voluntarily participated in the study. The semi-structured interviews were carried out in appropriate places such as the school laboratory or school library of teacher depending on the teachers' schedule. Before, each interview process, the researcher briefly explained the aim of the interview. Teachers' further questions regarding scenarios were explained during the interview. The researcher did not reveal her personal opinion about scenarios and tried to not direct and affect participants' opinions about scenarios. Only one interview was conducted in one day in order to prevent researcher's fatigue. The length of interviews ranged from 45 minutes to 75 minutes. At the beginning of the interview, all the scenarios were presented in written format to the participants in order to look at, examine and read any time that they wanted. At the beginning of each interview, teachers were asked about their teaching profession and school information. The gathered information about teaching profession and school information served as warm-up questions and were used for describing participants' characteristics. All the teachers participating in the interviews were interviewed separately.

Each interview session was audio-taped after taking required permission from the participants. Only three of the interviews were not audio-recorded based on teacher's request. Lincoln and Guba (1985) suggested taking handwritten notes during the interviews when recording the interview is not possible. Even the researcher could not note everything, the researcher can interpolate the questions and comments (p. 272). Therefore, the researcher took hand written notes during these three interviews and asked additional questions to clarify her understanding. In addition, she reviewed the hand written notes with the participants. She read her notes aloud after each scenario, and asked the participants whether her notes were in accordance with their thoughts. Additional notes were taken, if required. This process was repeated after each scenario in order to prevent the misunderstandings and possible forgetfulness of both researcher and the participant.

3.5. Data Analysis

The present study was designed as mixed method research design. Thus, both qualitative and quantitative methods were utilized in analyzing data. First, quantitative data analysis procedure including the analysis techniques used in pilot and main study were explained in detail. Then, qualitative data analysis methods including constant comparative method and open coding procedure was explained. Lastly, development of qualitative code book, description of the categories and codes in code book and sample excerpts for categories and codes are provided in following were provided in following sections.

3.5.1. Quantitative Data Analysis

For quantitative analysis, initially ITEMAN analyses results and confirmatory factor analysis results for Genetics Literacy Assessment Inventory, confirmatory factor analysis results for Attitudes towards Genetic Literacy Issues Scale in pilot and main study, and explanatory and confirmatory factor analysis results Perceptions of Teaching Issues in genetics literacy Scales in pilot and main study were examined. In addition, Cronbach alpha coefficients for each scale were calculated for ensuring internal validity of scales. Then, descriptive results for the GLAI, ATGLS and PTGLIS were examined. To be more specific, percentages, mean, range, standard deviation, minimum, maximum, skewness and kurtosis values were used as descriptive statistics to describe the sample as a result of teachers' demographic information scale, GLAI, ATGLS and PTGLIS. For inferential statistics, canonical correlation analysis (CCA) was used in order to investigate the relationship among teachers' background characteristics, genetics literacy levels, their attitudes towards various issues in genetics literacy and their perceptions. Before conducting confirmatory factor analysis, preliminary assumptions (linearity, multivariate normality, multicollinearity and singularity) as suggested by Tabachnick and Fidell (2013) were checked for any violation of assumptions underlying canonical correlation analysis. Data were analyzed by using IBM SPSS Statistics version 22.0 for Windows.

3.5.2. Qualitative Data Analysis

For qualitative part of study, constant comparative method was used (Glaser & Strauss, 1967). As a data analysis procedure open coding procedure which includes description and explanation of categories by using constant comparisons and integration of these categories for explaining underlying theory was used in present study (Lincoln & Guba, 1985). Miles and Huberman (1994) suggested “counting” as an interpretation technique of qualitative data. In counting, the theme or pattern are identified and expressed in numerical form indicating “the number of time” and “consistency”. Thus, the researcher can make generalization by interpreting which patterns are more “frequent” than the others or decide which pattern is more “important” or “significant” than others by making comparisons (p. 253). As the presented study aimed to investigate which factors are more influential on participants’ decision making process, frequency table was constructed and interpreted.

Miles and Huberman (1994) suggested using a “provisional start list” of codes which come from conceptual framework prior to field work (p. 58). Using a qualitative code book that consists of predetermined codes enables multiple researchers that code different transcripts as Creswell (2007) indicated. Thus, the previous studies that investigated similar topics were reviewed and a qualitative code book was developed (Bell, 1999; Bell & Lederman, 2003; Sadler, 2004a; Sadler & Zeidler, 2004a; 2004b; Sadler, 2003; Topcu, 2008; van de Zande et al. 2010; Zeidler, Sadler, Simmomn, & Howe, 2005; Zohar & Nemet, 2002). After the development of coding book, codes were revised as the interviews continued. The categories and codes used for data analysis and sample experts are presented in following section.

3.5.2.1. Description of categories and codes in code book

The description of categories namely, personal experiences, socio-cultural, emotive, religious, economic, technological, moral/ethical, value, socio-psychological, political, and legal considerations, family bias, pop culture, need more information, support of science and others, as well as description of codes were constructed based on the related literature (Bell, 1999; Bell & Lederman, 2003; Sadler, 2004a; Sadler & Zeidler, 2004a; 2004b; Sadler, 2003; Topcu, 2008; van de Zande et al. 2010; Zeidler, Sadler, Simmomn, & Howe, 2005; Zohar & Nemet, 2002). Description of categories and codes is presented in Table 3.30.

Table 3.30

Description of codes and categories that influence science teachers' decision making process

Themes	Codes	Code Descriptions
Personal experiences	Having own child Having a relative	Participants use their previous experiences in interpreting the scenarios articulated.
Socio-cultural considerations	Turkish culture, Turkish traditional family structure, Turkish customs	Concerns regarding the Turkish social and cultural family structure.
Emotive considerations	Sympathy, empathy	Participants' reactions such as empathy, sympathy towards fictions characters in the scenarios.
Religious considerations	Faith, God, religion	Participants use their religious understanding in interpreting use of genetic technologies.
Economic considerations	Financial issues (wealth-poverty, expenses of genetic application)	Concerns regarding the accessibility of gene therapies. For example, while poor people cannot afford to use these therapies, rich people can afford the applications.
Technological considerations	Credibility Side effects Risk factors Malicious use	Concerns regarding the role of technology /technicians in the development and use of new genetic technologies.

Table 3.30 (Continued)

Themes	Codes	Code Descriptions
Moral considerations	Taking human life	Concern regarding status of an embryo as a human being therefore sacrificing embryos violates a principle taking human life
	Means to an end	Concerns regarding use of embryos as resources or tools
	Disturbing natural order	Concerns regarding the applications of genetics alter natural process.
	Health improvement	Statements that emphasize improvement in the health of individuals
	Social stratification	Concerns regarding that use of genetic technologies may segregate a population by creating classes of "genetic haves" and "genetic have nots"
	Slippery slope	Concerns that permitting the application of genetics technologies in one acceptable context would lead to the use of that technology in unacceptable contexts.
	Societal betterment	Statements that imply the use of genetic technologies will improve society overall.
	Diversity	Statements that indicate participants' concerns about the genetics application will reduce the diversity thus will cause erosion of diversity

Table 3.30 (Continued)

Themes	Codes	Code Descriptions
	Informed consent of family	Statements that indicate informing the family about the possible consequences of treatment before any kind of genetic application
Value considerations	Patients/fetus’ rights/right to live	Statements that indicate the fetus/embryo has right to live or patients also have a right to say about their future.
	Parents’ rights/decisions/ responsibility	Statements that indicate that as fetus does not have right, it is parents’ responsibility to decide whether to abort or not abort fetus.
Socio-psychological considerations	Suffering, child-care Cope with difficulties, pain, etc.	Statements that indicate the difficulties that families will face when raising the child as well as the problems that patients will face such as sufferings, care problems etc.
Political considerations	Government policies, politics	Concerns regarding who will have access to these technologies, who will decide and the role of governments in development and use of these genetic technologies
Legal considerations	Standards in genetic application, Legal regulations and limitations	Statements that include the legal regulations or standard which organize the application of these genetic literacy issues
Family bias	The position change in ideas if the situation involved themselves or family members	Participants articulate their decisions but also suggested that their positions would change if the situation involved themselves or their family members.

Table 3.30 (Continued)

Themes	Codes	Code Descriptions
Pop culture	Information provided in the media	Films, documentaries and the media that influenced participants' decisions.
Support of science	Scientific developments, progress in science progress and developments in genetics	Statements that indicate participants' ideas about the importance of development of scientific research (e.g., the role of experimental studies in scientific developments)
Miscellaneous	Change in participant's ideas over time	Participants make decisions but they also indicate that their response may change during time
	Birth control	Participants' suggestions about use of birth control methods avoiding pregnancy
	Alternative treatment methods	Participants' suggestions about treatment options that can be alternative to proposed method in scenario which does not harm the fetus
	Need more information	Participants who asked additional information in order to decide and support his positions

Table 3.30 (Continued)

Themes	Codes	Code Descriptions
Miscellaneous (Continued)	2-edged sword	Difficulties/dilemmas in making decisions that participants faced when articulating their decisions related to a particular genetics application.
	Uncertainty	Participants' statements that indicated that there is uncertainty in all genetics applications and life itself as well.
	Nature of disease	Participants' statements that indicate their decisions will chance based on the characteristics or seriousness of disease.

3.5.2.2. Sample quotations illustrating the codes and categories

After the development of codebook, sample quotations for each themes and codes were provided in Table 3.31.

Table 3.31

The sample excerpts regarding categories and codes of factors that influence science teachers' decision making process

Themes	Codes	Sample Excerpts
Personal experiences	Having own child Having a relative	"I can give a specific example from my family. One of my relatives had similar symptoms to Huntington's disease. Specifically, my grandfather had similar symptoms during the last stages of cancer. Even a healthy man can experience similar symptoms to Huntington's disease. Therefore, Lale should not abort the fetus by considering the severe symptoms alone.
Socio-cultural considerations	Turkish culture, Turkish traditional family structure, Turkish customs	"When we consider Turkish customs and traditions, family members take care of the sick and old people. Thus, Lale should not abort the fetus simply by considering who will take care of her or her children when she is sick."
Emotive considerations	Sympathy, empathy	"It is a very interesting case [Fetal Tissue Transplantation]... What would I do if it happened to me? I really do not know. The case affected me deeply."
Religious considerations	Faith, God, religion	"This method [regarding Fetal Tissue Transplantation] contradicts with my religious beliefs. I believe that aborting a fetus is a sin. Thus, I think this method should not be applied."
Economic considerations	Financial issues (wealth-poverty, expenses of genetic application)	"I think it would definitely be expensive to have gene therapy. Meaning, only rich people could afford it whereas poor people could not, and this would create economic stratification in society."

Table 3.31 (Cont.)

Themes	Codes	Sample Excerpts
Technological considerations	Credibility	“I am concerned about who would be tampering with genes, and I consider this risky. I mean, are the people who would apply genetic applications dependable and trustworthy?”
	Side effects	“My biggest concern is whether there might be any side effects to interfering with human genes? Or might it trigger unforeseen problems. You are inferring with someone’s DNA, after all.”
	Risk factors	“The very existence of risk factor concerns me a lot. In addition to other factors, altering genes itself includes risk. For instance, is it possible to alter one gene without affecting the other genes? These kinds of questions give cause for concern.”
	Malicious use	“Gene therapy applications could be misused by the doctors or genetic scientists who develop (apply) these applications. For instance, they thought they would be making a massive contribution to science when they invented the atomic bomb but instead it is used for the massive destruction of a country.”
Moral considerations	Taking human life	“In the scenario, we would be destroying a living thing. When I abort the fetus intentionally, I terminate its life. Thus, I believe that fetal tissue transplantation should be the last method to conduct research”
	Means to an end	“In the case of fetal tissue transplantation, using fetal tissues is not ethical. Creating an embryo and using its tissues is unacceptable. Some women might even get pregnant intentionally simply to provide brain tissues for this application.”

Table 3.31 (Cont.)

Themes	Codes	Sample Excerpts
Moral considerations (Continued)	Disrupting natural order	“I would disagree with the use of gene therapy for altering the genes of an ordinary child. It would disturb the natural order. This practice is an affront to human dignity.”
	Health improvement	“As Parkinson's disease is fatal, and there is no treatment option other than fetal tissue transplantation at that moment, I would allow the application even it was an experimental trial.”
	Social stratification	“If gene therapy were to be used for increasing human intelligence, then, there would be some kind of genetic stratification in the form of people whose genes are altered and others whose genes are not. Those people whose genes are altered through gene therapy would be one step ahead of ordinary people.”
	Slippery slope	“I am concerned about using gene therapy for the purpose of determining sex, hair color or eye color of a baby. Using this method for determining sex, hair color or eye color of a child is morally unacceptable.”
	Societal betterment	“I would support the use of gene therapy if it is applicable to the entire human being all over the world. I do not see any harm in making someone more intelligent.”
	Diversity	“We should not destroy the existing heterogeneity in society. If the intelligence of all human beings were increased, there would be an uniform society which all the individuals resembled each other exactly, and there would be a single type of person.”

Table 3.31 (Cont.)

Themes	Codes	Sample Excerpts
	Informed consent of family	“The doctors who would apply the gene therapy treatment should inform the parents about the possible consequences of gene therapy and the parents’ approval should be a requirement for these applications.”
Value considerations	Patients/fetus’ rights/right to live	“Rather than aborting the fetus, Lale should consider the rights of the fetus. The fetus also has a right to live. I do not think that parents should have any right to choose on behalf of their unborn children.”
	Parents’ rights/decisions/ responsibility	“Parents should consider all the possibilities when making decisions about tampering with their child’s genes as this kind of intervention is irreversible.”
Socio-psychological considerations	Suffering, child-care Cope with difficulties, pain, etc.	“Raising a child with Cystic Fibrosis would be quite hard. The child would need special needs such as physiotherapy. The parents would need psychological support as well. These are all demanding processes.”
Political considerations	Government policies, politics	“I wonder how the governments would react to the use gene therapy for the purpose of increasing intelligence. It is a known fact that intelligent people are not easy to manage. Governments, however, desire easily manipulated people. Thus, it would be politically expedient for governments to prevent the development of gene therapy applications.”

Table 3.31 (Cont.)

Themes	Codes	Sample Excerpts
Legal considerations	Standards in genetic application, Legal regulations and limitations	“Gene therapy applications should be carried out consciously and in an organized fashion. Therefore, legal regulations are strongly needed.”
Family bias	The position change in ideas if the situation involved themselves or family members	“I believe that Lale should abort the fetus. It was easy for me to make a decision about Lale. But what would happen if it happened to me? I would definitely feel differently it were me dealing with this kind of decision”
Need more information	Additional information	“I exactly need to know how many weeks pregnant Lale is in order to decide. I mean, it is immoral to abort an eight-month-old fetus.”
Pop culture	Information provided in the media	“We always watch science fiction films about mutant creatures on TV. The possibility of creating mutant creatures in real life makes me concerned a lot.”
Support of science	Scientific developments, progress in science progress and developments in genetics	“I think that studies on fetal tissue transplantation should be continued. There is no treatment for Parkinson's disease at the moment. If these studies on fetal tissues would provide a treatment for Parkinson disease, empirical studies using fetal tissue should continue. Empirical findings might eventually provide a treatment for Parkinson's. Scientific research advances through new empirical findings.”

Table 3.31 (Cont.)

Themes	Codes	Sample Excerpts
Miscellaneous	Change in participant's ideas over time	"If the questions related to fetal tissue transplantation were asked ten years later my answers might be totally different because our ideas are continually changing over time."
	Birth control	"In the Huntington's disease scenario, Lale should have used birth control instead of considering abortion as an option. She should not have gotten pregnant to begin with."
	Alternative treatment methods	"I think such research studies as Fetal Tissue Transplantation can be conducted in different ways. For instance, using stem cells or umbilical-cord might be alternative options for the treatment of Parkinson's disease. We do not have to use fetal tissue."
	2-edged sword	"I am undecided on this scenario [Fetal Tissue Transplantation]. On the one hand, there is a treatment for Parkinson's disease. On the other hand, there is a living fetus. It is confusing. I could not decide whether using a fetus to develop a treatment of Parkinson's disease is acceptable or not."
	Uncertainty	"I could not decide whether to abort or abort the fetus [regarding Fetal Tissue Transplantation]". "It is so difficult to answer this question fetus [regarding Fetal Tissue Transplantation]."

Table 3.31 (Cont.)

Themes	Codes	Sample Excerpts
Miscellaneous (Cont.)	Nature of disease	“In the case of Cystic Fibrosis, there are ongoing research studies that are investigating the treatment of Cystic Fibrosis. But, in the case of Huntington's disease there are no research studies for its treatment. While there is a possibility of developing a treatment for Cystic Fibrosis, there is not any hope for patients with Huntington's disease yet. Thus, I believe that Lale [in Huntington's disease] should consider getting an abortion but Reyhan [in Cystic Fibrosis] should not abort the fetus.”

3.6. Trustworthiness of study

The trustworthiness of qualitative studies was reflected by the extent the researcher persuades the readers of the study about the validity and the reliability of the findings (Lincoln & Guba, 1985; Yıldırım, & Şimşek, 2008). According to Merriam (1992), reliability and validity issues are main concerns of qualitative studies that needs to be addressed. In addition, conducting study in ethical manner is considered as another concern (p. 212). Thus, reliability, validity and ethical issues were checked for ensuring trustworthiness of present study. This section is divided into three parts as validity of study, reliability of study and ethical issues.

3.6.1. Validity of the study

Internal validity refers to the match between the findings of the study and the reality (Merriam, 1992; p. 201). Accuracy of the findings should be ensured by employing multiple strategies as Creswell (2007) indicted. Thus, multiple strategies were employed in present study. The first strategy used was “Peer examination” proposed by Merriam (1998; p. 204). In this strategy, another researcher reviews and comments on the qualitative study (Creswell, 2007; p. 192). For ensuring this, another researcher in science education reviewed the codes as they emerged and gave feedbacks while developing codebook in present study. The second strategy was providing detailed descriptions of the settings to the readers which was known as using “rich, thick descriptions” (Creswell, 2007; Merriam, 1992). For ensuring this, a detailed information about the cases being investigated was provided to the participants in this study. Another strategy used in this study was “multisite designs”. In this strategy, the researcher uses several cases or situations for maximizing the diversity in explaining the issues being investigated (Merriam, 1992; p. 212). Thus, four different cases were used in present study in order to increase the diversity in explaining the participants’ decisions. Lastly, clarifying “researcher’s biases” strategy was used. In this strategy, the researcher’s position on research site and assumptions are clarifies for preventing biases that researcher bring to the study (Creswell, 2007; Merriam, 1992). Since the researcher is also considered as an instrument in qualitative study (Marshall and

Rossman, 2006; p. 72), it is important to clary her position in this study. For preventing researcher biases in research setting, the researcher firstly, explained her role before data collection. In addition, all the interviews were conducted by the same researcher. Lastly, tape recorder was used in order to analyze and interpret data without influencing original data itself.

3.6.2. Reliability of the study

Reliability of qualitative research can be described as consistency of researcher's inferences over time, location and circumstances (Gibbs, 2007; Fraenkel et al. 2013). For ensuring reliability of present study, inter-coder agreement was used (Miles & Huberman, 1994). Inter-coder agreement in a cross-checking procedure that is based of the agreement of two or more coders on the codes used for passages in the text (Creswell, 2007; p. 191). While the first coder is the researcher, the second coder was a doctoral candidate in the department of elementary education. The coders read and coded the same data on their own. Then, they discussed the categories and codes and a reliability analysis was performed using the followed formula by Miles and Huberman (1994).

Reliability= number of agreements / (total number of agreements + number of disagreements)

As a result, the inter-coder reliability was calculated as .93 which was considered as excellent by Cichetti (1994). Also, this value was more than .80 which was desired as cut off point by Miles and Huberman (1994). Accordingly, the inter-coder reliability was fulfilled.

3.6.3. Ethical issues

Conducting studies in ethical manner is considered to be an important concern in both qualitative and quantitative studies (Merriam, 1992; p. 212). Thus, before conducting study, required permission from Ethical Committee of Middle East Technical University and from Ministry of National Education were obtained in order to administer the instruments and interviews (See Appendix B and Appendix C). Only science teachers who accepted to participate this study voluntarily and signed the "Voluntary Participation Form" (see Appendix D) were participated in this study. Teachers were not placed under any risk while responding the instruments of study. In addition, any kind of deception was involved in the present study. For ensuring this, the researcher explained her role and the aim of the study before data collection in both qualitative and quantitative data collection procedures. Moreover, for ensuring the privacy of these participants, their real names were not used for anonymity while presenting the results. Furthermore, only the researcher and her advisor had accessibility to original data and data findings for providing confidentiality of research data.

3.7. Assumptions and Limitations of Study

It is important to present the assumptions and limitations of present study which might affect the interpretations of results and the drawn conclusions based on the results. Thus, firstly, the underlying assumptions of present study were presented below. Then, the limitations which might limit the generalizability of research findings were presented in following section.

3.7.1. Assumptions of the study

The following assumptions were made by the researcher of present study:

1. All participants' responses to the instruments used in the present study including their responses to the questions in the cases used in decision making interviews were sincere.
2. All the instruments were administrated under standard conditions.
3. There was no interaction between science teachers in the same school during the administration of instruments.
4. The participants were ensured that their names would be kept concealed in order to decrease any kind of pressure of personal exposure.

5. The participants for qualitative part of study were selected purposefully based on their teaching experiences. It was assumed that teaching experience is an important criteria for selecting good representatives in terms of understanding and giving diverse answers to the cases presented.

3.7.2. Limitations of the study

Some limitations regarding quantitative and qualitative part of present study were presented below:

1. For both qualitative and quantitative part of study, only science teachers who were volunteer were participated in present study. Thus, the number of participants were limited to the voluntarily partition of science teachers.
2. The study was limited by its reliance on self-reported questionnaires and trusting in the self-reported levels of the related constructs as indicated by the science teachers.
3. The qualitative data were limited to participants' responses, comments, experiences and perceptions about the cases presented in the study.
4. The determined factors that influence science teachers' decision making processes are valid within the framework of the cases used in present study.

CHAPTER IV

RESULTS

This chapter is divided into two sections. The first section encompasses the results of quantitative data analyses. In the second section, the qualitative data analyses are presented.

4.1. Results of Quantitative Analyses

In this section, descriptive and inferential statistics were presented. Firstly, descriptive statistics regarding background characteristics, (i.e., self-perceived knowledge and interest in genetics, source of information), teachers' genetics literacy levels, their attitudes towards a variety of issues in genetics literacy and their perceptions of teaching issues in genetics literacy are presented. Then, inferential statistics including Canonical Correlation Analysis results are given.

4.1.1. Descriptive statistics

This sub-section is divided into four parts. Descriptive statistics for background characteristics, teachers' genetics literacy levels, attitudes towards issues in genetics literacy and perceptions of teaching issues in genetics literacy are presented in following headings.

4.1.1.1. Teachers' background characteristics

This sub-section represents the findings concerning descriptive statistics of science teachers' perceptions of knowledge and interest in genetics as well as the source of information where they obtain their knowledge regarding genetic literacy issues.

4.1.1.1.1. Teachers' self-perceived knowledge in genetics

Frequency distribution regarding self-perceived knowledge in genetics was presented in Figure 4.1. Great majority reported themselves as "sufficiently" knowledgeable in genetics (74.8%). While nearly a quarter of participants reported that they had "a little" knowledge in genetics (23.1%), a few reported having “a lot” knowledge in genetics (1.5%). Very few (0.6%) rated them as not knowledgeable in genetics.

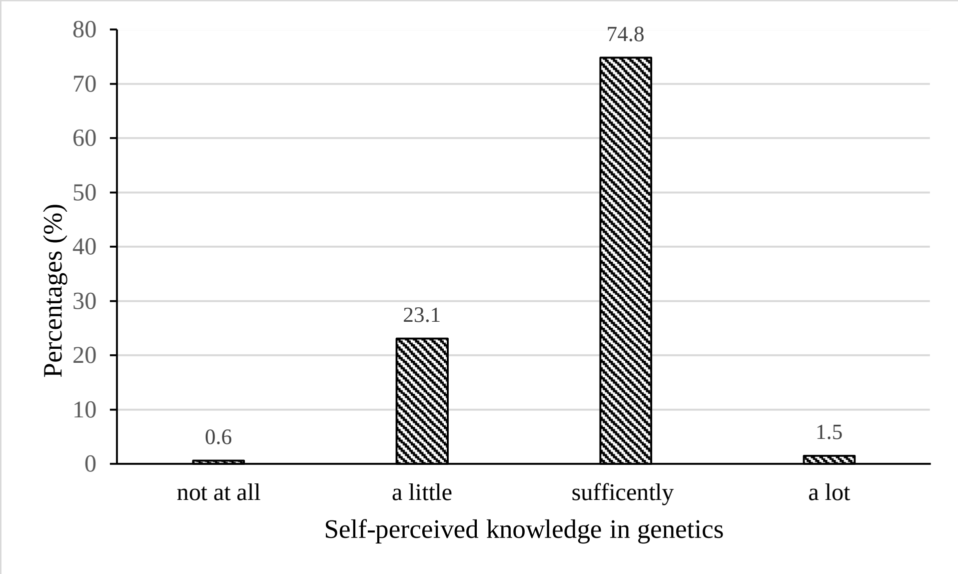

Figure 4. 4 Frequency distribution of self-perceived knowledge in genetics

In following part, results related to teachers’ self-perceived interest in genetics are described.

4.1.1.1.2. Teachers’ self-perceived interest in genetics

In terms of self-perceived interest in genetics, half of the participants (50%) claimed to have “a little” of interest in genetics and 41% claimed to have “a great deal” of interest in genetics. Whereas less than 10% reported that they were “barely” interested in genetics (7.8%). Only 1.2% rated themselves as “not interested” in genetics (see Figure 4.2).

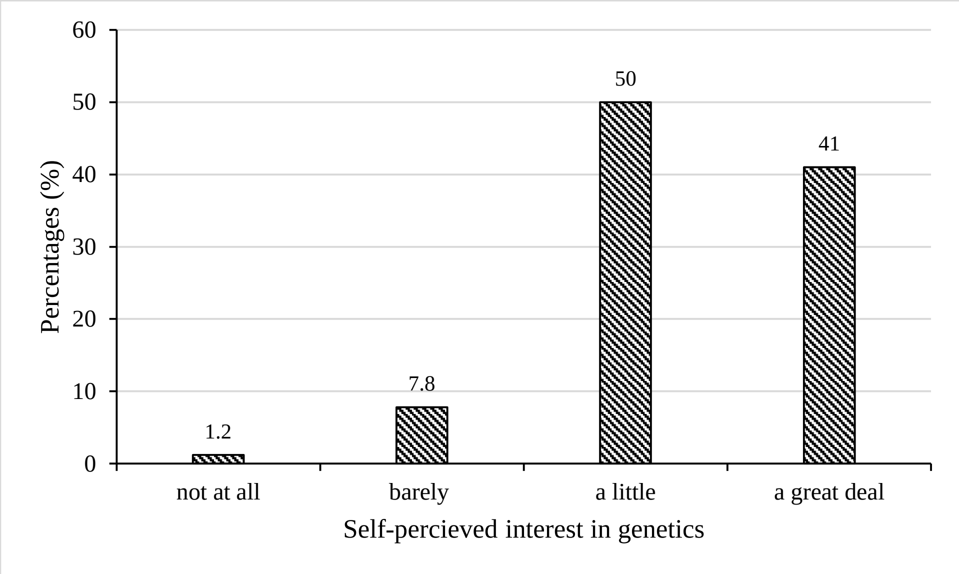

Figure 4. 5 Frequency distribution of self-perceived interest in genetics

Findings regarding science teachers' responses to source of information where they obtain their knowledge regarding issues in genetics literacy are presented in next section.

4.1.1.1.3. Teachers' responses to source of information regarding issues in genetics literacy

Participants mentioned about various source of information about genetic literacy. Results revealed that their main sources of information were internet (92.2%), followed by scientific journals (90.7%), television (87.3%) and university courses (82.4%). Newspapers and magazines were also frequently mentioned (78.2%). Relatively few identified their friends (26%) as the main source of information.

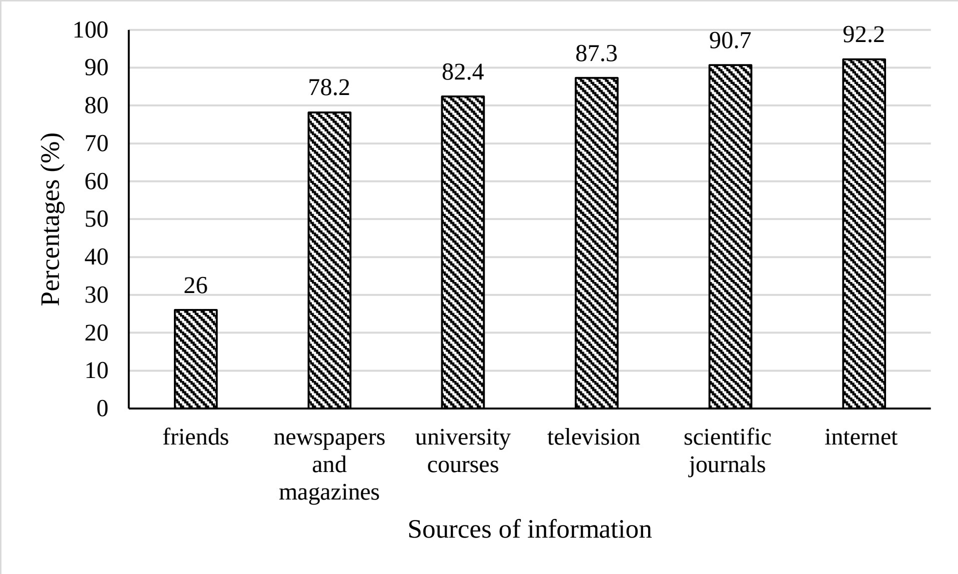

Figure 4. 6 Frequency distribution of sources of information

In following the part, results related to science teachers' genetics literacy levels are presented.

4.1.1.2. Science Teachers' genetics literacy levels

In this part, science teachers' genetics literacy levels with respect to the dimensions of GLAI is presented. Means, standard deviations and percentages of correct answers to the questions are given in Table 4.32.

Table 4. 32

Descriptive Statistics of GLAI

Dimension	Total item number	Mean (M)	Standard deviation (SD)	% of participants with the correct answer
Nature of the Genetic Material	7	4.30	1.48	50.11
Transmission of Genes	4	3.22	1.04	80.40
Gene Expression	4	1.47	0.98	49.04
Gene Regulation	4	2.04	1.18	50.98
Evolution	4	1.32	1.03	33.05
Genetics &Society	6	2.81	1.46	40.49
Total	29	15.16	4.54	

Of a possible 29 correct responses on the Inventory, science teachers attained a mean score of 15.16 (*SD*= 4.06) which means that they answered correctly slightly more than half of the questions presented in the Inventory, indicating a moderate level of genetic literacy. Specifically, majority of teachers (80%) correctly responded to the questions in *transmission of genes* dimension implying that they are quite knowledgeable in concepts related to Mendelian pattern of inheritance and meiosis. Half of teachers responded correctly to the questions in *nature of genetic material*, *gene regulation* and *gene expression* dimensions (51%, 50% and 49% respectively) indicating they are moderately knowledgeable in the concepts such as properties of DNA, DNA-gene-chromosome interactions, gene activity and description of genetic variation, Functions of genes in protein synthesis, multiple genes, and disorders associated with multiple genes as well as the concepts regarding gene regulation such as genetic variations and turn-on and turn-of genes. On the other hand, less than half (40%) correctly answered the questions in *genetics and society* dimension. Teachers are found to be less knowledgeable in relationships among science, ethic and genetics concerns, current-future applications of genetics and genetics technologies when compared to the other dimensions. Slightly more than a quarter (33%), on the other hand, correctly responded to the questions in *evolution* dimension. They had difficulty in understanding of concepts related to evolution and the role of genetic variation in evolution as well as in human ethnic groups as measured by the Inventory (See Table 4.1).

In following the part, descriptive statistics related to teachers' attitudes towards issues in genetics literacy are given.

4.1.1.3. Science teachers' attitudes towards issues in genetics literacy

In this part, descriptive statistics related to teachers' attitudes towards various issues in genetics literacy, namely, general attitude, use of genetic information, abortion, pre-implementation genetic diagnosis, gene therapy and gene therapy applications are given respectively. Descriptive statistics regarding general attitude towards genetics applications, use of genetic information, abortion, pre-implementation genetic diagnosis, gene therapy and specific applications of gene therapy with respect to the total sample were presented in Table 4.33.

Table 4.33

Descriptive statistics for issues in genetics literacy scale

Dimension	Likert Scale Type	M	SD
General attitude	5 point	3.28	.40
Use of genetic information	5 point	2.42	.81
Abortion	3 point	1.95	.67
Pre-Implementation Genetic Diagnosis	3 point	1.67	.69
Gene Therapy	4 point	2.25	.67
Gene Therapy Applications	5 point	1.89	.80

Considering multiple Likert scale format, science teachers' mean scores indicated a wide range of approaches to attitudes towards *Issues in Genetics Literacy.* For instance, while teachers mainly remained undecided in general attitude and use of genetic information dimensions, they agreed on abortion and use of pre-implementation genetic diagnosis in some cases such as mental disability. Participants' ideas in each dimension were explored in details below.

4.1.1.3.1. Science teachers' general attitudes

While analyzing data in attitude scale and perception scale, all strongly agree and agree categories are collapsed into one category of agree and strongly disagree and disagree categories are elected to disagree category. Moreover, the mean score between 2.5 and 3.25 indicated little persuasion about the statements showing personal involvement in issues regarding genetics literacy. Teachers' responses to *general attitude* dimension revealed that participants, in general, remained uncommitted to many items presented (M= 3.28, SD= 0.40). For instance, around 30% of participants were remained unsure about interfering people's genes, prohibition of changing genes as it is tampering with the nature and the benefits of research into human genes. Even they remained neutral to the items regarding changing genes, a vast majority appeared to believe in benefits of modern science (96%) and disagreed with the idea of benefits of modern genetics are exaggerated (63.8%). They also agreed on that genetic treatments will reduce human suffering (83.6%). A vast majority supported that idea that scientists should look for genetic cures (81.4%). While many teachers remained hesitant about changing genes, more than half agreed that it is better to cure illness without changing genes (57.3%) and facilities should be provided for disabled people instead of changing their genes (54.4%). They, however, disagreed that it would be better if we did not know to change people's genes at all (55.4%). On the other hand, more than half of teachers reported they are unaware of the impact of modern genetics on society (52.6%). Majority disagreed on the allowance of new genetic treatments on children (75.8%). The frequency distribution of teachers' responses to each item in general attitude dimension was given in Table 4.34.

Table 4.34

The frequency distribution of teachers' responses regarding general attitude

Item no	General attitude items	Percentage				
		SD	D	U	A	SA
1	We believe too often in science and not enough in feelings and faith	15.9	35.9	15.4	24.4	8.5
2	Overall, modern science does more harm than good	40.2	46.0	7.6	4.6	1.6
3	Research into human genes will do more harm than good	31.7	43.0	14.3	8.3	2.8
4	Many of the claims about the benefits of modern genetic science are greatly exaggerated	17.6	46.2	19.5	14.7	1.8
5	Nobody really knows what impact modern genetic science will have on society.	5.1	24.1	18.2	43.4	9.2
6	Genetic treatments for illness will do a lot to reduce human suffering	1.4	3.0	11.9	47.8	35.8
	Changing a person's genes is too risky, whatever the benefit might be	2.1	15.4	40.4	30.6	11.5
8	It is better to try to cure illness without changing people's genes	2.3	14.9	25.5	40.5	16.8
9	That in the end, research into human genes will do more to help us than to harm us	3.9	15.4	30.1	40.0	12.2
10	It would be better if we did not know to change people's genes at all	22.5	42.9	23.4	7.4	3.7
11	We should never interfere with people's genes	9.2	44.6	28.5	11.7	6.0

Table 4.34 (Continued)

Item no	General attitude items	Percentage				
		SD	D	U	A	SA
12	Scientists should not look for genetic cures because the world become too overpopulated	29.7	51.7	9.0	6.2	3.4
13	Changing genes should be forbidden as it is tampering with nature	16.8	37.7	27.6	12.4	5.5
14	That rather than change the genes of disabled people we should provide facilities to make life easier for them	4.4	21.6	19.5	37.2	17.2
15	It should be allowed to test new genetic treatments on children	47.1	28.7	14.3	6.0	3.9

Note: SD= strongly disagree; D=disagree; U=undecided; A=agree; SA=strongly agree

In following the part, descriptive statistics related to teachers' attitudes towards the use of genetic information are presented.

4.3.1.3.2. Descriptive statistics for teachers' attitudes towards the use of genetic information

In a 5-point scale, relatively low mean score (*M*= 2.42) obtained by teachers, implying their unfavorable attitudes towards the use of genetic information by different stakeholders such as insurance companies, employers or other authorities. Particularly, participants generally refused the idea that insurance companies should use genetic test results to accept or refuse people's life insurances and that the employer should have the right to see the genetic test results of employees (69.1%). Similarly, a vast majority disagreed on the idea that the employer should have the right to see the result of genetic tests (75.6%) and that the employer should have a right to make job applicants to have a test (78.3%). They, however, agreed on the issue that the employer should have a right to make job applicants to have a test to see if they are particularly sensitive to any substances like chemicals that they may be exposed in workplace. Frequency distribution of teachers' responses to the items in use of genetic information dimension is depicted in Table 4.35.

Table 4. 35

The frequency distribution of teachers' responses regarding use of genetic information

Item no	Use of genetic information item	Percentages				
		SD	D	U	A	SA
1	Genetic tests should be used by insurance companies to accept or refuse people for life insurance policies	37.2	31.9	14.7	11.7	4.4
2	The employer should have the right to see the result of this test	40.4	35.2	10.8	10.1	3.4
3	The employer should have the right to make job applicants to have a test	40.0	38.3	11.7	7.1	2.8
4	The employer should have the right to make job applicants to have a test to see if they are particularly sensitive to chemicals that may be used in the workplace	9.2	9.0	13.8	50.1	17.9

Note: SD= strongly disagree; D=disagree; U=undecided; A=agree; SA=strongly agree

In following the part, descriptive statistics related to teachers' attitudes towards abortion and pre-implementation genetic diagnosis are presented.

4.3.1.3.3. Descriptive statistics for teachers' attitudes towards abortion and pre-implementation genetic diagnosis

Participants' attitudes towards abortion and pre-implementation genetic diagnosis were explored by through cases related to severe medical conditions. In a 3-point Likert scale, teachers obtained a mean score of 1.95 (SD= .67) indicating that abortion "sometimes" should be a legal right for women. Their attitudes towards abortion, however, changed depending on the seriousness of the medical condition under consideration. For instance, while that they agreed that abortion should be legal right if the fetus was very likely to be born with a *severe mental disability* and be born with *physical disability* and would never be able to live an independent life (79.2% and 75.3% respectively). More than half of the participants, however disagreed with abortion if the child would be healthy but never grew taller than an eight-year-old. In similar manner, nearly half of the participants were opposed abortion if the child was very likely to be born with a condition that meant it would live in good health but then would die in its 20s or 30s (37.1%) (See, Table 4.36).

Table 4.36

The frequency distribution of teachers' responses regarding abortion

It would be always right for the woman to have a legal abortion if the child was very likely to… (Do you think it would be right or not for the woman to have a legal abortion...)	Percentage		
	AR	SR	NR
Be born with a serious mental disability and would never be able to live an independent life	59.1	20.1	20.8
Be born with a physical disability and would never be able to live an independent life	42.3	33.0	24.7
Be born with a condition that meant it would live in good health but then would die in its 20s or 30s	27.8	35.1	37.1
Be healthy but never grow taller than an eight year old.	20.4	27.7	51.9

Note: AR=Always right; SR=sometimes right; NR= never right

Teachers' opinions about *Pre-Implementation Genetic Diagnosis (PGD)* revealed that they "sometimes" agreed on the use of PGD (*M*= 1.67, *SD*= .69). While vast majority indicated their willingness to use PGD in severe *mental* and *physical disability* (84.2% and 82.9% respectively), slightly less than half (22%) opposed to use of PGD in case of having a child which was very likely to live a good health but then would die in its 20s or 30s. Likewise, more than a quarter (31%) disagreed on the use of PGD in case of having a child that would be healthy, but never grow taller than an eight year old (see Table 4.37). Overall, their attitudes changed depending on the seriousness of the medical condition under consideration.

Table 4. 37

The frequency distribution of teachers' responses regarding pre-implementation genetic diagnosis

There is another way in which couples can try to avoid having a child with a serious medical condition. The woman's eggs are fertilized outside her body with her partner's sperm and genetically tested. Only eggs without the condition are put back, and may then grow into a baby. Suppose it was likely that a couple would have a child… Do you think it would be right or not right for them to have this sort of treatment?	Percentage		
	AR	SR	NR
with a serious mental disability	65.9	18.3	15.8
with a serious physical disability	60.4	22.5	17.1
which would give a good health but then would die in its 20s or 30st	48.2	29.8	22.0
which would be healthy but never grow taller than an eight-year-old	42.2	26.8	31.0

Note: AR=Always right; SR=sometimes right; NR=never right

4.3.1.3.4. Descriptive statistics for teachers' attitudes towards gene therapy

Teachers' ideas about gene therapy were also explored through different cases. Their responses to these cases revealed that gene therapy should be used in some cases. For instance, vast majority thought that gene therapy should be used in cases such as *heart disease, breast cancer, having schizophrenia*, *making a person average weight rather than overweight, making a person less aggressive or violent* (see Table 4.38). They, on the other hand, were against to the use of gene therapy for *determining the sex of an unborn baby*, and *making someone more intelligent* or *taller/shorter* as well as *making someone to have full hair rather than being bald*. While half of participants agreed on the use of gene therapy to make a person straight rather than gay or lesbian, the other half were opposed the idea (51.5% and 48.5%, respectively).

Table 4. 38

The frequency distribution of teachers' responses regarding gene therapy

Suppose it was discovered that a person's genes could be changed. Do you think this should be allowed to or not allowed to…	Percentage			
	DA	PA	PNA	DNA
Make a person taller or shorter	11.7	34.0	20.9	33.4
Make a person more intelligent	21.2	30.3	20.2	28.3
Make a person straight rather than gay or lesbian	26.2	31.4	22.8	19.6
Make a person's chance of getting heart disease	52.4	33.8	7.8	6.0
Decrease a person's risk of getting breast cancer	59.1	29.2	6.2	5.5
Make a person average weight, rather than very overweight	35.2	35.3	14.7	14.7
Determine the sex of an unborn baby	9.2	19.8	17.2	53.8
To give someone a full of hair rather than being bald	18.9	30.3	21.1	29.6
To stop someone having schizophrenia	60.9	26.9	8.1	4.1
To make them less aggressive or violent	32.8	31.5	16.3	17.2

Note: DA=definitely allowed; PA= probably allowed; PNA=probably not allowed; DNA=definitely not allowed

4.3.1.3.5. Descriptive statistics for teachers' attitudes towards gene therapy applications

In this part, participants' opinions about specific applications of gene therapy, namely somatic gene therapy, germ-line gene therapy and in-utero gene therapy were explored by using cases related to *heart disease, cystic fibrosis* and *baldness*. While participants agreed on the use of specific applications of gene therapy *in heart disease* and *cystic fibrosis* cases, they opposed to using these applications in *baldness* case (see Table 4.39).

Table 4. 39

The frequency distribution of teachers' responses regarding specific applications of gene therapy

	Percentage				
Somatic Gene Therapy *Suppose it was discovered changing someone's genes by giving them injection. These new genes would not go onto any children they might later have. Do you think this should be allowed or not allowed?*	DA	PA	PNA	DNA	DMI
1. Someone in their 20s who has serious heart disease	57.0	28.9	6.9	4.4	2.8
2. Someone in their 20s who is bald and feels very embarrassed about it	23.7	32.3	22.7	18.4	3.9
3. Someone in their 20s born with cystic fibrosis.	54.7	26.2	9.2	3.4	6.4
Germ-line Therapy *Now, what if the new genes were passed onto their future children. Do you think this should be allowed or not allowed?*					
4. To give them less chance of getting serious heart disease in their 20s	63.8	24.8	5.5.	4.6	1.1
5. So they would not go bald in their 20s	30.1	31.5	17.0	19.1	3.0
6. So they would not have cystic fibrosis	59.7	23.2	7.8	4.1	5.1
In-utero Therapy *Now suppose a person's genes could be changed before they were born-by treatment while still in their mother's womb. The new genes would not be passed onto any children they later have. Do you think this should be allowed or not allowed?*					
7. To give them less chance of getting serious heart disease in their 20s	64.6	25.5	5.3	3.0	1.6
8. So they would not go bald in their 20s	33.8	30.1	17.4	15.6	3.1
9. So they would not have cystic fibrosis	61.3	24.8	6.1	3.4	4.4

Note: DA=definitely allowed; PA= probably allowed; PNA=probably not allowed; DNA=definitely not allowed; DMI=it depends/needs more information

Descriptive statistics regarding teachers' responses to gene therapy applications, namely, somatic, germ-line and in-utero gene therapy are presented.

4.1.1.4. Descriptive statistics for teachers' perceptions of teaching issues in genetics literacy

Science teachers' perceptions of teaching issues in genetics literacy were analyzed under three factors, namely *necessity of introducing issues in genetics literacy, factors that impede introducing issues in genetics literacy* and *teachers' personal science teaching efficacy (PSTE) beliefs regarding teaching issues in genetics literacy.* Results revealed that participating teachers tended to believe the necessity of mentioning issues in genetics literacy in the science classes (*M*= 3.85, *SD*= .42), had moderate sense of self-efficacy beliefs regarding teaching issues in genetics literacy (*M*= 3.55, *SD*= .62), and acknowledged that there are same factors that prevent them teaching these issues to students (*M*= 3.15, *SD*= .69). Descriptive statistics with respect to teachers' perceptions of teaching issues in genetics literacy were presented in Table 4.40.

Table 4.40

Descriptive statistics for teachers' perceptions of teaching issues in genetics literacy

Dimension	# of items	M	SD
Necessity of introducing issues in genetics literacy	8	3.85	.42
The factors that impede introducing issues in genetics literacy	5	3.15	.69
Teachers' personal teaching efficacy regarding issues in genetics literacy	4	3.55	.62

In following part, participants' perceptions about the necessity of introducing issues in genetics literacy, the factors that impede introducing issues in genetics literacy and teachers' personal teaching efficacy beliefs regarding teaching issues in genetics literacy are presented in detail.

4.1.1.4.1. Teachers' perceptions of the necessity of introducing genetics literacy in their classrooms

Participants' perceptions about the necessity of introducing genetics literacy in their classrooms were evaluated by eight items in the scale. Specifically, a great majority believed in the importance genetics literacy as much as teaching the rest of science topics (89.2%) and believed in genetics literacy does indeed worth the effort and time (93.7%) (See Table 4.10). In addition, they expressed the necessity of introducing issues in genetics literacy (79.1%). Moreover, they stressed the necessity of inadequacy of students' background regarding issues in genetics literacy (92.9%). They also agreed that introducing issues in genetics literacy into science classes would increase students' interest in science (85.2%). They also indicated their willingness to use materials in class related to genetics literacy if they can get (87.9%), develop teaching and learning materials on issues in genetics literacy for their classes (81%) and to participate in a program that helps deal with issues in genetics literacy (86.9%).

Table 4. 41

The frequency distributions of teachers' responses regarding perceptions of the necessity of addressing issues in genetics literacy

Item description	Percentages				
	SD	D	U	A	SA
I want to develop teaching and learning materials on issues in genetics literacy for my science class	.2	5.7	13.1	48.4	32.6
If I can get materials on issues in genetics literacy, I am willing to use them in class	-	5.7	6.4	61.6	26.3
I am willing to participate in a program that helps deal with issues in genetics literacy.	.7	4.4	8.0	55.2	31.7
The inadequacy of students' background in science regarding issues in genetics literacy needs to be addressed.	.5	2.5	4.1	56.0	36.9
Introducing genetic literacy issues into science classes will increase students' interest in these issues.	.2	3.4	9.2	51.7	33.5
Genetics literacy education is not as important as the rest of the science curriculum.	37.2	52.0	5.7	4.1	1.0
Genetics literacy teaching is not worth the effort and time.	49.4	44.3	4.4	1.4	.5
Introducing issues in genetics literacy into science classes is definitely necessary.	3.2	4.4	13.3	40.0	39.1

Note: SD= strongly disagree; D=disagree; U=undecided; A=agree; SA=strongly agree

4.1.1.4.2. Teachers' perceptions of the factors that impede addressing issues in genetics literacy in their classrooms

Teachers' perceptions about the factors that impede addressing issues in genetics literacy were assessed by five items in PTIGLS. Participants' responses to the items in this dimension revealed that teachers acknowledged the existence of some obstacles to addressing genetics literacy in science classes. Descriptive statistics suggested that teachers had some difficulties in addressing issues in genetics literacy (See Table 4.42). To be more precise, a considerable proportion of participants agreed that students are not mature enough to be interested in and understand addressing issues in genetics literacy in science classes (55.5%). In addition, more than a quarter (36.6%) indicated that classes dealing with issues in genetics literacy are most likely for high achieving students. Furthermore, participants remained uncommitted about whether dealing with genetics literacy using various teaching strategies (role plays and group activities) is possible or not (23.2%) and whether issues in genetics literacy confuse students about their own values (25.7%).

Table 4. 42

The frequency distributions of teachers' responses regarding perceptions of the factors that impede addressing issues in genetics literacy

	Percentages				
Item	SD	D	U	A	SA
I believe that students are not mature enough to be interested in and understand issues in genetics literacy	4.6	24.1	15.8	40.0	15.5
I believe that students are barely interested in issues in genetics literacy.	23.0	49.2	15.6	9.0	3.2
Classes dealing with issues in genetics literacy are most likely to be for high achieving students	12.9	36.0	14.5	25.3	11.3
Addressing issues in genetics literacy in science classes could confuse students about their own values.	4.6	31.0	25.7	32.0	6.7
Dealing with issues in genetics literacy using various teaching strategies (role plays and group activities) is hardly possible in a "real" classroom situation.	7.8	42.0	23.2	20.9	6.1

Note: SD= strongly disagree; D=disagree; U=undecided; A=agree; SA=strongly agree

4.1.1.4.3. Teachers' perceptions of the personal teaching efficacy beliefs regarding issues in genetics literacy

Participants' responses to personal teaching efficacy beliefs regarding issues in genetics literacy dimension revealed that they were not highly confident in their abilities to teach issues in genetics literacy. For instance, a considerable proportion of participants (42.5%) expressed a high level of uncertainty about their abilities to develop teaching and learning materials about issues in genetics literacy. Relatively fewer participants (33.3%) remained unsure about necessary knowledge to teach issues in genetics literacy effectively. They, on the other hand, seemed to perceive themselves as having sufficient understanding of issues in genetics literacy (73.6%) and having the ability teach issues in genetics literacy as well as they did most subjects, even if they tried hard (62.1%).

Table 4. 43

The frequency distribution of teachers' responses regarding personal teaching efficacy beliefs about issues in genetics literacy

	Percentages				
Item	SD	D	U	A	SA
Even if I try very hard, I will not teach issues in genetics literacy as well as I will most subjects.	12.9	49.2	19.5	14.7	3.7
I sufficiently understand what issues in genetics literacy in science and technology is.	.9	4.1	21.4	57.2	16.4
I have confidence in developing teaching and learning materials about issues in genetics literacy.	.2	13.3	42.5	35.6	8.4
I have the knowledge necessary to effectively teach about issues in genetics literacy to my middle school students.	1.6	12.4	33.3	44.1	8.6

Note: SD= strongly disagree; D=disagree; U=undecided; A=agree; SA=strongly agree

In following part, inferential statistics including canonical correlation analysis results is presented.

4.1.2. Inferential Statistics

This part is divided into sub-parts. Firstly, the assumptions required for canonical correlation analysis is checked. Then, the canonical analysis results are presented.

4.1.2.1. Assumptions of Canonical Correlation Analysis

In this sub-part, assumptions of canonical correlation analysis, namely, normality, linearity, homoscedasticity, outliers, multicollinearity and singularity were checked as Tabachnick and Fidell (2013) proposed. Firstly, the data screening for exploring missing data patterns was performed.

4.1.2.1.1. Missing data

The data screening for exploring missing data patterns was performed with total scores in GLAI, general attitude, use of genetic information, abortion, pre-implementation genetic diagnosis, gene therapy and gene therapy applications, the necessity of introducing genetics literacy, impeding factors and personal teaching efficacy regarding issues in genetics literacy as well as the independent variables, namely, gender, teaching experience, self-perceived knowledge and interest in genetics. Data screening revealed that only missing cases in variable named "teaching experience" (0.5%) in total scores as well as the independent variables (see Table J.1 in Appendix J). Thus, the two cases were removed and the rest of analyses were performed with remaining 435 cases.

4.1.2.1.2. Normality

Normality of data can be assessed by checking skewness and kurtosis values. In addition, histogram with symmetrical, bell-shaped curve are assumed to be normal. (Pallant, 2007). Thus, descriptive statistics of dependent variables namely, GLAI, general attitude, use of genetic information, abortion, pre-implementation genetic diagnosis, gene therapy and gene therapy applications as well as the necessity of introducing genetics literacy, impeding factors and personal teaching efficacy regarding issues in genetics literacy were checked. Moreover, histograms and Normal Q-Q and P-P plots for each dependent variables were explored (See from Figures J.2.1 to Figures J.2.30 in Appendix J). The skewness and kurtosis values for each variables were found the between the range of +2 and -2 as Pallant (2007) suggested. The exploration of histograms revealed the variables generally have a symmetrical and bell-shaped curves. In addition, exploration of normal Q-Q and P-P plots showed a reasonably straight line which suggested a normal distribution.

Table 4. 44

Descriptive statistics regarding dependent variables in the study

	M	SD	Max	Min	Range	Skewness	Kurtosis
GLAI	15.16	4.54	24	0	24	-.63	.84
General attitude	3.28	.40	4.47	1.60	2.87	-.47	.56
Use of genetic information	2.42	.81	5	1	4	.49	.16
Abortion	1.95	.67	3	1	2	.21	-1.12
Pre-implementation genetic diagnosis	1.67	.69	3	1	2	.69	-.80
Gene therapy	2.25	.67	4	1	3	.41	-.46
Gene therapy applications	1.89	.80	5	1	4	1.14	1.34
Necessity	3.85	.42	2.13	4.88	2.75	-.62	.89
Impeding factors	3.15	.69	5	1	4	-.12	.05
Efficacy	3.55	.62	5	1	4	.06	.10

In following part, another assumption of canonical correlation analysis, namely linearity assumption was checked and the results are presented.

4.1.2.1.3. Linearity and homoscedasticity

Linearity is an important assumption of canonical correlation as canonical correlation is performed on correlations that only reflects linear relationships (Tabachnick & Fidell, 2013, p. 575). Similarly, canonical correlation analysis gives best results when the relationships among variables are homoscedastic which means the variability in scores for variable X should be similar at all values of variable Y (Pallant, 2007; Tabachnick & Fidell, 2013). Both linearity and homoscedasticity assumptions can be checked throughout scatterplots (Pallant, 2007). Thus, scatterplots were examined for ensuring whether these assumptions were met or not (see Figure J.3.1 to Figure 3.1o in Appendix J for residuals scatterplots). Examination of residual scatterplots revealed most of the scores concentrated in the center. Thus, the linearity assumption is met. In addition, it was revealed that the band enclosing the residuals is close to the width at all values of the predicted dependent variables which means that the homoscedasticity assumption is met.

4.1.2.1.4. Outliers

Another assumption of canonical correlation analysis is checking for outliers. Outliers can be checked by inspecting Mahalanobis distances as Pallant (2007) suggested. According to Tbachnick and Fidell (2013), critical value of Mahalanobis distance with four variables at a = .001 is 18.467 (p. 595). The Mahalanobis distance value calculated in this study was found as 18.226 that did not exceed the critical value of 18.447. Thus, no outliers were detected in present study.

4.1.2.1.5. Multicollinearity and singularity

The last assumption of canonical correlation analysis is checking multicollinearity and singularity. While multicollinearity occurs when the variables in each set are highly correlated (more than .7), singularity occurs when one independent variable is actually a combination of other independent variables (Pallant, 2007; Tabachnick & Fidell, 2103) Multicollienarity assumption can be checked throughout correlations among variables. The correlation coefficient among independent variables are presented in Table 4.45. The correlation coefficents between variables were found to be less than .7. In addition, multicollinarity and singularity assumptions were checked throughout collinarity diagnostics. According to Pallant (2007), the presence of multicollinearity can be detected if tolerance value is found to be less than .10, or VIF value is found to be above 10. The examination of collinearity statistics revealed that there is no multicollinearity and singularity in present data (See Table 4.46)

Table 4. 45

The correlation coefficents among independent variables

	1	2	3	4	5	6	7	8	9	10
1. GLAI	1.00									
2. General attitude	.10	1.0								
3. Use of genetic information	.065	-.36**	1.0							
4. Abortion	.40	.220*	-.023	1.0						
5. Pre-implementation genetic diagnosis	.18	.220**	.06	.422**	1.00					
6. Gene therapy	.52	.164*	-.208**	.226**	.176**	1.00				
7. Gene therapy applications	.10	.255**	-.057	.247**	.267**	.533**	1.00			
8. Necessity	.019	-.312**	.035	-.186**	-,220**	-.236**	-.320**	1.00		
9. Impeding factors	.066	-.251**	.052	-,035	-.138**	-.092	-.152**	.381**	1.00	
10. Teaching efficacy beliefs	-.030	-.181**	-.029	-.059	-.123*	-.169**	-.232**	.372**	.355**	1.00

**$p < 0.01$
* $p < 0.05$

Table 4. 46

Collinarity statistics of independent variables

Variable	Tolerance	VIF
GLAI	.958	1.022
General attitude	.831	1.203
Use of genetic information	.940	1.064
Abortion	.773	1.294
Pre-implementation genetic diagnosis	.772	1.295
Gene therapy	.665	1.503
Gene therapy applications	.637	1.570
Necessity	.704	1.420
Impeding factors	.783	1.277
Teaching efficacy beliefs	.797	1.255

In following part, canonical correlation analysis results are presented.

4.1.2.2. Canonical Correlation Analysis Results

In order to examine, the nature of the independent relationships between two sets of multiple dependent and multiple independent variables, canonical correlation analysis was preferred over simple regression analysis, as suggested by Tabachnick and Fidell (2013). Science teachers' background characteristics as gender, teaching experience, self-perceived interest and knowledge in genetics were determined as SET 1. Teachers' GLAI scores, their attitudes towards general attitude, use of genetic information, abortion, pre-implementation genetic diagnosis, gene therapy and gene therapy applications, and the necessity of introducing genetics literacy, impeding factors and personal teaching efficacy regarding genetics literacy issue were determined as SET 2.

The full model (Function 1 to 4 and Function 2 to 4) were statistically significant (Wilk's Lambda (λ)= .670, F(40, 1590.65)= 4.436, p< .001 and Wilk's Lambda (λ)= .863, F(27, 1227.26= 2.360, p< .001, respectively). Subsequent pairs were not accounted because χ^2

tests were not statistically significant (p>.05). Thus, the first to pairs of canonical variates are accounted for significant relationships between two sets of variables. The first canonical correlation was .50 (25% overlapping variance) and the second canonical correlation was .32 (10% overlapping variance). Data on the first two pairs of canonical variates were provided in Table 4.47. In detail, correlations between the variables and the canonical variates, standardized canonical variate coefficients, within-set variance accounted for by the canonical (percent of variance), redundancies, and canonical correlations were presented (see Table 4.47).

With a cutoff correlation of .3, the first canonical variate was positively correlated with gender (.30), self-perceived interest (.63) and self-perceived knowledge (.83). Among SET 2 variables; the first canonical variate was positively related with genetics literacy levels (.47), general attitude (.33), teachers' perceptions of importance of teaching issues in genetics literacy (.58), impeding factors (.55) and self-efficacy beliefs (.82); but negatively related with gene therapy (-.33) and gene therapy applications. The first pair of canonical variates demonstrated that female science teachers who perceived themselves as more knowledgeable and more interested in genetics were likely to be more genetically literate and held favorable general attitudes as well as perceived the necessity of addressing issues in genetics literacy in their classes and perceived positive self-efficacy beliefs about teaching genetics literacy in their classes. In addition, they perceived more impeding factors that hinder teaching issues in genetics literacy in their classes. They, however, were likely to held negative attitudes towards gene therapy and gene therapy applications.

On the other hand, the second canonical variate was negatively associated with teaching experience (-.93) and self-perceived knowledge in issues in genetics literacy (-.38). Among SET 2 variables, the second canonical variate was positively related with teachers' genetics literacy levels (.48), their attitudes towards abortion (.64), gene therapy (.50) and gene therapy applications (.36). The second pair of canonical variates demonstrated that experienced science teachers who perceived themselves knowledgeable in genetics literacy were likely to be less genetically literate and held negative attitudes towards abortion, gene therapy and gene therapy applications. Besides, the percentage of variance values revealed that the first canonical variate pair extracts 30% of variance of from set 1 and second canonical variate pair extracts 26% of variables from set 1.

Table 4. 47

Correlations, standardized canonical coefficents, canonical correlations, percent of variance and redundancies between background characteristics (SET 1) and genetics literacy levels, attitudes towards issues in genetics literacy and perceptions of teaching issues in genetics literacy (SET2) variables and their corresponding canonical variates

	First canonical variate		Second canonical variate	
	Correlation	Coefficent	Correlation	Coefficent
SET 1				
Gender	.30	.22	-.17	-.22
Teaching experience	.19	.37	-.93	-.93
Self-perc. interest	.63	.42	-.07	.20
Self-perc. knowledge	.83	.72	-.38	-.23
% of variance	.30		.26	Total=.56
Redundancy	.07		.02	Total=.09
SET 2				
GLAI	.47	.33	.48	.52
General attitude	.33	.01	-.25	.01
Use of genetic information	-.24	-.24	-.04	.11
Abortion	.15	-.01	.64	.62
Pre-implementation genetic diagnosis	.27	.05	.16	-.10
Gene therapy	-.40	.18	.50	.38
Gene therapy applications	-.33	.09	.36	.14
Necessity	.58	.17	.07	.35
Impeding factors	.55	.19	-.28	-.35
Self-efficacy beliefs	.82	.64	-.06	-.02
% of variance	.21		.12	Total =.33
Redundancy	.05		.01	Total =.06
Canonical correlation	.50		.32	

4.2. Findings of Qualitative Analyses

The aim of this study is to determine the factors influencing how science teachers make decisions in matters involving genetic research and its applications. To this end, the data obtained from semi-structured interviews with 18 science teachers were analyzed using the qualitative method proposed by Miles and Huberman (1994). Using this method, the researcher interprets which patterns are more frequent and decides which ones are more important or significant than the others (Miles & Huberman, 1994, p. 253). The factors influencing how science teachers make decisions are as follows: personal experience, socio-cultural factors, emotional factors, religious factors, economic factors, technology factors, moral factors, values, political factors, legal factors, family bias, pop culture, the need for more information, scientific support and others. The themes for each factor are presented below. Then, every factor was examined using frequency analysis taking quotes from the answers given by the teachers to questions during the interviews. Each factor and its corresponding frequency are shown in Table 4.48.

Table 4. 48

Frequencies of factors that influence participants' decision making processes

Themes	Themes	Frequency	Percentage (%)
Personal experiences	Having own child Having a relative	15	1.78
Socio-cultural considerations	Turkish culture Turkish traditional family structure Turkish customs	14	1.66
Emotive considerations	Sympathy Empathy	44	5.22
Socio-psychological concerns	Suffering, child-care Cope with difficulties, pain, etc.	70	8.30
Religious considerations	Faith, God, religion	33	3.91
Economic cons.	Financial issues (wealth-poverty, expenses of genetic application)	21	2.49

Table 4.48 (Cont.)

Themes	Themes	Frequency	Percentage (%)
Technological concerns	Side effects	44	5.22
	Malicious use	29	3.44
	Risk factors	9	1.07
	Credibility	6	0.71
Moral considerations	Health improvement	123	14.59
	Slippery slope	40	4.74
	Taking human life	39	4.63
	Disrupting natural order	30	3.56
	Societal betterment	20	2.37
Moral considerations	Social stratification	18	2.13
	Means to an end	17	2.02
	Diversity	5	0.59
	Patients/fetus' rights/right to live	29	3.44
Value considerations	Parents' rights/decisions/responsibility	19	2.25
	Informed consent of the family	14	1.66
Family bias	The position change in ideas if the situation involved themselves or family members	15	1.78
Political concerns	Government policies, politics	4	0.47
Legal concerns	Standards in genetic application, Legal regulations and limitations	24	2.85
Pop culture	Information provided in the media	7	0.83
Need more information	Additional information	12	1.42
Support of science	Scientific developments, progress in science progress and developments in genetics	50	5.93
	Alternative treatment methods	30	3.56
	2-edged sword	30	3.56
	Uncertainty	10	1.19
Miscellaneous	Nature of disease/ type of disease	12	1.42
	Birth control	6	0.71
	Change in participant's ideas over time	4	0.47

In the following section, the factors are listed in order of frequency from highest to lowest with the corresponding percentages (%) together with sample quotations. When teachers' quotations are reported the letter "T" and a number are used to indicate each teacher. While the letter "F" represents female teacher, the letter "M" represents male teachers in the study. Square brackets [ ] are used to complete the meaning that teacher tried to express during the interview. Abbreviations for each case are presented in the quotations. For instance, "FTT" is used for *Fetal Tissues Transplantation Scenario*, "HD" is used for *Huntington's Disease Scenario*, "CF" is used *Cystic Fibrosis Scenario*, "GTHD" is used for *Gene Therapy on Huntington's Disease Scenario* and "GTI" is used *Gene Therapy on Intelligence Scenario* (see Appendix I1 to I4).

4.2.1. Moral considerations

Science teachers mainly took moral issues into consideration when making decisions (35% of total statements). Teachers generally focused on the possible consequences of genetic applications by making a utilitarian analysis of the benefits of genetic applications. Some principles were also taken into account such as perceiving an embryo as a living human being, meaning that sacrificing an embryo violates the principle of taking human life. The frequencies for each code under the theme of moral considerations are presented in Figure 4.7.

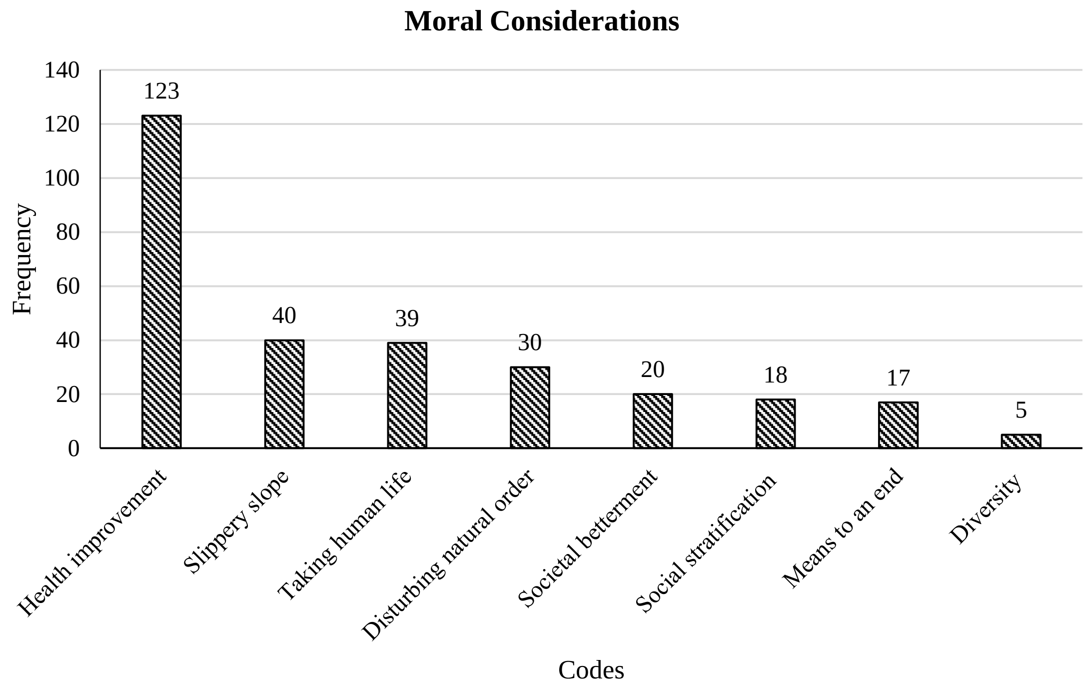

Figure 4. 7 Frequencies of moral considerations that influence participants' decision making processes.

As depicted in Figure 4.7, teachers generally concerned about health improvement, followed by slippery slope, taking human life, disrupting natural order, societal betterment, social stratification means to an end and diversity codes. Each topic under the moral considerations theme together with its corresponding frequency and percentage (%) will be explained in detail including example quotations.

4.2.1.1. Health improvement

As indicated in Figure 4.7, the most frequently stated factor affecting participants' decision making regarding genetic applications was found to be "health improvement" (14.59 % of total statements). All the 18 science teachers agreed on the use as well as the development of genetic applications would be beneficial in the case of health improvement. In fact, using genetics applications for the purpose of treating diseases was found to be very common among the participants' responses. The statements below provide quotes highlighting how teachers approved the use of genetic applications for medical treatment purposes.

> Assuming it was a real case [Gene Therapy on Huntington's disease], I would accept it for the treatment of diseases. Ultimately, it is a treatment method that has been discovered by a human being. There is no reason not to apply it (GTHD; T2, F)
>
> In the case of fetal tissue transplantation, the family decided to terminate the pregnancy. So, the fetus can be used for treatment of Suzan's father, who suffers from Parkinson's disease. (FT; T4, F)
>
> As Parkinson's disease is fatal, and there is no treatment option other than fetal tissue transplantation at that moment, I would allow the application even it was an experimental trial, (FT; T6, F)
>
> I think gene therapy method should only be used for the treatment of diseases by changing the infected genes with the healthy ones. (GTI; T9, M)

As can be seen from the teachers' responses, all teachers agreed on the use of genetic applications presented in scenarios involving the treatment of diseases.

4.2.1.2. Slippery Slope

Slippery slope was another significant moral consideration that was frequently stated by teachers (4.74% of total statements). Most of the teachers indicated their concerns that permission to use genetic applications in one acceptable context may lead to the use of that technology in unacceptable contexts. Teachers' concerns were concentrated mainly in gene therapy scenarios. For example, a teacher might support gene therapy for the treatment of diseases but would oppose its use for making cosmetic alterations. They especially disapproved the use of gene therapy for cosmetic reasons such as changing someone's external appearance (e.g., hair color or eye color). Here are some sample quotations:

> I am concerned about using gene therapy for the purpose of determining sex, hair color or eye color of a baby. Using this method for determining sex, hair color or eye color of a child is morally unacceptable. (GTHD; T2, F)

> There should be some limitations. For instance, this [gene therapy] should not be used for making someone have blonde hair or making someone more intelligent. Allowing gene therapy without any limitation can get out of control at some point. (GTHD; T4, F).

> Using gene therapy for eliminating the Huntington's disease gene is acceptable. But I have some doubts about how this method will be used in future. Today it might be used for eliminating Huntington's disease genes, but in the future, a mother might prefer to have a baby with blonde hair or more appealing external appearance. Thus, gene therapy should entirely be forbidden. (GTHD; T5, M)

> Gene therapy should only be used for situations that affect human life negatively like diseases. But using it for other issues like intelligence, beauty or height could be dangerous. We would not be able to control it. (GTHI; T9, M)

The teachers' statements revealed that their tendency to draw a line between what is acceptable and what is not acceptable in the field of gene therapy.

4.2.1.3. Taking human life

Teachers' concerns regarding the status of an embryo as a human being were grouped under the taking human life theme (4.63% of total statements). 10 out of 18 teachers believed that the embryo was a living human, so sacrificing embryos violates the principle of taking human life. This code generally emerged in scenario involving fetal tissue transplantation. They, usually, opposed fetal tissue transplantation as it requires the sacrificing of human embryos. The statements below provide examples of how the teachers approached the fetal tissue transplantation scenario:

> This method [fetal tissue transplantation] is based on experimentation; therefore, we could not be 100% sure whether it would be successful or not. In addition, we have to consider that the embryo being used is alive. Thus, I would disagree with the idea of using this method. (FTT; T2, F)

> In the scenario, we would be destroying a living thing. When I abort the fetus intentionally, I terminate its life. Thus, I believe that fetal tissue transplantation should be the last method to conduct research (FTT; T3, F)

> This method is acceptable unless it harms the fetus. I think that terminating someone else's life is not correct even if tissue transplantation is required for the treatment of Suzan's father. (FTT; T11, F)

Besides, in their responses some of the teachers expressed the opinion that conducting research using human embryos is not "ethical". These teachers specifically emphasized the ethical issues associated with fetal tissue transplantation. Sample quotations from teachers' responses that emphasize the ethical aspect of fetal tissue transplantation method are presented below:

> This method does seem unethical to me because we terminate someone else's life. As because the fetus is also a living thing, using a healthy fetus with the purpose of treatment of Parkinson Disease is not humanistic. (FTT; T13, M)

> I am against the use of fetal tissue transplantation because you have to consider taking human life. What I mean is you are actually killing a living thing by using this method. I think any research that terminates others' life is not ethical. (FTT; T18, F)

Lastly, one of the teachers (T12), unlike the other participants, agreed on the use of the fetal tissue transplantation method only in early stages of pregnancy. According to him, a fetus is not alive during the early stages of pregnancy. The following statement corresponds to this situation:

> This method can be applied in the first phase of pregnancy because the fetus is not alive and the tissues have not been formed yet. But it is alive in the later phases of pregnancy. At that point, this method is not appropriate. (FTT, T12, M)

As can be seen from the teachers' statements, most of the teachers believed that life begins at the moment of fertilization; therefore using the fetus in fetal tissues transplantation is tantamount to murder. Only one teacher (T12) believed that the fetus is not alive at the moment of fertilization.

4.2.1.4. Disrupting the Natural Order

Another moral concern that teachers indicated was that the genetics application might alter the natural process (3.56% of total statements). This code was prominent in scenarios involving gene therapy on human intelligence where teachers mainly emphasized altering the natural process. Here are some examples of teachers' comments on this:

> I would disagree with the use of gene therapy for altering the genes of an ordinary child. It would disturb the natural order. This practice is an affront to human dignity (GTI, T9, M)
>
> I am against the use of gene therapy unless we are talking about a severe disease. I think using gene therapy for anything else is an excessive violation of the natural process. You should not mess with the natural flow of things. (GTI, T14, F)

The teachers' statements indicated that they were concerned about the use of gene therapy applications because it constituted outside intervention in the natural process.

4.2.1.5. Social stratification

Teachers' concerns regarding that use of genetic technologies that could segregate a population by creating classes of "genetic haves" and "genetic have nots" were grouped under the social stratification code. Eight teachers stressed that genetics applications might create some kind of class division in society (2.13% of total statements). Teachers' statements indicating their concerns regarding the segregation of society into more classes are presented below:

> If gene therapy were to be used for increasing human intelligence, then, there would be some kind of genetic stratification in the form of people whose genes are altered and others whose genes are not. Those people whose genes are altered through gene therapy would be one step ahead of ordinary people. (GTI, T2, F)

> What makes me concerned is that when people's genes are changed they would become more intelligent. But that would cause another social line in addition to the ones we already have. (GTI, T11, F)

> There is already segregation in society such as public and private schools. Likewise, we would create people who are more "intelligent" by changing their genes, and there would be "ordinary" people. Eventually, we would create further segregation in society. (GTI, T13, M)

As can be seen from the teachers' responses, teachers' concerns mainly focused on the use of gene therapy on human intelligence. While they agreed on the use of gene therapy for the treatment of Huntington's disease (i.e. health improvement code), they stressed that using gene therapy for increasing human intelligence would cause segregation in society.

4.2.1.6. Societal betterment

Teachers' statements that imply the use of genetic technologies will improve society overall are grouped under the "societal betterment" theme. Eight out of 18 teachers emphasized how genetic applications, specifically those increasing human intelligence, might contribute to the betterment of society (2.37% of total statements). The statements below provide examples of how teachers approved the use of genetic applications for treatment purposes:

> I would support the use of gene therapy if it is applicable to the entire human being all over the world. I do not see any harm in making someone more intelligent. (GTI, T1, M)

> Our knowledge about how the universe works is limited, and this knowledge has been constructed by intelligent people like Newton or Einstein. If it were possible to make everyone more intelligent, there would be more people who can solve the problems that human beings are faced with. Thus, there would be an overall improvement in society. (GTI, T13, M)

Some of the teachers also stressed that the gene therapy treatment for Huntington's disease would benefit humanity by eliminating defective genes from mankind's gene pool. Example quotations of teachers expressing their viewpoints about how the elimination of defective genes would benefit humanity are presented below:

> Defective genes should be eliminated in order to create a healthy society. (GTHD, T3, F)

> There is nothing wrong with gene therapy applications. By eliminating defective genes, it is possible to consolidate and stabilize the human race throughout the world. (GTHD, T17, F)

> I think she [Lale] should abort the fetus. In developed countries, populations are productive; that is why they are developed. If Lale does not abort the fetus, the defective genes could be passed on to offspring, and this should somehow be prevented. (HD; T6, F)

4.2.1.7. Means to an end

Some of the participants have concerns regarding the use of embryos as a tool or resource in genetic applications. The teachers stated their concerns about this in the issue of fetal tissue transplantation, which involves using a fetus' brain tissues (2.03% of total statements). Teachers generally indicated their concerns about getting pregnant intentionally solely to providing tissues for fetal tissue transplants. An example quotation from one of the teachers supporting this view is presented below:

> In the case of fetal tissue transplantation, using fetal tissues is not ethical. Creating an embryo and using its tissues is unacceptable. Some women might even get pregnant intentionally simply to provide brain tissues for this application. (FTT, T2, F)

Some of the teachers were not totally opposed to fetal tissue transplantation. They insisted that the fetal tissue transplantation method can be used with fetus brain tissues under some circumstances such as unintentional pregnancies or pregnancies that are needed to be terminated because of health problems. Quotations indicating teachers' conditional acceptance of using fetus brain tissues are presented below:

> I am not opposed to the use of fetal tissue transplantation if there was an unintended pregnancy that the parents just wanted to terminate. (FTT; T6, F)

> "Under some circumstances such as some possible complications with either the baby or the mother a termination is recommended. In these situations, it might be necessary to terminate the pregnancy. Thus, the family might have to abort the fetus. The aborted fetus could then be used in fetal tissue transplantation. But I am against aborting a healthy fetus and using its brain tissues. (FTT, T13, M)

4.2.1.8. Diversity

Only a few teachers (three teachers) expressed concerns that genetics applications might reduce the existing diversity in society, which in turn would result in a highly homogeneous society. Quotations from teachers' responses regarding how genetic applications might affect diversity are presented below:

> What happens if all the individuals in society are gifted? There should be some kind of diversity. We should consider how to promote diversity because differences create a heterogeneous society. (GTI; T4, F)

> We should not destroy the existing heterogeneity in society. If the intelligence of all human beings were increased, there would be an uniform society which all the individuals resembled each other exactly, and there would be a single type of person. (GTI; T18, F)

4.2.2. Technological Concerns

Science teachers' technological concerns about the role of technology and technicians in genetic technologies are grouped under the "technological concerns" code (10.44% of total statements). Under this theme, teachers' concerns about the credibility, risk factors, malicious use as well as side effects were examined in detail (See Figure 4. 8).

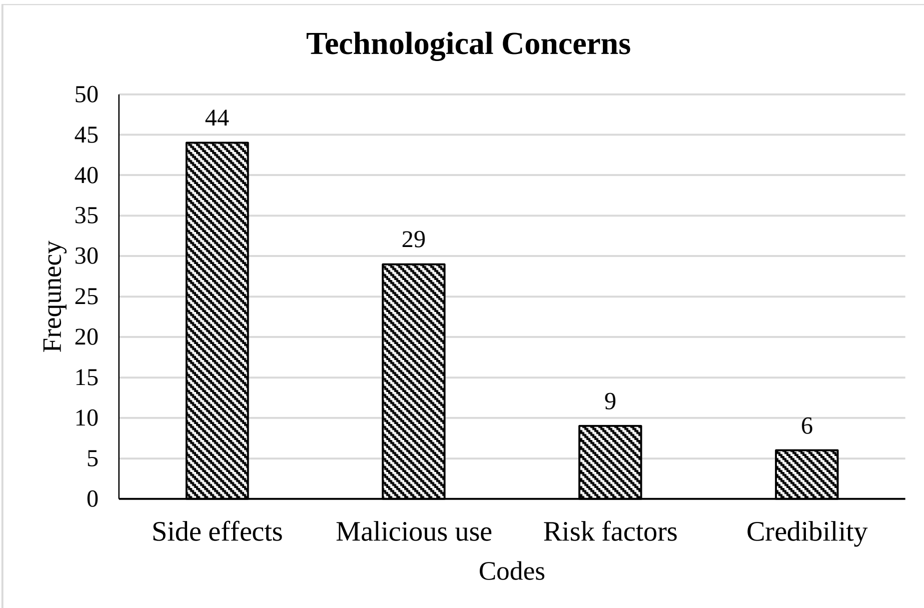

Figure 4. 8 Frequencies of the technological considerations that influence teachers' decision making processes.

4.2.2.1. Side effects

Majority of teachers (13 teachers) indicated that they had concerns about the side effects of technological applications (5.22 % of the total statements). Regardless of the type of disease, they were concerned that interfering with genes might result in side effects. Quotations from teachers' replies concerning side effects are as follows:

> While we are trying to cure an illness, we could create a monster. When we are trying to cure an illness by changing deleterious genes, we might cause some important changes in physical or

> psychological traits that were kept in check by those deleterious genes. (GTI; T6, F)
>
> Ultimately, we are interfering with human genes. We might cause something undesired. (GTHD; T8, F)
>
> My biggest concern is whether there might be any side effects to interfering with human genes? Or might it trigger unforeseen problems. You are inferring with someone's DNA, after all. (GTI; T18, F)

As demonstrated in the above excerpts, teachers' concerns regarding side effects were mainly grouped in those scenarios related to gene therapy for Huntington's disease and human intelligence. Detailing their concerns regarding side effects, two teachers (T7 and T11), however, mentioned the "domino effect" implying that changing one gene might trigger all entire change in a person's DNA or the functions of genes. Quotations from the teachers are presented below:

> There are lots of human genes whose functions are not exactly known yet. Changing a gene might cause a domino effect by initiating some events which were undesired. (GTI; T7, F)
>
> When there is outside intervention in genes there is always the possibility of coming up with something unexpected. There might be some side effects. For instance, eliminating the defective gene might negatively affect the functions other genes. (GTHD; T11, F)

In addition, teacher 10 (T10) pointed out that her main concern is that gene therapy has not applied on human beings yet, and so the consequences are unknown. This teacher is quoted as saying:

> Gene therapy applications have not been applied to human beings. So, we do not know what kind of consequences we will encounter in the future. We might end up with undesired consequences. (GTI; T10, F)

Lastly, one teacher (T14) used "genetically modified food" as an example while explaining her concerns regarding the side effects of gene technologies.

> We do not know how gene therapy would turn out. While trying to eliminate the genes related to Huntington's disease, it is possible to come up with something undesired. For instance, genetically modified foods… Scientists did not predict through the consequences while developing genetically modified foods. And now it turns out that genetically modified foods may cause cancer. (GTHD; T14, F)

4.2.2.2. Malicious use, risk factors and credibility

Participants' concerns regarding the role of technology and technicians in the development and application of new genetic technologies, as well as the existence of risk factors, were grouped together (5.22% of total statements). Teachers were specifically concerned about the malicious use of gene therapies and perceived malicious use of genetic technologies as a risk factor. The statements below provide examples of how teachers perceive the malicious use of genetic applications for treatment purposes as a risk factor.

> Gene therapy applications could be misused by the doctors or genetic scientists who develop (apply) these applications. For instance, they thought they would be making a massive contribution to science when they invented the atomic bomb but instead it is used for the massive destruction of a country. (GTHD & GHI, T4, F)

> I am concerned about who would be tampering with genes, and I consider this risky. I mean, are the people who would apply genetic applications dependable and trustworthy? (GTHD & GTI; T12, M)

> During gene therapy applications genetic scientists should know exactly how the genes function. Thus, these applications are risky. As the function of genes is very complicated the scientists could not know exactly whether the application is successful or not. In addition, under some circumstances, the scientist might tamper with genes for unethical reasons such as earning money. (GTHD & GTI; T15, F)

> The very existence of risk factor concerns me a lot. In addition to other factors, altering genes itself includes risk. For instance, is it

> possible to alter one gene without affecting the other genes? These kinds of questions give cause for concern. (GTHD & GTI; T18, F)

As can be seen from the example quotations, while some of the teachers were concerned about the misuse of genetic applications and they perceived this misuse as a risk, some of the teachers emphasized the importance of the dependability of the doctors or genetic specialists who would apply gene therapy applications.

4.2.3. Value Considerations

In addition to moral and technological considerations, teachers emphasized the patients'/fetus' rights as well as parents' rights in their responses. Moreover, some of the teachers stressed the importance of "informed family consent" for any kind of genetic application. Teachers' concerns about the patients'/fetus' and family rights, and informed family consent were grouped under the "value considerations" theme and explained in detail in the following section (see, Figure 4.9).

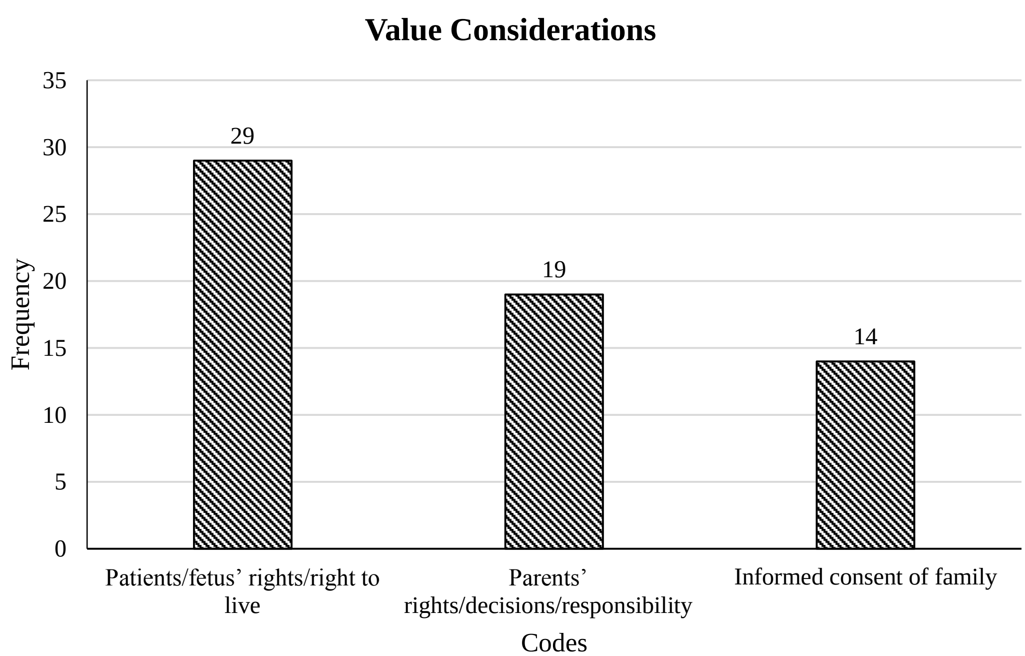

Figure 4. 9 Frequencies of the value considerations that influence participants' decision making processes.

4.2.3.1.Parents' and fetus' rights, and informed consent of family

Teachers' emphasized that parents should make decisions by considering the fetus' rights and stated that they should respect their right to live. Out of 18, ten teachers indicated that the fetus/embryo has the right to live or that patients also are entitled to say something about their future (3.44% of total statements). Quotations demonstrating their positions are presented below:

> Rather than aborting the fetus, Lale should consider the rights of the fetus. The fetus also has a right to live. I do not think that parents should have any right to choose on behalf of their unborn children." (HD; T13, M)
>
> We are altering someone's genes without his/her acknowledgement. The child might not have wanted altered genes. This is more like a violation of that child's rights. (GTHD; T14, F)
>
> Regarding the cystic fibrosis scenario, I support the idea that everyone has a right to live. We should not take someone else's right to live. (CF; T18, F)

In addition, one teacher (T4) stressed the importance of the decision making process in gene therapy applications. That teacher's statement is presented below:

> Parents should consider all the possibilities when making decisions about tampering with their child's genes as this kind of intervention is irreversible. (GTHD; T4, F)

While some teachers stressed the importance of decision making processes and fetus' rights to live, other teachers ignored those rights and indicated that the parents should have the final word regarding abortion. Example quotations corresponding to this are presented below:

> Reyhan should conduct genetic testing to confirm whether the fetus has cystic fibrosis genes or not. If it turns out that the fetus does have cystic fibrosis genes, aborting the fetus should be left up to Reyhan to decide. (CF, P6)

> The ultimate decision about whether or not to abort the fetus even if the fetus has cystic fibrosis genes should be left to the parents. (CF, T9, M)

In addition, some teachers indicated that the informed consent of the family is critical in genetics applications. An example quotation emphasizing the importance of informed consent is presented below:

> The doctors who would apply the gene therapy treatment should inform the parents about the possible consequences of gene therapy and the parents' approval should be a requirement for these applications. (GTHD, T1, M)

4.2.4. Socio-psychological concerns

Another commonly stated concern is that socio-psychological concerns influence their decision (8.30 % of total statements). In particular, teachers frequently expressed their ideas and positions reflecting concerns for those individuals who would potentially be influenced by their decisions. For instance, they used statements that indicate the difficulties that families would face when raising the patient such as suffering and care problems. In addition to the difficulties that families would face, teachers also pointed out the difficulties that the patients would face. Example quotations from the teachers' responses are presented below:

> Raising a child with Cystic Fibrosis would be quite hard. The child would need special needs such as physiotherapy. The parents would need psychological support as well. These are all demanding processes. (CF; T2, F)

> The decision about whether or not to abort the fetus is a vital one. But the difficulties faced by child while being raised should also be considered. Cystic Fibrosis is a fatal disease, and the child would require the continuous support of his/her parents. As this disease can be detected before birth, the pregnancy should be terminated. (CF; T4, F)

> Cystic Fibrosis disease would create many problems in the child's future life. Thus, terminating the pregnancy sounds logical to me. (CF; T15, F)

> I think Lale would be sorry about the possibility of having a child with Huntington's disease. Therefore, she would be affected negatively and would need professional support for coping with this situation. (HD, T16, F)

4.2.5. Support of Science

Science teachers frequently used statements that are categorized under the "support of science" theme. All the science teachers who participated in the interviews indicated this in their decision making processes implying that it is a key factor among participants' responses (5.93% of total statements). Two major patterns were emerged: The first one is the *empirical nature of scientific research,* and the other one is the *tentative nature of scientific knowledge*. For instance, some of the teachers emphasized the empirically based nature of scientific research in explaining their positions. Example quotations from the teachers' responses corresponding to the empirical based nature of science are presented as:

> I think that studies on fetal tissue transplantation should be continued. There is no treatment for Parkinson's disease at the moment. If these studies on fetal tissues would provide a treatment for Parkinson disease, empirical studies using fetal tissue should continue. Empirical findings might eventually provide a treatment for Parkinson's. Scientific research advances through new empirical findings. (FTT; T5, M)

> I support studies on fetal tissue transplantation because the fetal tissue transplantation method is based on a string of empirical research which also consists of empirical errors. But with the new empirical findings gathered by this empirical research, this method will eventually be tailored for the treatment of Parkinson disease. Similarly, science also advances through new empirical findings. (FTT; T17, F)

Some of the teachers emphasized that scientific knowledge is not fixed and thus the developments in science might contribute to our understanding of science. Example quotations from teachers' replies concerning how technological developments will contribute to scientific research are as follows:

> If a child is born with the Cystic Fibrosis disease the family should follow up the current scientific research studies regarding Cystic fibrosis genes. Our knowledge about genes is constantly changing as science progresses. Therefore, it may be possible to find a treatment option for Cystic Fibrosis disease in the future (CF; T2, F)
>
> Even there is no treatment for Huntington's disease at the moment there is an ongoing progress in science that enables researchers to develop treatments for all kinds of genetic diseases like Huntington's disease. New treatment methods might be developed within as little as 50 years. (HD; T15, F)

As can be seen from the above quotations, the teachers believed that our knowledge about genetic diseases is not fixed and that it is subject to change within the light of new empirical findings. Those quotations supported the teachers' ideas about the tentative and empirical nature of science.

4.2.6. Emotive considerations

Another concern frequently emphasized by teachers is "emotive considerations". 15 out of 18 science teachers had "emotive considerations" when deciding about genetics applications (5.22% of total statements). Teachers mainly used statements indicating the empathy towards the parents or patient/child in the given scenarios. When making decisions, they put themselves in the shoes of patients and used statements like "If I were Lale… (A fictitious character in the Huntington's disease scenario). Example quotations from the teachers' replies are as follows:

> It is a very interesting case [Fetal Tissue Transplantation]... What would I do if it happened to me? I really do not know. The case affected me deeply. (FTT; T2, F)
>
> Regarding Huntington's disease case, I put myself in the place of parents who would have a child with Huntington's disease. I would

> not want my child to be born with Huntington's disease. (GTHD; T3, F)
>
> When making decisions, I put myself in the place of both the child who would have Huntington's disease and the parents who would have a child with Huntington's disease. Both cases affected me deeply. Therefore, it is acceptable to use gene therapy for eliminating the Huntington's disease genes. (GTHD; T11, F)

As demonstrated in the above quotations, the participants approached scenarios sympathizing or empathizing with the fictitious characters from the scenarios. One teacher (T12) stated, "As I was not diagnosed with Huntington's disease I cannot experience the same emotions as the patients" implying that the teachers' emotive considerations do influence the participants' decisions. While considering emotionality teacher 8 (T8) indicated that her current status as a mother influenced her decision. This teacher said:

> I was deeply affected by the fetal tissue transplantation scenario as I myself have a son. Considering abortion as a treatment option makes me feel uneasy. Questions like that [regarding abortion] should not be asked to mothers. (FTT; T8, F)

Lastly, teachers' thoughts regarding the Fetal Tissue Transplantation scenario differed according to the teachers' individual viewpoints. While some teachers supported fetal tissue transplantation as it would enable their father to survive, one teacher (T12) perceived the method as unacceptable as both the fetus and his father are "important" to him. Both teachers had emotive considerations but decided differently. The teachers said:

> I cannot accept the Fetal Tissue Transplantation method. I cannot let someone die for the survival of another. What I mean is I cannot kill my own child in order to let my father live. Both of them are precious to me. (FTT; T12, M)

4.2.7. Religious considerations

Another theme found in participants' statements was "religious concerns". Although this concern is not mentioned as frequently as others, the teachers drew from their religious beliefs when making decisions (3.91% of total statements). This theme mainly emerged in the fetal tissue transplantation, Cystic Fibrosis and Huntington's disease scenarios, all of which require the abortion of a fetus. Teachers' statements regarding their concerns are presented below:

> This method [regarding Fetal Tissue Transplantation] contradicts with my religious beliefs. I believe that aborting a fetus is a sin. Thus, I think this method should not be applied. (FTT; T3, F)
>
> Ultimately, the disease [Cystic Fibrosis] is very severe and fatal. Reyhan certainly should get an abortion. According to my religious beliefs, there is no problem with an abortion up until the tenth week of pregnancy. (CF; T4, F)
>
> My religious beliefs influenced my decisions. For instance, I was raised in a family that believes abortion is a sin. Thus, it is not possible to decide by putting my religious beliefs aside. (FTT; T7, F)
>
> God created all the living things, so you cannot kill the fetus as it is alive. This is unethical. Thus, this kind of application [fetal tissue transplantation] requiring the abortion of a fetus is kind of problematic for me. (FTT; T11, F)

Although not stated by the other teachers, one teacher (T8, F) pointed out that she would "consult with a cleric or religious scholar" before deciding to abort the fetus in the case of fetal tissue transplantation. She said this:

> In the fetal tissue transplantation scenario, abortion seems logical according to me. But it is still an abortion. According to my religious beliefs, abortion is a sin. Thus, it would be better to consult with a cleric or religious scholar. (FTT; T8, F)

The same teacher also indicated that gene therapy should be used for the treatment of diseases. She explained her position by stressing her religious beliefs as:

> If it [gene therapy] is not going to be used for the treatment of diseases it should not be allowed because you are changing something that God created. Otherwise, it would be acceptable according to my religious beliefs. (GTHD; T8, F)

4.2.8. Legal considerations

Teachers' statements referring to the need for legal regulations or standards that regulate genetics applications and determine the limitations for them are categorized under the "legal issues" theme. 2.85% of total statements were grouped under this theme. 11 teachers referred to the necessity for legal restrictions and regulations in genetic applications. Example quotations emphasizing the importance of legal restrictions and regulations are presented as:

> There should be some standards regulating the application of gene therapy for the purpose of increasing human intelligence. (GTI; T1, M)

> Gene therapy applications should be carried out consciously and in an organized fashion. Therefore, legal regulations are strongly needed. (GTHD; T6, F)

Teachers also talked about the authority of and regulation of the mechanism that is responsible for the application of these technologies. While some teachers indicated that the restrictions should be determined and regulated by "governments", other teachers emphasized the need for scientific councils to regulate genetic applications. In addition, some teachers pointed out the checks and balances mechanisms for gene therapy applications should be in the hands of doctors. Examples of teachers' statements about different authority mechanisms responsible from genetic applications are presented below:

> There should be some restrictions and these restrictions should be determined by the government. The checks and balances mechanism should also belong to the government. Otherwise, it would be very hard to regulate this kind of application. (GTHI; T8, F)
>
> I believe that gene therapy should be under the control of medical doctors. There should be some universally accepted standards that regulate gene therapy applications. (GTHI; T1, M)
>
> There should be specialist institutions for regulating these applications. There should be specialist scientific councils as well as specific regulations determining the limitations of gene therapy applications. (FTT; T13, M)

4.2.9. Economic considerations

Teachers' concerns regarding the economic aspect of the accessibility of genetic technologies are grouped under the "economic considerations" theme. Eight out of 18 participants' mentioned economic factors as a constraint in the accessibility of genetic applications (2.49% of total statements). An example quotation from one of teachers' statements indicating her concerns about economic factors is presented as:

> Ultimately, this application would require a huge amount of money. People who could afford this application would change their children's genes in order to increase their intelligence. There would be other people who simply could not afford this application, and this would create inequality in society. (GTHI; T2, F)
>
> I think it would definitely be expensive to have gene therapy. Meaning, only rich people could afford it whereas poor people could not, and this would create economic stratification in society. (GTHI; T4, F)

4.2.10. Family bias

Seven teachers indicated that their decisions about the scenarios might change if the situation involved themselves or their family members (1.78% of total statements) as opposed to a fictional character. Example quotations from the teachers' responses are presented below:

> I believe that Lale should abort the fetus. It was easy for me to make a decision about Lale. But what would happen if it happened to me? I would definitely feel differently it were me dealing with this kind of decision (HD, T2, F)
>
> I think it is easy to decide whether or not to allow gene therapy based on the fictitious characters in the scenarios. But what would happen if it happened to me? I honestly do not know how I would react in that situation. (GTHD; T14, F)

4.2.11. Personal experiences

Some of the teachers (nine teachers) formulated their decisions based on their previous experiences. Example quotations indicating the role of personal experiences are presented below:

> I can give a specific example from my family. One of my relatives had similar symptoms to Huntington's disease. Specifically, my grandfather had similar symptoms during the last stages of cancer. Even a healthy man can experience similar symptoms to Huntington's disease. Therefore, Lale should not abort the fetus by considering the severe symptoms alone. (HD; T1, M)
>
> It is not possible to know how long a healthy individual is going to live. For instance, the sister of a friend of mine was diagnosed with kidney failure and the doctors informed her family that she had approximately 10 years left to live. But she is 26 now, and she is still alive. Who knows? Even a healthy person may not live till his/her 50s. Therefore, Lale should not decide to abort fetus by only considering the lifetime of a patient with Huntington's disease. (HD; T18, F)

4.2.12. Socio-cultural factors

Six teachers mentioned the importance of Turkish social and cultural family structure in their decision making process (1.66% of total statements). Example statements corresponding to this theme are presented as:

> When we consider Turkish customs and traditions, family members take care of the sick and old people. Thus, Lale should not abort the fetus simply by considering who will take care of her or her children when she is sick. (HD; T2, F)
>
> The transplantation of fetal tissues from grandchild to grandfather does not sound logical to me. I am certainly influenced by cultural factors and by my own family. I believe that the Turkish society does not approve of fetal tissue transplantation. (FTT; T13, M)

4.2.13. Need more information

Eight teachers reported that they would need additional information regarding the scenarios or gene therapy applications in order to make decisions and support their positions (1.42% of total statements). The statements below provided examples of what kind of information the teachers would need in order to make their decision:

> I exactly need to know how many weeks pregnant Lale is in order to decide. I mean, it is immoral to abort an eight-month-old fetus. (HD; T12, M)
>
> I would like to learn more about whether there is any progress in the treatment of Huntington's disease. If I knew more about the treatment options of Huntington's disease, I would be better able to make my decision. (HD; T14, F)

4.2.14. Pop culture

Compared to the other factors that were mentioned by the teachers, a relatively small percentage of participants' responses (0.83% of total responses) were influenced by the media such as films or documentaries. Example quotations corresponding to the role of pop culture in decision making process are presented as:

> We always watch science fiction films about mutant creatures on TV. The possibility of creating mutant creatures in real life makes me concerned a lot. (GTHD; T2, F)

> Using fetal tissues should be allowed. I have seen real body tissues such as fetuses and embryos that were exhibited in the Body World Exhibition. If a fetus can be used for the purpose of exhibition, it can also be used for the purpose of treatment as well. (FTT, T5, M)

> There is no reason that can justify an abortion. For instance, there was a character which was diagnosed with Huntington's disease in the House M.D. drama on television. She fought till the very end. She became a doctor. Lale’s child could survive till his/her 50s. Thus, Lale should not abort the fetus simply because the fetus was diagnosed with Huntington's disease. (HD; T11, F)

4.2.15. Political concerns

A few participants’ responses (three out of 18 teachers) referred the concerns regarding politics as a factor that influence their decisions. One example quotation explaining teachers’ concerns about politics is presented below:

> I wonder how the governments would react to the use gene therapy for the purpose of increasing intelligence. It is a known fact that intelligent people are not easy to manage. Governments, however, desire easily manipulated people. Thus, it would be politically expedient for governments to prevent the development of gene therapy applications. (GTI; T1, M)

4.2.16. Miscellaneous

Some of the teachers’ statements about alternative treatment methods, dilemmas about genetic applications, suggestions about birth control, the uncertainty of genetic applications and changes in ways of thinking are congregated under the “miscellaneous” theme (See Figure 4.10). Each theme is explained in detail with quotes in the following section.

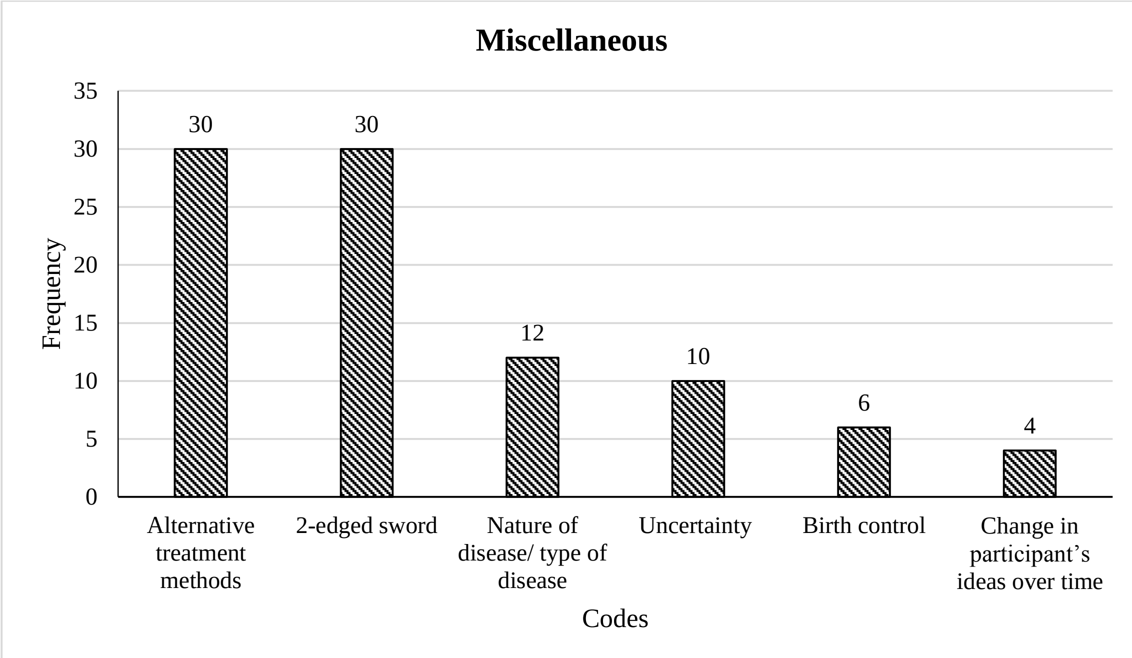

Figure 4. 10 Frequencies of miscellaneous considerations that influence the participants' decision making processes.

4.2.16.1. Alternative treatment options

Some teachers proposed alternative methods for the treatment of the diseases presented in the scenarios. Out of 18 participants, 13 proposed alternative treatment options/possibilities for the scenarios (3.56% of total statements). The teachers mainly proposed an alternative method such as using Serotonin, artificial cells, umbilical-cord or stem cells in the fetal tissue transplantation scenarios requiring the abortion of the fetus. Teachers' statements regarding alternative treatment options are presented below:

> I think such research studies as Fetal Tissue Transplantation can be conducted in different ways. For instance, using stem cells or umbilical-cord might be alternative options for the treatment of Parkinson's disease. We do not have to use fetal tissue. (FTT; T1, M)

> There should be alternative methods for the treatment of Parkinson's disease instead of using fetal tissue. For instance,

> Serotonin could be used in the treatment of Parkinson's disease. (FTT; T2, F)

> The research studies regarding the treatment of Parkinson's disease should definitely be continued. At first, genetic scientists might use fetal tissue. But eventually, they might be able to generate artificial cells by using fetal tissues. Afterwards, they would not need the fetus at all and would able to treat Parkinson's disease just by using the artificial cells. (FTT; T17, F)

Unlike the other statements, one of the teachers (T18) proposed using animal brain cells instead of fetus brain cells as an alternative treatment option under fetal tissue transplantation. She explained her position as:

> There should be other treatment options which would not threaten the lives of living things. For instance, animal brain cells might be used instead of fetus brain cells in fetal tissue transplantation. (FTT, T18, F)

4.2.16.2. Two-edged sword

Participants' difficulties and dilemmas when articulating their decisions concerning a particular genetics application were categorized under the "two-edged sword" theme. 14 out of 18 teachers' responses were categorized under this category (3.56% of total statements). Teachers mainly faced difficulties or dilemmas regarding genetic technologies. Example quotes representing teachers' concerns are presented below:

> I am undecided on this scenario[Fetal Tissue Transplantation]. On the one hand, there is a treatment for Parkinson's disease. On the other hand, there is a living fetus. It is confusing. I could not decide whether using a fetus to develop a treatment of Parkinson's disease is acceptable or not. (FTT, T3, F)

> The genetic applications are generally confusing. On the one hand, they provide treatments for diseases, but on the other they also might lead to the occurrence of other diseases. For instance, we use cell phones to communicate but cell phones also emit radiation which is harmful to our bodies…Or think of nuclear power plants and their effects on human health… It is really confusing… (GTHD & GTI; T11, F)

Unlike the participants' previous responses, one of the teachers (T16) expressed the difficulty of being a "subject" in an experiment. The following statement is corresponding to this situation:

> Even it is only an experimental trial, I am hopeful about the development of treatment for Parkinson's disease. On the other hand, I am afraid of being a "subject" in such experiment. I do not desire to see my father used as a subject in an experiment. But if my father does not participate this experimental trial his disease will progress. It is a dilemma for me (FTT; T16, F)

4.2.16.3. Nature of the Disease

A relatively small percentage of teachers indicated their decisions would change based on the type of disease in question (1.42% of total statements). An example quotation from one teacher's statement regarding this theme is presented as:

> In the case of Cystic Fibrosis, there are ongoing research studies that are investigating the treatment of Cystic Fibrosis. But, in the case of Huntington's disease there are no research studies for its treatment. While there is a possibility of developing a treatment for Cystic Fibrosis, there is not any hope for patients with Huntington's disease yet. Thus, I believe that Lale [in Huntington's disease] should consider getting an abortion but Reyhan [in Cystic Fibrosis] should not abort the fetus. (HD; T4, F)

4.2.16.4. Birth Control and Change in Participants' Ideas over Time

A few participants proposed using "birth control" for the couples who have a high risk of getting a sick child (0.71% of total responses). Example quotations from the teachers' responses are presented below:

> In the Huntington's disease scenario, Lale should have used birth control instead of considering abortion as an option. She should not have gotten pregnant to begin with. (HD; T2, F)

> In this case [Cystic Fibrosis], if Reyhan knew the risk of having a sick child prior to the pregnancy, she should not have gotten pregnant and should have used birth control methods.(CF; T6, F)

A few teachers (4 teachers) indicated that their decisions might change over time. The statements below provide example quotations from the teachers' responses:

> If the questions related to fetal tissue transplantation were asked ten years later my answers might be totally different because our ideas are continually changing over time. (FTT, T1, M)
>
> There are paradigms that are changing over time. Our ideas, as well as our personalities, continually change over time, and this is bound to affect our decision-making processes. (GTI; T1, M3)

4.2.17. Summary of Findings of Qualitative Analysis

The qualitative findings of the study revealed that science teachers' decisions were mainly influenced by moral considerations. Among moral considerations, health improvement was found to be a significant theme. All the science teachers agreed on the use as well as the development of genetic applications would be beneficial in the case of health improvement. They, however, had some concerns about that permission to use genetic applications in one acceptable context may lead to the use of that technology in unacceptable contexts. In addition, they expressed their concerns about interfering with genes might result in side effects and perceived the malicious use of genetic applications as a risk factor and economic factors as a constraint in the accessibility of genetic applications. Moreover, they also questioned the credibility and the dependability of the doctors and genetic specialist who would be responsible for genetic application. Despite their existing concerns about genetics and genetic applications as misuse, risk factors, side effects, as well as the dependability and credibility of genetic scientists; they demonstrated high reliability in science and scientific research. Moreover, teachers, in this study showed empathy or sympathy towards the fictitious characters in the scenarios and considered about the pain and the suffering of both parents and the patients. In addition, they tended to include their religious beliefs while making decisions. They emphasized the need for legal regulations or standards that regulate genetics applications and determine the limitation. While some teachers noted that they need additional information for making decisions, some teachers indicated their decisions might change if the situation involved themselves or their family members. Some of the teachers expressed the dilemmas they went through decision making. In addition, they proposed alternative methods such as using artificial cells or umbilical-cord in fetal tissue transplantation requiring the abortion of the fetus. To conclude, teachers' decision making processes regarding issues covered in genetics literacy were influenced by a wide range of factors. In addition, teachers tended to adopt multiple perspectives and used multiple factors during decision making processes.

CHAPTER V

DISCUSSION

This chapter is devoted to the discussion of findings in terms of science teachers' genetics literacy levels, their attitudes towards various issues in genetics literacy their perceptions of teaching genetics literacy as well as the factors that affect their decision making. Then, conclusions based on the findings were presented. Lastly, implications for teachers, teacher education programs and teacher educators were presented.

5.1. Discussion

This chapter begins with the discussion about the findings for relationships among science teachers' background characteristics as gender, teaching experience, self-perceived interest and knowledge in genetics, their genetics literacy levels, their attitudes towards issues in genetics literacy and their perceptions of teaching genetics literacy are presented. Then, the findings for the factors influencing science teachers' decision making processes are discussed.

5.1.1. Discussion of the findings for genetics literacy

In this part, findings obtained from canonical correlation analysis were discussed in the light of related literature. As mentioned in result chapter, canonical correlation analysis revealed that being female, having high level of interest in issues in genetics literacy and perceiving themselves as knowledgeable in genetics literacy associated with higher levels of knowledge in genetics literacy and favorable attitudes towards general attitudes as well as believing the necessity of introducing genetics literacy and holding higher self-efficacy teaching beliefs. They, however, were likely to emphasize more hinderer factors as well as holding unfavorable attitudes towards gene therapy and gene therapy applications. That is, science teachers who were females, had high level of interest and knowledge were likely to understand concepts comprising genetics literacy and develop positive attitudes towards some dimensions genetics literacy. These teachers were also, more efficacious with respect to teaching genetics literacy to their students and tended to understand the necessity of these issues. On the other hand, teaching experience and gender were not found to be associated with their genetics literacy levels, their attitudes towards issues in genetics literacy as well as their perceptions of teaching genetics literacy. Overall findings indicated that the effects of background characteristics were context-dependent implying participants' attitudes differed regarding the issues being investigated. As findings consisted of the relationship among a number of variables such as gender, teaching experience, age, enrolled courses, previous courses taken; existing literature exploring the relationship among knowledge, attitude, self-efficacy beliefs regarding teaching background characteristic provided a rich context to discuss (Acra, 2006; Boone et al., 2006; Cantrell, Young, & Moore, 2003 ; Chabalengula et al., 2010; 2011; Črne-Hladnik et al., 2009, 2012; Ozden et al. 2008; Sahin et al., 2010; Sohan et al., 2002; Sonmez & Kilinc, 2012; Šorgo & Ambrožič-Dolinšek, 2009, 2010; Tekkaya et al., 2002; Turkmen & Darcin, 2007).

In present study, gender appears to play an important role in explaining the variation in the components of genetic literacy. Female science teachers tended to hold more favorable attitudes towards some issues in genetics literacy. Females holding more favorable attitudes about some issues in genetics literacy can be explained by sex roles of females as explained by Blocker and Eckberg (1997). According to Blocker and Eckberg (1997), the roles like homemaker and childrearing role of women might influence their attitudes. In addition to their roles, females tended to feel more responsible in terms of taking care of their homes and children. Moreover, the gender difference favoring females was explained by two theories as structural and socialization based theories by Weaver (2002). While socialization-based theories focused on women's role as caregiver which is strongly determined by cultural and social norms; structural theories focused on gender based segmentation in both workplace and economy which is contrary to the traditional men's role as breadwinner. Thus, it is possible to explain to explain the gender difference found in present study by adopting two existing theories. As science teachers have roles determined by their gender as caregiving and childrearing, it is an expected result to be more concerned about genetics related issues and holding favorable attitudes. In addition, different socialization role of males and females in society may be useful in explaining the gender difference found in present study. Zelezny and his colleagues (2000) explained that while females are tended to be more cooperative and nurturing, males tended to be independent and competitive. Thus, both socialization role and caregiver role of women in society may influence their attitudes. With this respect, it may be illogical to think women roles apart from their values, and existing cultural and religious norms. Indeed, qualitative part of the present study supported this idea. Science teachers frequently referred the role of values, socio-cultural norms as well as religious norms in their decision-making processes. To be more specific, science teachers emphasized "rights" notion during their decision-making process. For instance, they referred that fetus should also has right to live and the patients should have the right to choose or say something about their future. They indicated that the entire process should not be left to the parents. Teachers also considered parents' rights such as being informed about the possible consequences of genetic applications, being responsible about their decisions as well as making decisions about their children. Parallel with these findings, there were other studies that explored the role of values in decision making processes in different genetic issues in the context of biotechnology and SSIs (Bell & Lederman, 2002; Boerwinkel et al. 2011; Christenson et al. 2012; Grace & Ratcliffe, 2002; Kolstø, 2006; Lee, 2012; Ozer-Keskin, 2013; van der Zande et al. 2011, 2012). Conducted with different participants (students, pre-service teachers, teachers), the available studies revealed that participants' decisions were influenced by the values that the participants had and should be considered while dealing with controversial issues in science classes. To illustrate, Grace and Ratcliffe (2002) examined how students made decisions in conservation unit and reported that participants frequently appealed the "right to live" notion while explaining the reasons underlying their decisions. As seen, illuminating the values that teachers have in this study showed that both teachers and students had similar value constructs while making decisions which may be helpful in further developing teaching strategies for effective implementation of issues in genetics literacy. In this respect, there may be a connection among values, cultural and religious norms. Indeed, the science teachers in present study, referred cultural norms regarding Turkish social and cultural family structure and religious terminologies while explaining the factors that influence their decisions. For instance, some teachers indicated that Turkish family structure and Turkish tradition about raising child or taking care of child affected their decisions. In a similar manner, some teachers indicated that their religious beliefs influenced their positions. This was the most evident in fetal tissue transplantation, Cystic Fibrosis and Huntington Disease scenarios where abortion of fetus or status of fetus are taken into consideration. Teachers pointed out the status of embryo as a living in religious terms was important in determining their positions about the genetic applications presented in the scenarios. Moreover, teachers indicated that their opinions were influenced creationism. Even not evidently stated, teachers' statements such as "changing genes that God give" or "God gives life to the living things" imply that they had creationist ideas about life origins. This finding is also confirmed by quantitative results of current study which reported that teachers were relatively less knowledgeable about evolution concepts. Thus, it was expected that the teachers who had insufficient knowledge about evolution might also had creationist ideas. Believing in creationism is related with religious beliefs as Nehm, Kim and Shepherd (2009) indicated. As far as the majority of Turkish public is considered to be Muslim, the religious beliefs might affect their decisions as well as their attitudes. In fact, the previous studies also reported the similar findings which concluded that both socio-cultural norms and religious beliefs influenced participants' decisions (Halverson et al. 2009; Khishfe, 2012; Lee, 2007; Lee et al., 2012; Ozer-Keskin, 2013; Topcu, 2008; Zeidler et al. 2002). Parallel with existing literature, this study confirmed the role socio-cultural and religious norms in decision making processes, especially dealing with the controversial issues that requires changing genes, aborting fetus or use of aborted fetus. At this point, it is important to clarify the role socio-cultural and religious norms in decision making processes for Turkish science teachers as their role of implementing issues in genetics literacy considered. To conclude, the difference in female science teachers' favorable attitudes may be related with their roles as caregiver in society which may be shaped by their values and socio-cultural norms as well as their religious beliefs.

Although the present study revealed that females held favorable general attitudes, the same teachers also tended to held unfavorable attitudes towards gene therapy and gene therapy applications. The reason why science teachers' attitudes differed could be explained in several ways: First explanation may be that the teachers' attitudes were differed with respect to the issues being investigated. Indeed, the descriptive statistics of current study provided evidence that participants demonstrated a wide range of approaches towards issues in genetics literacy. For instance, while most of teachers were undecided about many items presented in general attitude dimension, they showed reluctance about use of genetic information. Teachers, particularly, had difficulty in deciding whether to interfere with people's genes or not. Moreover, they expressed doubts in benefits of modern genetics and using genetic technologies. The difficulty in deciding about interfering people's genes or changing genes may be caused by the controversial nature of issue or having moral concerns as Gaskell and his colleagues (2000; 2003) indicated. They, on the other hand, appeared to be reluctant about the use of their personal genetic information by insurance companies or employers. Parallel with this finding, use of genetic information by different stakeholders such as insurance companies, employers or other authorities was perceived as a concern in numerous studies (e.g., Gaskell et al. 2003; Fonseca et al. 2012; Tan et al. 2007). For example, Gaskell and his colleagues (2003) reported that European public perceived the use of genetic information by governments or insurance companies as unacceptable. In a study which investigates Asian and American adults' attitudes towards genetic testing, Tan and his colleagues (2007) found both Asian and American adults had concerns about use of genetic testing results by insurance companies. In another study exploring Portuguese biology teachers' attitudes towards biotechnology, participates showed unwillingness to give their genetic information to genetic databanks (Fonseca et al. 2012). Indeed, teachers in this study were reluctant to give their genetic information to third party like employers or insurance companies.

With respect to other dimensions of attitude scale including abortion, pre-implementation genetic diagnosis, gene therapy and gene therapy applications; science teacher also demonstrated differing attitudes with respect to the purpose of the issues being investigated. Teachers, in general, believed in the use of abortion and pre-implementation genetic diagnosis in case of serious mental and physical diseases but not in case of having a child which was very likely to live a good health but would die in its 20s or 30s. Participants' attitudes towards abortion and pre-implementation genetic diagnosis might be influenced by the religious aspect of issues presented as dealing with these issues required a judgment on the moral status of an embryo (Halverson et al., 2010). Thus, participants generally tended to accept these applications in mental and physical disabilities but not in other conditions such as dwarfism. This pattern is also consistent with the literature reporting that individuals tended to show an agreement on the use of abortion and pre-implementation genetic diagnosis in mental and physical disabilities (Sturgis et al., 2002). Similarly, diseases seemed to be an important theme in gene therapy issues. While Turkish science teachers agreed on the use of gene therapy in cases such as breast cancer or having heart disease, they disagreed on the cases such as making a person more intelligent. As evident, usefulness and the purpose of genetics applications are distinctive factors in determining participants' attitudes towards genetics related issues. That is, participants' attitudes showed a wide range of approaches based on their perceptions regarding genetic applications. The teachers in our sample tended to favor genetic applications which they perceive as "useful" based on the purpose of application. In general, the descriptive statistics of present study provided evidence that science teachers' attitudes varied with respect to the issue being investigated. Supporting the present finding, usefulness and the purpose have been reported as the main factor that influence attitudes towards genetics related issues (Chabalengula et al. 2011; Dawson 2007; Fonseca et al. 2012; Klop and Severiens 2007; Ozden et al. 2008; Sturgis et al. 2002; Usak et al. 2009). Indeed in literature, studies conducted in Turkey and in other countries, reported that both pre-service/college students as well as teachers' attitudes changed based on the genetics application being investigated. For instance, studying with American pre-service teachers, Chabalengula et al. (2011) explored participants' attitudes towards a wide range of issues in biotechnology. Results revealed that PSTs tended to hold favorable attitudes towards of genetic modification of plants/foods, they showed reluctance in genetic modification of animals and human genes. In another study, conducted in Turkish context, Usak and his colleagues (2009) reported that while undergraduate students tended to favor agricultural biotechnology, they tended to less favor use of genetically modified foods. In a similar manner, both Slovenian pre-service and in service teachers were reported as holding favorable attitudes towards the use of genetic modifications in plants and microorganisms but generally remained uncommitted other genetic modifications in animals or human genes (Črne-Halanick et al. 2009, 2012). In sum, teachers' attitudes can vary with respect to the issue being investigated.

Another explanation for female science teachers' holding different attitudes towards issues in genetics literacy may be having lack of content knowledge regarding genetics. Indeed, some previous studies reported relationship between understanding of genetics issues and attitudes towards genetics (e.g., Črne-Hladnik et al. 2009, 2012; Dawson, 2007; Klop & Severiens, 2007; Sohan et al., 2002; Šorgo & Ambrožič-Dolinšek; 2009, 2010). For instance, investigating undergraduates' attitudes towards various biotechnology issues, Sohan and his colleagues (2002) reported that females tended to hold unfavorable attitudes towards a wide range of issues in biotechnology. The researchers attributed this to the lack of content knowledge in biotechnology issues suggesting a positive relationship among gender, content knowledge and attitudes towards biotechnology issues. In fact, in present study, the female teachers who held favorable general attitudes were also found to be more knowledgeable in genetics literacy when compare to male counterparts.

The teachers, in present study, however, were not quite knowledgeable in all dimensions comprising genetics literacy. For instance, science teachers were found to be moderately knowledgeable, particularly in DNA, DNA-gene-chromosome interactions, gene activity and description of genetic variation, functions of genes in protein synthesis, multiple genes, and disorders related with multiple genes as well as the concepts regarding gene regulation such as genetic variations and turn-on and turn-of genes. Moreover, they were found to be quite knowledgeable in concepts related to Mendelian patterns of inheritance and meiosis. They, however, did not exhibit a greater understanding of concepts of evolution concepts in general, natural selection or genetic variation, and applications of genetics technologies. This result, to some extent, was not surprising as far as the nature of Turkish national science curriculum is considered. Mendelian patterns of inheritance, DNA structure and functions are among the mostly emphasized concepts of the curriculum for years. Thus, the science teachers, as a student, had exposed these concepts at each stage of their previous formal education and as a teacher; they are responsible for teaching of these concepts to their students. Moreover, they were mainly trained about Mendelian patterns of inheritance and DNA and DNA structure during university education. In line with the findings of present study regarding lack of knowledge in concepts comprising genetics literacy, the previous studies also concluded both pre-service and in-service teachers were lacked of sufficient knowledge regarding modern genetics issues (Acra, 2006; Bowling et al. 2008; Cebesoy & Tekkaya, 2012; Chabalengula, et al. 2010, 2011; Sohan et al. 2002; Šorgo & Ambrožič-Dolinšek, 2009), and evolution concepts even they possessed sufficient knowledge in Mendelian genetics (Deniz, Donnely, & Yilmaz, 2008; Eve & Dunn, 1990; Griffith & Bram, 2004; Nehm & Reilly, 2007; Peker, Comert, & Kence, 2010). Specifically, vast majority of the empirical studies reported both pre-service and in-service teachers held inadequate knowledge regarding genetics related issues such as genetically modified foods, genetic modifications in microorganisms, in animals and in humans as well as stem cells and cloning (Boone et al. 2006; Darcin & Turkmen, 2007; Ozden et al. 2008; Šorgo & Ambrožič-Dolinšek, 2009; 2010; Usak et al. 2009).

Even though mandated in the curriculum, teachers in present study were comparably less knowledgeable about the applications of biotechnology, their advantages, disadvantages, and historical development as well. Evolution, on the other hand, has not covered well in the national curriculum and has not been addressed effectively in the science classes (Deniz et al. 2008; Peker et al. 2010). In fact, science teachers' lacked of understanding of evolution in addition to their unwillingness to teach it, and their inadequate preparations were reported in literature (Aquillard, 1999; Eve & Dunn, 1990; Griffith & Brem, 2004; Nehm & Reilly, 2007). Indeed, as teachers get more training regarding biotechnology and evolution, they will learn more about and will be confident in teaching these issues as Chan and Lui (2002) stated.

Even though the present study revealed some positive relationship between teachers' understanding of genetics literacy and their attitudes towards a wide range of issues in genetics literacy, some studies reported contradicting results with respect to knowledge and attitude relationship (e.g., Cebesoy & Tekkaya; 2012; Dawson & Schibeci, 2003; Klop & Severiens, 2007). While Dawson and Schibeci's (2003) study revealed no relationship between understanding and attitudes towards biotechnology, Klop and Severiens' (2007) study suggested different patterns explaining the relationship between knowledge and attitude. While there was a positive relationship between some students' knowledge and their attitudes towards biotechnology, the other group students demonstrated sufficient understanding in biotechnology but held unfavorable attitudes towards biotechnology due to their concerns and worries about biotechnology issues. Their instrument that was used to collect data consisted of affective and cognitive evaluation as well as behavioral intention items beside knowledge items. Thus, the researchers attributed the inverse relationship to the participants' concern and worries about biotechnology issues. As the scales used in present study did not include affective and cognitive evaluation items as Klop and Severien's (2007) scale, it is not possible to directly interpret the inverse relationship between knowledge and attitude dimensions by teachers' concerns and worries. However, holding unfavorable attitudes towards gene therapy and gene therapy applications might be related to teachers' perceptions of changing human genes as nearly half of participants were remained unsure about changing human genes in present study. This also be related with status of embryo (Halverson et al. 2010). Even gene therapy and gene therapy applications required no elimination of human embryo, moral status of embryo as perceived by teachers may cause developing unfavorable attitudes. Another explanation of holding unfavorable attitudes towards gene therapy and gene therapy application might be that females tended to hold higher risk perceptions as suggested by Črne-Hladnik et al. (2009, 2012).

Additionally, the current study revealed that female science teachers who were knowledgeable in genetics literacy tended to be more efficacious with respect to teaching genetics literacy to their students and tended to understand the necessity of these issues. They were also aware of the factors that might prevent them from effective implementation. The positive relationship between knowledge and self-efficacy was anticipated because the studies reported that that highly efficacious teachers tended to have sufficient conceptual understanding as well as have less misconceptions (Schoon & Boone, 1998; Sonmez & Kilinc, 2012; Tekkaya et al. 2002). For instance, Schoon and Boone (1998) investigated the relationship between pre-service elementary teachers' teaching efficacy beliefs and the number of alternative conceptions. A total of 619 pre-service teachers were surveyed throughout a survey that measured both science teaching efficacy beliefs and alternative conceptions. The results indicated revealed no relationship between number of alternative conceptions and science teaching efficacy beliefs. The findings indicated that high efficacious PSTs were more knowledgeable in science concepts being assessed by the inventory. Likewise, Tekkaya and her colleagues (2002) investigated the relationship between Turkish senior pre-service science teachers' understanding of science concepts and their teaching self-efficacy beliefs regarding science. The results implied that the number of courses completed and having sufficient conceptual understanding in science increased PSTs' personal teaching efficacy beliefs regarding science positively. As the PSTs in their study were senior student about to begin their teaching experience, the findings supported the findings of present study. Even though the findings of present study reported a positive relationship among gender, knowledge and teaching perceptions, some studies reported no gender difference (Cantrell et al. 2003; Sahin et al. 2010; Sonmez & Kilinc, 2012). For instance, the work of Sonmez and Kilinc (2012) investigated pre-service science teachers' knowledge levels, risk perceptions and attitudes about genetically modified foods (GM foods) as well as their self-efficacy beliefs about teaching GM foods. While researchers explored a number of factors (knowledge, risk perceptions and attitudes about GM foods, age, gender, preparing project and joining science Olympiads) that affect PSTs' self-efficacy beliefs by using step-wise regression model, they concluded that, only knowledge in GM foods and joining science Olympiads influenced PSTs' self-efficacy beliefs positively. As indicated, the aforementioned studies suggested the idea of knowledgeable individuals perceiving more efficacious regarding teaching genetics related issues. Thus, it is anticipated that more knowledgeable individuals to have/develop higher levels of self-efficacy beliefs regarding teaching genetics literacy.

Even though the present study revealed that female science teachers who were knowledgeable in genetics literacy tended to be highly efficacious with respect to teaching genetics literacy, descriptive statistics indicated that were not highly confident in their abilities to teach genetics literacy to their students and showed moderate sense of self-efficacy beliefs. While this study findings regarding teachers' self-efficacy beliefs are in parallel with previous studies conducted with Turkish pre-service biology teachers that was reported having moderate sense of self-efficacy teaching beliefs (Sesli & Kara, 2012), other studies conducted with pre-service and in-service science teachers reported that PSTs showed high level of confidence in their teaching abilities to teach (Aydin & Boz, 2010; Sahin, Ertepinar, & Isiksal, 2010; Tekkaya, Cakiroglu, & Ozkan; 2002). Researchers attributed their confidence in teaching science to the number of courses the PSTs had during their undergraduate education which help them to gain experience (Aydin & Boz, 2010; Tekkaya et al. 2002). As conforming their views, Aydin and Boz (2010) reported grade level differences among elementary science teachers and reported that senior PSTs were more efficacious when compared to the freshmen. On the other hand, in this study, teachers even they completed undergraduate courses and had teaching experience in public schools showed moderate self-efficacy beliefs. The decrease in teachers' confidence maybe related to the hinderer factors that they reported. As genetics literacy mainly focuses on controversial issues, teachers' perceptions regarding these hinderers may shape their instructions as well as their confidence.

Besides being female, more knowledgeable and more efficacious with respect to teaching genetics literacy, science teachers in our sample, acknowledged the necessity of these issues as well as the existence of factors such as maturity or conflicting with students' own values that hinder them. In line with this finding, Lazarowitz and Bloch (2006) indicated that more knowledgeable teachers tended to be aware of the importance of teaching controversial issues in their classes. Moreover, these teachers also acknowledged the hinderer factors that might prevent effective implementations. As mentioned, highly efficacious teachers are more likely to be aware of their strengths and weakness in terms of teaching and classroom management as well as the other factors that influence students' learning (Czerniak & Haney, 1998; Czerniak & Schriver, 1994). Moreover, a number of studies reported that even teachers acknowledged the importance of issues like biotechnology or genetically modified foods, they tended to express many factors that prevent them effective implementation of these issues into their classes (Bryce & Gray, 2004; Borgerding et al., 2013; Fonseca et al. 2012; Lazarowitz & Bloch, 2005; Lee et al. 2006; Steele & Aubusson, 2004; van der Zande et al. 2012). For instance, Fonseca and her colleagues (2012) indicated that even science teachers showed willingness to participate training programs regarding biotechnology and use as well as develop materials, they reported that curriculum restrictions limit their implementations. External examinations such as state or university entrance exams (Lazarowitz & Bloch, 2005; Steele & Aubusson, 2004), lack of material and time and curriculum overload (Lee et al., 2006; Borgerding et al. 2013) and student difficulties and maturity (Lee et al., 2006; Steele & Aubusson, 2004); and low self-efficacy beliefs about effective teaching of controversial issues (Lee et al. 2006) were other factor being reported. To sum up, even teachers, in this study felt the necessity and importance of issues in genetics literacy for their raising students as genetically literate, they stressed a number of factors which also reported in literature.

It has been noted that female science teachers who were knowledgeable in genetics literacy tended to be more efficacious as stated earlier. As the present study focused on more than one specific dimension of genetics literacy by considering knowledge, attitude and teaching perceptions, it is possible to obtain a gender difference in this study. As reported in the literature, gender was an important factor that has long been investigated in explaining and interpreting knowledge and attitude towards various issues in genetics and biotechnology as well as the relationships between knowledge and attitude constructs (e.g., Acra, 2006; Cantrell et al. 2003; Sohan et al. 2002; Šorgo & Ambrožič-Dolinšek; 2009, 2010; Usak et al. 2008; Sahin et al. 2010; Sonmez & Kilinc, 2010). Previous studies conducted with pre- and in-service teachers as well as college students which explored the relationship between self-efficacy beliefs and gender revealed no gender difference while some reporting only knowledge and self-efficacy relationship (Sonmez & Kilinc, 2010). As this study did not just focus on the relationship between self-efficacy beliefs and gender, but also focused on knowledge and other factors at the same time, it may be possible to expect contrasting results with existing literature. The previous studies exploring gender often presented mixed results with some studies reported no gender difference (Črne-Hladnik et al. 2009, 2012; Klop & Severiens, 2007), while others found females having less favorable attitudes towards various issues (Ishiyama et al. 2008; Klop & Severiens, 2007; Rundgren, 2011; Sohan et al. 2002; Usak et al. 2009; Qin & Bown, 2007; 2008). Even mixed results within same population have been reported (Črne-Hladnik et al. 2009, 2012). For instance, Črne-Hladnik and her colleagues (2009, 2012) reported no gender difference in participants' attitudes towards some issues such as Bt corn and somatic gene therapy, while females held unfavorable attitudes towards germ-line gene therapy. Indeed, in present study knowledgeable female teachers who were highly officious were also held unfavorable attitudes towards gene therapy and gene therapy applications. Thus, as the present study explored the relationship among more than two constructs (knowledge, attitudes towards various issues and teaching perceptions) as well as a number of factors that possibly in relation to these constructs at the same time, it is possible to get gender difference in present study. In fact, the relationship among genetics literacy levels, attitudes towards various issues in genetics literacy as well as teaching perceptions had not been explored before by considering factors such as gender, teaching experience or self-perceived interest and knowledge in genetics.

With respect to the second pair of canonical variates, teaching experience and self-perceived knowledge was associated with lower levels of genetics literacy as well as holding unfavorable attitudes towards abortion, gene therapy and gene therapy applications. That is, that experienced science teachers who perceived themselves knowledgeable in genetics literacy, in fact, were likely to be less genetically literate and held unfavorable attitudes towards abortion, gene therapy and gene therapy applications. In fact, the literature regarding teaching experience demonstrated conflicting results. Low levels of genetics literacy were associated with developing unfavorable attitudes towards specific issues, namely abortion, gene therapy and gene therapy application. This finding, in fact, is not in parallel with the findings discussed above which reported knowledgeable science teachers tended to held unfavorable attitudes towards gene therapy and gene therapy applications, while holding favorable attitudes towards general attitude items. Indeed, this finding might be expected as the previous studies exploring relationships between knowledge and attitude constructs towards various issues in genetics literacy did not present a unified conclusion either direct-reverse or no relationship explaining the relationship between knowledge and attitude constructs. Thus, when the second pair of canonical variates considered, revealing different patterns than the first pair of canonical variate might be possible as the literature demonstrated a wide range of explanation for the relationship between knowledge and attitude constructs. For instance, teaching experience is an important factor that might cause a difference between first and second pair of canonical variates. While our study revealed experienced science teachers were less knowledgeable in terms of genetics literacy and holding unfavorable attitudes towards some issues, previous studies demonstrated diverse results explaining the role of teaching experience. While there was not any study directly investigated the role of teaching experience on genetics literacy levels or attitudes towards issues such as gene therapy, some studies were available focusing on biotechnology issues in the literature. For instance, some studies reported that teaching experience did not affect participants' attitudes and knowledge regarding biotechnology issues (Boone et al. 2006). On the other hand, some other studies found in literature reported that experienced science teachers tended to be less informed regarding biotechnology issues (Fonseca et al. 2012). The findings of this study regarding teaching experience is confirmed by Fonseca and her colleagues' (2012) study which explored Portuguese biology teaches' beliefs about teaching biotechnology issues and the relationship between their beliefs and biotechnology teaching. They concluded that experienced teachers perceived themselves less informed about biotechnology issues. Indeed, in our study, experienced science teachers were found to be less knowledgeable in genetics literacy. In contrast to this finding, some studies reported that experienced teachers were more aware of their students' use of different reasoning skills (van der Zande et al. 2009), and the importance of genetics related issues, thus, prefer to teach them (Borgerding et al. 2013) as well as used more problem based activities (van der Zande et al. 2013). The difference between research findings may be caused by the focus of research, cultural differences or methods adopted in different research. For instance, van der Zande and his colleagues' studies (2009, 2012) focused on genetic testing, while, Fonseca et al. (2009) and Borgerding et al. (2013) focused on biotechnology issues in general. Also, these studies were conducted with science teachers in different cultural contexts as Portuguese, Dutch and American science teachers. While the aforementioned studies adopted qualitative methods for exploring teachers' preferences and ideas about implementing genetics related issues into their classes, the present study finding focused on the interpretation of quantitative data gathered from science teachers. Altogether, there might be some differences with respect to the teaching experience. Thus, additional interviews were conducted to further explore the underlying factors that influence Turkish science teachers' decisions in present study.

It is important to mention that, both pairs of canonical variates revealed unfavorable attitude towards gene therapy and gene therapy applications. This may be caused by the moral status of embryo and risk perceptions as perceived by teachers as discussed above (Črne-Hladnik et al. 2009; 2012; Halverson et al. 2010). Another explanation for explaining teachers' holding unfavorable attitudes towards gene therapy and gene therapy applications might be related with participants' concerns about "designer babies" issue (Lederman et al. 2014; Leslie & Schibeci, 2006; Nielsen, 2012). The term "designer baby" referred to the use of gene therapy for different purposes other than eliminating severe hereditary diseases as Nielsen (2012) indicated. Lederman and his colleagues (2014) indicated that letting parents to design their own child can create "a genetic caste system" which is a major concern for participants. Thus, the science teachers in present study may hold unfavorable attitudes towards gene therapy issues. Their concerns and reasons behind their concerns about gene therapy will be discussed within the light of their responses to the interview questions in following chapter.

5.1.3. Discussion of the findings for factors influencing science teachers' decision making process

The literature examining informal reasoning and decision making processes regarding genetics related issues including *socio-scientific issues* and *biotechnology* revealed a wide range of factors that influence participants' decisions (Bell, 2002; Bell & Lederman, 2003; Christenson et al. 2012; Dawson, 2011; Grace & Ratcliffe, 2002; Halverson et al. 2009; Lee & Witz, 2009; Sadler & Zeidler, 2004, 2005a; Sadler et al. 2006; van der Zande et al. 2009; 2011). Decision making processes, specifically focusing on controversial issues like genetics related issues are influenced by multiple factors (Halverson et al. 2009). As teachers' implementation as well as integration of issues regarding genetics literacy into their science classes are closely related with their ideas, values, philosophies and personal concerns as Lee and Witz (2009) indicated, the factors that might influence teachers' decisions, which in fact determine their classroom applications, have become prominent. In present study, while quantitative data gathered from administration of scales served as describing general tendencies of science teachers in terms of genetics literacy, attitudes and teaching perceptions as well as the relationship among them; the qualitative data gathered from teacher interviews served to determine the possible factors that might influence their decisions.

The qualitative results of present study revealed that science teachers' decision making processes were influenced by a wide range of factors. The most evident result is that science teachers' decisions are influenced by moral considerations (35% of total statements). The moral considerations emerged from present study were *taking human life, means to an end, disturbing natural order, health improvement, social stratification, slippery slope, societal betterment* and *diversity* which were originated from the studies exploring informal reasoning patterns in the context of SSIs that were referred as rationalistic informal reasoning patterns (Sadler & Zeidler, 2004; Sadler & Zeidler, 2005a).

Some of rationalistic moral considerations rooted from moral principles (referred as principle-based) such as using embryo as a tool or altering the natural process and some of them were based on the consequences of genetic applications (referred as consequalistic such as health improvement, creating classes of “genetic haves” and “genetic have nots”, using genetic application in unacceptable contexts, improvement of society overall and erosion of diversity (Sadler & Zeidler, 2004; 2005a). While science teachers in present study frequently used consequalistic moral patterns (25% of total statements) when compared to principle based patterns (10% of total statements) implying that teachers’ decisions were mainly influenced by the consequences of the genetic applications. Among these consequalistic patterns, “health improvement” was the most frequently stated one by science teachers in the present study. All the science teachers evaluated the genetic applications in the scenarios by considering improvements in the health of individuals at first hand. While all the science teachers clearly approved the use of genetic applications for the purpose of treatment of diseases, they opposed the same genetics applications for other purposes such as changing eye color or hair color of individuals. For instance, teachers approved gene therapy applications for treatment of Huntington disease or cystic fibrosis, but they clearly indicated that they had concerns about the use of gene therapy in other areas such as for the purpose of increasing intelligence, determining of an unborn baby’s hair or eye color. This finding was also supported the quantitative part of present study which reported that science teachers’ attitudes were changed based on the issue being investigated. For example, the teachers showed a great tendency to accept gene therapy, gene therapy applications as well as pre-implementation genetic diagnosis for the treatment of serious diseases such as heart disease or breast cancer. Indeed, in this study, teachers favored and accepted the genetic applications presented in the scenarios for the treatment of diseases. In line with this finding, some studies also reported that health issues were important while making decisions in controversial issues (e.g., Khishfe, 2012; Halverson et al. 2009; Lee, 2012; Ozer-Keskin, 2013; Sadler & Zeidler, 2004, 2005a). For instance, in her study Khishfe (2012) reported that some students favored genetic engineering applications as these applications make people healthier. Likewise, quantitative studies that reported that participants favored genetic applications in the context of health related issues (Ishiyama et al. 2012; Ozer-Keskin, 2013; Sohan et al. 2002).

One explanation for the significant role of moral consideration on science teachers' decision making role may drive from the socio-cultural factors. Along with religious and value considerations, as explained earlier in first part of discussion, science teachers' decisions are deeply influenced from Turkish socio-cultural norms. The available literature in the context of biotechnology, and socio-scientific issues suggested that moral/ethical considerations as an important factor that influence participants' decision making processes including students (Christenson et al. 2012; Črne-Hladnik et al. 2012 Zande et al. 2009), undergraduates (Sadler & Zeidler, 2004, 2005a; Topcu, 2008) as well as teachers (Lee & Witz, 2009; van der Zande, 2011). In line with the findings of present study, studying with college students, Sadler and Zeidler (2004) indicated that college students mostly used rationalistic reasoning patterns when compared to emotive based or intuition-based reasoning while making decisions. Likewise, studying with Turkish pre-service science teachers, Topcu (2008) found out that PSTs mainly used rationalistic informal reasoning patterns in gene therapy, cloning and environmental socio-scientific issues. He claimed that participants' religious beliefs might be influential in the participants' rationalistic reasoning patterns. Indeed, in present study, even though not stated frequently as other factors, religious factors were another influential factor to be considered.

In addition to the moral factors revealed in this study, teachers also showed empathy or sympathy towards the fictious characters in the scenarios which implied their decisions were also influenced by emotive considerations. While some teachers showed empathy towards the parents or patient/child in articulated scenarios, some teachers stated that their current status as being mother influenced them and thus, their decisions emotionally. Along with emotive factors, teachers indicated their concerns regarding the difficulties that families will face when raising the child as well as the problems that patients will face with such as sufferings or care problems. All the teachers participated in this study considered both parents' and child' psychological state when articulating their opinions. In fact, the studies focusing on informal reasoning patterns also explored participants' emotive and intuitive informal reasoning patterns along with rationalistic informal reasoning patterns (Črne-Halanick et al. 2012; Dawson & Venville, 2009; Sadler & Zeidler, 2004, 2005a, 2005b; Topcu, 2008, van der Zande et al. 2009). In addition, some studies specifically explored how psychological state of both participants and the fictious characters influenced the participants' decisions and reported that socio-psychological concerns indeed influenced the participants' decisions thus, should be included and considered while exploring decision making patterns (Boerwinkel et al. 2011; Lee, 2012; Kolstø, 2006; van der Zande et al. 2011). Interestingly, studies exploring adults (college students or pre-service science teachers) and students' decision making patterns reported while students' decisions are mainly influenced by their emotive considerations (e.g., Dawson & Venville, 2009; van der Zande et al. 2009), college students and pre-service teachers' decisions are based on rationalistic moral reasoning patterns (e.g., Sadler & Zeidler, 2004; Topcu, 2008). As discussed above, this is an important finding that shows the discrepancy between the main factors that influence teachers' and students' decisions. Actually, this was an expected situation as Dawson (2007) revealed that as students get older, they develop deeper understanding of biotechnology, cloning and genetically modified foods. Moreover, exploring decision making competence, Eggert and Bögeholz (2010) developed an instrument for assessing students' decision making competence and revealed students' decision making competence increased with respect to level of education implying that as the students get older, they develop more comprehensive decision making skills. Thus, college students and pre-service science teachers might develop deeper understanding about issues in genetics literacy as well as develop more comprehensive decision making skills throughout their formal education. Indeed, in current study, science teachers dealt with a wide range of factor while making decision which can be an indicator of developing comprehensive decision making skills. Also, science teachers might be aware of their students' decision making processes as well. In line with this, in their study, van der Zande and his colleagues (2009) explored science teachers' awareness of the patterns that their students' use while making decisions. They reported that teachers noticed the existence of different reasoning patterns of their students, but they failed to make a distinction between reasoning patterns and to choose appropriate skills for addressing different reasoning patterns in their classes. Accordingly, even science teachers acknowledged the existence of different reasoning patterns that their students use while making decisions, holding low self-efficacy beliefs regarding teaching of issues in genetics literacy may hinder them choosing appropriate teaching skills as well as having confidence to teach these issues.

Another important finding that interviews illuminated was that all the teachers referred scientific evidences, experimental nature of the treatments and tentative nature of scientific knowledge in their decisions. Specifically, teachers' referring to the scientific evidence and experimental nature of treatments was most evident in fetal tissue transplantation scenario which was specifically emphasized as being an experimental in the scenario. Teachers' also highlighted the tentative nature of science in the all the scenarios as they showed high degree of faith in scientific developments even though they obviously did not refer tentativeness as a characteristic of nature of science. In line with this finding, the studies focusing on the relationship between nature of science and decision making processes revealed that participants frequently used characteristics of nature of science such as experimental nature of science or tentative nature of science (Chang & Chiu, 2008; Khishfe, 2012; Lee et al. 2012). For instance, exploring Taiwanese undergraduate students' informal reasoning patterns, Chang and Chiu (2008) identified one of the sources that students use while making decisions as scientific beliefs which refers participants' beliefs about the value of scientific research as well as uncertainty and temporary nature of science. In another study investigating how Korean pre-service teachers dealt with SSIs, Lee and her colleagues (2012) revealed that PSTs tended to possess a high degree of faith in science and technology. On the other hand, in a previous study conducted with university science and non-science professors, Bell and Lederman (2002) reported that the participants failed to identify the role of experimental nature of science, the role of scientific knowledge and tentativeness in science while dealing with fetal tissue transplantation scenario. Accordingly, while some studies highlighted that participants' decisions were influenced by some characteristics of nature of science such as tentativeness or experimental nature of science, some studies revealed that participants were not aware of the role of these characteristics on their decisions. Indeed, in present study, teachers explicitly refereed these characteristics and showed high reliance of science and technological developments. Actually, the relationship between decision making and NOS has been an issue for some studies (Bell, 2001; Bell & Lederman, 2002; Khishfe, 2012). Thus, teachers' acknowledgement of NOS is important for their classroom applications.

Despite having faith in science and scientific developments, science teachers in current study identified some concerns that genetics technologies have created such as the credibility of the scientists, side effect of new technological applications, the possibility of misuse of genetic applications as well as risk factors and uncertainty associated with new genetic technologies. All the teachers expressed that they were concerned about misuse of genetic applications such as creating new diseases or using genetic applications with purposes other than treatment of existing diseases. In fact, the existing literature focusing on SSIs and biotechnology issues frequently emphasized that participants showed a wide range of concerns about genetic applications such as uncertainty (Boerwinkel et al. 2011; Chang & Chiu, 2008; Kolstø, 2006; Lee, 2012; van der Zande et al. 2011); risk factors and risk analysis (Črne-Halanick et al. 2012; Ishiyama et al. 2008; Kolstø, 2006; Lee, 2012; Lee et al. 2012; Sohan et al. 2002) and side effect of genetic applications (Sadler & Zeidler, 2005a, 2004).

Lastly, teachers in present study indicated some concerns regarding economic, politic and legal aspects of genetic applications. Regarding economic concerns, teachers highlighted the possible inequalities in accessing the genetic application between poor and rich people. Indeed, Topcu (2008) also reported that Turkish pre-service teachers' concern about economic situations and indicated that economic factors were distinctive in their informal reasoning skills. In addition, other studies conducted with issues in genetics literacy confirmed this finding (Halverson et al. 2009; Lee, 2012; Khishfe, 201). Considering legal issues, science teachers referred the necessity of legal limitations and regulations in genetic applications. In addition, they indicated that the regulations should be done by international independent scientific committees. With this respect, a few teachers emphasized the role of governments in development and use of these genetic technologies. These findings are important as previous studies conducted in Turkey did not reveal participants' concerns about political and legal aspects regarding issues in genetics literacy (e.g., Topcu, 2008; Ozer-Keskin, 2013), even though the international studies emphasized the existence of legal concerns (Lazarowitz & Bloch, 2006; van der Zande et al. 2012), politic concerns (Christenson et al. 2012) as factors influencing decision making framework.

As a conclusion, the discussed factors above asserted that the decision making process regarding controversial issues in genetics literacy could not be influenced by a major factor. Instead the decision making process were influenced a wide range of factors and interactions among these factors. In line with this finding, previous studies unveiled similar factors such as political, cultural and social factors (Lee, 2007); risk factors (Kolstø, 2006; Lee, 2012); sociocultural and psychological factors and uncertainty (Boerwinkel et al. 2011; Lee, 2012; Kolstø, 2006); rationalistic, emotive and intuitive factors (Črne-Halanick et al. 2012; Dawson & Venville, 2009); religious factors (Halverson et al. 2009; Khishfe, 2012; Lee, 2007; Lee et al., 2012; Ozer-Keskin, 2013; Topcu, 2008; Zeidler et al. 2002); value factors (Bell & Lederman, 2002; Boerwinkel et al. 2011; Christenson et al. 2012; Grace & Ratcliffe, 2002; Kolstø, 2006; Lee, 2012; Ozer-Keskin, 2013; van der Zande et al. 2011, 2012), personal choice (Ozer-Keskin, 2013), legal concerns (Lazarowitz & Bloch, 2006; van der Zande et al. 2012), politic concerns (Christenson et al. 2012) and economic factors (Lee, 2012; Khishfe, 2012). Even the reported studies used different frameworks including different factors, some researchers emphasized the need of a wider framework including multiple factors as well as considering the interaction among these factors in decision making process (Christenson et al. 2012; Lee, 2012). Indeed, the present study supported the necessity of a wider framework including multiple factors. In addition to aforementioned factors, some studies emphasized the crucial role of content knowledge in decision making (Sadler & Zeidler, 2005b; van der Zande et al. 2011). For instance, exploring the factors that influence science teachers' decision making in the context of genetic testing, van der Zande et al. (2011) revealed that besides ethical, legal and social aspects and characteristics as uncertainty, complexity, probability, and morality of genetic testing, content knowledge was required. Even the qualitative results did not directly reveal the role of content knowledge in genetics, the quantitative results of current study illuminated the role of content knowledge as well as relationship among genetics literacy levels, attitudes towards a wide range of issues and teaching perceptions about genetics literacy. While quantitative results of present study revealed there is some degree of relationship among science teachers' genetics literacy levels, attitudes towards a wide range of issues in genetic literacy and teaching perceptions about genetics literacy, the qualitative results revealed science teachers' decisions were influenced by a large number of factors. As teachers' implementations are deeply influenced by their ideas, values, philosophies and personal concerns (Lee & Witz, 2009; Lee, 2012), illuminating the factors that influence teachers' decisions may also be helpful in understanding how the they shape their classroom implementations regarding issues in genetics literacy.

5.2. Conclusions

In the current study, the relationship among science teachers' genetics literacy levels, their attitudes towards various issues in genetics literacy, namely, general attitude, use of genetic information, abortion, pre-implementation genetic diagnosis, gene therapy and gene therapy applications and teaching perceptions with respect to the teachers' background variables as gender, teaching experience, self-perceived interest and knowledge in genetics were explored. Findings of the study concluded that being female, having high level of interest in issues in genetics literacy and perceiving themselves as knowledgeable in genetics literacy associated with higher levels of knowledge in genetics literacy and favorable attitudes towards general attitudes as well as believing the necessity of introducing genetics literacy and holding higher self-efficacy teaching beliefs. They, however, were likely to emphasize more hinderer factors as well as holding unfavorable attitudes towards gene therapy and gene therapy applications. In addition, experienced science teachers who perceived themselves knowledgeable in genetics literacy, in fact, were likely to be less genetically literate and held unfavorable attitudes towards abortion, gene therapy and gene therapy applications.

As the background characteristics did not fully explained the variance in the relationships among genetics literacy levels, attitudes towards various issues dealt with in genetics literacy framework and teaching perceptions, it is possible that there is also other factors that may influence teachers' attitudes as well as their teaching perceptions. Beyond exploring quantitative relationships, the present study also explored how teachers made decisions regarding controversial issues considered in genetics literacy framework. Qualitative results of current study revealed that science teachers' decisions were influenced by a wide range of issues including moral, emotive, value, economical, legal, socio-cultural, religious, political as well as technological considerations. The most influent factor was moral considerations. Specifically, teachers mainly used consequalistic moral considerations while making decisions. Health improvement was apriority in their decisions. Furthermore, all the teachers' decisions were influenced by the interaction of multiple factors.

5.3. Implications of the Study

The present study has some important implications for both pre-service and in-service teacher professional development attempts as well as science teacher educators and policy makers. The findings of this study revealed that there is complex relationship among teachers' genetics literacy levels, their attitudes towards various issues and their teaching perceptions which was influenced by multiple factors as moral, emotive, value, economical, legal, socio-cultural, religious, political as well as technological considerations. As teachers' implementations are deeply influenced by their ideas, values, philosophies and personal concerns (Lee & Witz, 2009; Lee, 2012), teachers' role in science classes should be reconsidered with the light of the findings of current study. As a result of rapid technological developments in genetics, issues regarding genetics such as gene therapy, genetic modifications of animals and foods, stem cell research possibilities have become prominent part of daily life. Therefore, students come to classes by being exposed to many information from mass media sources like internet or television programs. Thus, teachers are needed to be ready for answering their students' questions as well as providing appropriate environments for their students to take part in debates or discussions regarding controversial genetic related issues. They also are needed be able to create teaching environments which are open to discussions considering arguments, counter arguments based on the evidences which in turn will be resulted in the development of students' decision making processes as well as preventing development of misconceptions. So, their students will be enable to understand different perspectives on an issue and to respect others' ideas and make informed decisions. Thus, they can raise their students as future citizens of modern society by considering their students' needs besides teaching solely knowledge as Lazarowitz and Bloch (2006) argued. Therefore, science teacher educators as well as curriculum developers should able to acknowledge the importance of inclusion of these controversial issues into science classes as well as the role of these issues in raising students who are able to make informed decisions in daily life issues consisting ethical, legal or social dilemmas such as genetic testing situations.

These issues are also needed to be part of curriculum as Lazarowitz and Bloch (2006) argued without including controversial ethical issues related with genetics into science curriculum, science teachers might demonstrate unwillingness to teach or discuss these issues in their classes. As teachers include these issues in their classes, they could create environment which enhance active participation of their students. With this respect, the instructional interventions have become prominent. Halverson and her colleagues (2009) clarified that these kind of instructional interventions are effective ways of translating scientific content knowledge into decision making tasks. It was also stated effective implementations of teacher are supposed to enhance students' reasoning abilities as Zeidler and his colleagues (2002) proposed. While developing interventions, teachers should consider a wide range of approaches such as dramatic interpretations, storytelling and critical reading and writing activities as well as role plays (Oulton et al. 2004;

Rattcliffe, 2009). In addition to these activities, argumentation regarding controversial issues and case-based socio-scientific issues can be another ways for development of students' reasoning abilities (Zeidler et al. 2005; Zohar & Nemet, 2002). With this respect, advance knowledge in genetics literacy may influence science teachers' reasoning abilities and decision making strategies as well as development of confidence in teaching. Therefore, it is important to include issues reflected in genetics literacy such as gene therapy or genetic testing to both pre-service and in-service teacher education courses for ensuring that science teachers to develop abilities to deal with these issues during their classes. These development programs should include moral, emotive, value, economical, legal, socio-cultural, religious, political as well as technological considerations which may be associated with these issues in order to help teacher to develop abilities to consider multiple perspectives. While developing these kind of professional programs as well as undergraduate courses, appropriate environments should be provided teachers as well as pre-service teachers in order to recognize their beliefs and positions while making decisions and freely entitled their decisions in controversial issues. With this respect, this study also revealed that participants' attitudes and decisions regarding genetics related controversial issues with respect to issues and thus, even they approved some genetics applications in some cases, for instance, diseases like cancer they might not approve them in other cases such as determining of sex of unborn baby. This finding is actually important in terms of developing multidimensional consideration of the same genetic application at the same time. Such training will enable them to consider multiple perspectives while dealing with the same controversial issues as well as enlarge their view of science teaching. In addition, they will recognize their way of thinking while making decisions regarding controversial issues. With this respect, teachers may need professional assistance as Lumpe and his colleagues (1998) indicated. Therefore, science teacher educators should provide successful implementation examples and create possibilities to teachers and pre-service teachers to practice and develop their abilities as well as developing confidence during practices in order to alter practice problems.

There are a number of factors that teachers should acknowledge while developing activities. As because of the nature of controversial genetics issues requires multiple perspectives to consider, science teachers develop teaching activities by considering multiple perspectives. With this respect, including ethical, legal and social aspects of issues in genetics literacy into teaching tasks may be helpful as van der Zande et al. (2012) proposed. Another point for effective implementation is that teachers should be able to recognize their students' reasoning skills. By acknowledging their students' reasoning skills, teachers are more easily be able to develop teaching activities for issues in genetics literacy. Effective activities will provide students to weight possible negative and positive consequences of controversial issues involving economical, moral, social concerns and make a collective decision. Also these kind of activities are supposed to increase students' motivation and interest. In addition, At this point, teachers' role in the classrooms also is needed to be clarified. Teachers generally should demonstrate a balanced view by remaining neutral in discussion of controversial issues in their classes.

Lack of material and time and curriculum overload and student difficulties and maturity are among the constraints that hinder effective implementation of controversial issues in science classes those were reported in literature (Borgerding et al. 2013; Lee et al., 2006; Steele & Aubusson, 2004) as well as within this study. Therefore, science curriculum developers should able to acknowledge the existing hindering factors in front of effective implementations and provide possible ways to overcome these difficulties. Curriculum developers should recognize the importance of these issues for raising students that are able to make informed decisions regarding these issues which modern societies needed and reconsider the role of these issues in current curriculum within the light of emerging technological developments.

5.4. Limitations and Recommendations

The present study has some limitations that should be acknowledged. First, the data were collected from teachers' self-report instruments which have limited number of questions and qualitative interview protocols. As the number of questions found in the GLAI and the attitude scale may not sufficiently asses the genetics literacy levels of science teachers as well as the attitudes towards various issues in genetics literacy. As the relationship among science teachers' background characteristics and their genetics literacy levels, their attitudes towards various issues in genetics literacy and their teaching perceptions are correlational in nature, the findings of current study help to understand the relationships among the aforementioned variables but does not state cause- effect relationship. Another limitation that should be considered in that the quantitative data analysis strategies may not reveal the actual relationship among teachers' genetics literacy levels, their attitudes towards various issues in genetics literacy and their teaching perceptions. Therefore, qualitative interview protocols were utilized in present study for getting deeper understanding how possible relationship among the aforementioned construct were shaped as the issues in genetics literacy consisted of controversy in their nature as Oulton et al. (2004) indicated. It is also possible to adopt other data collection procedures for enlarging of findings of present study. For instance, classroom observation of science teachers can be useful for enlightening teachers' actual practices. As this study only explored how various factors influenced science teachers' decisions while making decisions regarding issues in genetics literacy, teacher actual practices or how their practices are influenced by the factors revealed in interviews can be observed throughout classroom observations in detail. Additionally, classroom teaching tasks as well as case-based issues might be beneficial for exploring science teachers' actual practices in their classes. Actually, case-based approaches in controversial issues have been proposed in literature (Sadler & Zeidler, 2004; 2005a). Thus, modules including case-based approaches in genetics literacy can be beneficial for effective implementation of these issues. Moreover, the effective participation of students into the classes including case-based issues can be helpful in assessing the effectiveness of the developed modules. Longitudinal studies can also be informative in terms of observing the developments in both science teachers' and students' decision making processes and how they handle the controversial issues over time. In addition to case-based approaches, argumentation and discourse can be helpful in the development of modules for both teachers and students.

The data of present study were collected from schools that are located in Ankara, the capital city of Turkey. Thus, even collected from a large number of teachers in a wide range of districts of Ankara, a nationwide study including different regional districts of Turkey can be useful in order to gather a more representative sample of Turkey. Thus, the results may be representative of Turkish science teachers in nation-wide. With this respect, another recommendation is that as the current study was conducted with only public middle school science teachers, it will be beneficial to include private middle school science teachers in order to provide a more representative sample of Turkish middle school science teachers. In addition, it will enable the researchers to make comparisons between private and middle school science teachers' perceptions of genetics literacy.

As the current study revealed that science teachers' decisions are influenced by a wide range of factors not only a single factor, it may be worthwhile to explore the relationships among these factors. Another recommendation is that exploring the factors within cross-case analysis. Thus, it becomes possible to observe how participants' decisions are changed within a case.

To sum up, further research is needed to explore the complex relationships among science teachers' genetics literacy levels, their attitudes towards various issues in genetics literacy and their teaching perceptions by considering how they make decisions regarding these issues.

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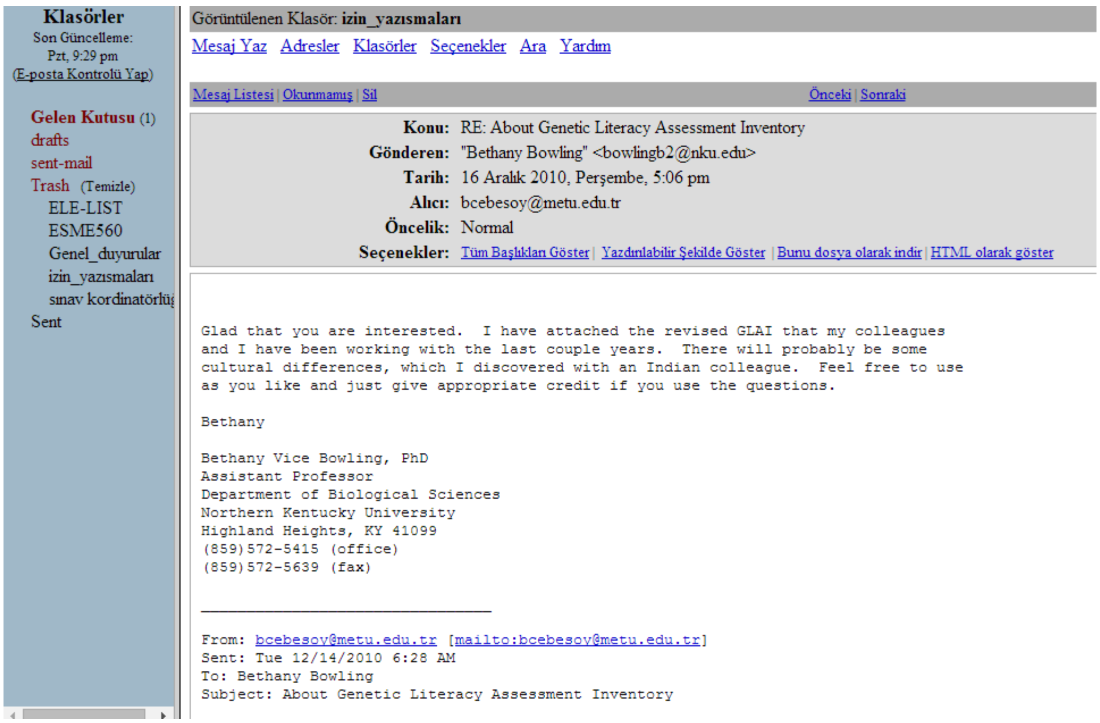
APPENDICES

APPENDIX A

PERMISSIONS OBTAINED FROM THE DEVELOPERS OF GLAI



Klasörler
Son Güncelleme:
Pzt, 9:29 pm
(E-posta Kontrolü Yap)

Gelen Kutusu (1)
drafts
sent-mail
Trash (Temizle)
ELE-LIST
ESME560
Genel_duyurular
izin_yazısmaları
sınav kordinatörlü
Sent

Görüntülenen Klasör: **izin_yazısmaları**

Mesaj Yaz Adresler Klasörler Seçenekler Ara Yardım

Mesaj Listesi | Okunmamış | Sil   Önceki | Sonraki

Konu: RE: About Genetic Literacy Assessment Inventory
Gönderen: "Bethany Bowling" <bowlingb2@nku.edu>
Tarih: 16 Aralık 2010, Perşembe, 5:06 pm
Alıcı: bcebesoy@metu.edu.tr
Öncelik: Normal
Seçenekler: Tüm Başlıkları Göster | Yazdırılabilir Şekilde Göster | Bunu dosya olarak indir | HTML olarak göster

Glad that you are interested. I have attached the revised GLAI that my colleagues and I have been working with the last couple years. There will probably be some cultural differences, which I discovered with an Indian colleague. Feel free to use as you like and just give appropriate credit if you use the questions.

Bethany

Bethany Vice Bowling, PhD
Assistant Professor
Department of Biological Sciences
Northern Kentucky University
Highland Heights, KY 41099
(859)572-5415 (office)
(859)572-5639 (fax)

____

From: bcebesoy@metu.edu.tr [mailto:bcebesoy@metu.edu.tr]
Sent: Tue 12/14/2010 6:28 AM
To: Bethany Bowling
Subject: About Genetic Literacy Assessment Inventory

APPENDIX B

ETHICAL COMMITTEE APPROVAL OF METU

1956

Orta Doğu Teknik Üniversitesi
Middle East Technical University

Fen Bilimleri Enstitüsü
Graduate School of
Natural and Applied Sciences

06800 Ankara, Türkiye
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Sayı: B.30.2.ODT.0.AH.00.00/126/84 – 856

4 Temmuz 2012

Gönderilen: Prof. Dr. Ceren Tekkaya
İlköğretim Bölümü

Gönderen : Prof. Dr. Canan Özgen
IAK Başkan Yardımcısı

İlgi : Etik Onayı

" Fen Bilgisi Öğretmenlerinin Genetik Okuryazarlık Düzeylerinin ve Genetik Okuryazarlığa Yönelik Tutumlarının Belirlenmesi " isimli araştırmanız "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

04/07/2012

Prof.Dr. Canan ÖZGEN
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkanı
ODTÜ 06531 ANKARA

APPENDIX C

PERMISSIONS OBTAINED FROM MINISTRY OF NATIONAL EDUCATION

ÖĞRENCİ İŞLERİ DAİRE BAŞKANLIĞI
REGISTRAR'S OFFICE

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI
06800 ÇANKAYA/ANKARA
T: +90 312 210 34 17 - 21 31
F: +90 312 210 79 60
oidb@metu.edu.tr
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B.30.2.ODT.72.00.00/400 - 4801 - 1040 07.09.2012

EĞİTİM FAKÜLTESİ DEKANLIĞINA

Ankara Valiliği Milli Eğitim Müdürlüğü'nden alınan, İlköğretim Ana Bilim Dalı Doktora Programı öğrencisi Ümran Betül Cebesoy'a ait yazı ilgisi nedeni ile ilişikte sunulmuştur.

Bilgilerinize arz ederim.

Saygılarımla.

Nesrin ÜNSAL
Öğrenci İşleri Daire Başkanı

SSD/

ÖĞRENCİ İŞLERİ
DAİRE BAŞKANLIĞI
... Saat :

T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

SAYI : B.08.4.MEM.0.06.20.01-60599/63448 27/08/2012
KONU : Ümran Betül CEBESOY

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi: a) M.E.B. Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 2012/13 nolu Genelgesi.
b) Üniversiteniz Öğrenci İşleri Daire Başkanlığının 31/07/2012 tarih ve 4025 sayılı yazısı.

Üniversiteniz İlköğretim Ana Bilim Dalı doktora öğrencisi Ümran Betül CEBESOY'un **"Fen bilgisi öğretmenlerinin genetik okuryazarlık düzeylerinin ve genetik okuryazarlığı yönelik tutumlarının belirlenmesi"** konulu tezi ile ilgili çalışma yapma isteği Müdürlüğümüzce uygun görülmüş ve araştırmanın yapılacağı İlçe Milli Eğitim Müdürlüğüne bilgi verilmiştir.

Mühürlü anket örnekleri (8 sayfadan oluşan) ekte gönderilmiş olup, uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde iki örneğinin (CD/disket) Müdürlüğümüz Strateji Geliştirme Bölümüne gönderilmesini rica ederim.

İlhan KOÇ
Müdür a.
Şube Müdürü

EKLER : Anket (8 Sayfa)

06.09.12*014810

İl Milli Eğitim Müdürlüğü - Beşevler
Bilgi İçin: Nermin ÇELENK
Tel : 221 02 17 - 134 / 135
Faks: 223 75 22
istatistik06@meb.gov.tr

APPENDIX D

VOLUNTARIY PARTICIPATION FORM

GÖNÜLLÜ KATILIM FORMU

Bu çalışma, Arş. Gör. Ümran Betül Cebesoy tarafından Prof. Dr. Ceren Öztekin danışmanlığındaki doktora tezi kapsamında yürütülen bir çalışmadır. Çalışmanın amacı, fen ve teknoloji öğretmenlerinin genetik okuryazarlık durumları, genetik okuryazarlığa yönelik tutumları ve genetik okuryazarlık öğretimine yönelik algılarıyla ilgili bilgi toplamaktır. Çalışmaya katılım gönüllülük esasına dayanmaktadır. Ankette, sizden kimlik veya çalışılan kurumun belirlenmesine yönelik hiçbir bilgi istenmemektedir. Cevaplarınız tamimiyle gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir; elde edilecek bilgiler bilimsel yayımlarda kullanılacaktır.

Anket, genel olarak kişisel rahatsızlık verecek soruları içermemektedir. Anket sonunda, bu çalışmayla ilgili sorularınız olması durumunda, sorularınız araştırmacı(lar) tarafından cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için İlköğretim Bölümü öğretim üyelerinden Prof. Dr. Ceren Öztekin (Oda:116; Tel: 210 4194; E-posta: ceren@metu.edu.tr) ya da araştırma görevlisi Ümran Betül Cebesoy (Oda: 104; Tel: 210 4065; E-posta: bcebesoy@metu.edu.tr) ile iletişim kurabilirsiniz.

Bu çalışmaya tamamen gönüllü olarak katılıyorum ve istediğim zaman yarıda kesip çıkabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlı yayımlarda kullanılmasını kabul ediyorum. (Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

Ad- Soyad:	Tarih	İmza
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APPENDIX E

TEACHER DEMOGRAPHIC INFORMATION SCALE

KİŞİSEL BİLGİ FORMU

1. Cinsiyetiniz:
❑ Kadın ❑Erkek

2. Branşınız:
❑ Fen Bilgisi Öğretmenliği
❑ Biyoloji Öğretmenliği
❑ Fizik Öğretmenliği
❑ Kimya Öğretmenliği
❑Diğer (Lütfen Belirtiniz)
…………………………………

3. Mezun Olduğunuz Fakülte:
❑ Eğitim Fakültesi
❑ Fen Fakültesi
❑ Diğer (Lütfen belirtiniz)
……………..…………………

4. Fen fakültesi mezunu iseniz formasyonunuz var mı?
❑ Evet ❑ Hayır

5. Mesleki Deneyiminiz:
❑ 1 yıl ❑ 11-13 yıl
❑ 2-4 yıl ❑ 14-16 yıl
❑ 5-7 yıl ❑ 16-19 yıl
❑ 8-10 yıl ❑ 20 yıldan fazla

6. Genetik konusu ile ne kadar ilgilisiniz?
❑ Çok ilgili ❑ Biraz
❑ Çok az ilgili ❑ İlgisiz

7. Genetik ile ilgili, genel olarak, ne kadar bilginiz olduğunu düşünüyorsunuz?
❑ Çok fazla ❑Yeteri kadar
❑ Az ❑ Bilgim yok

8.Genetik uygulamaları ile ilgili bilgilerinizi nereden ediniyorsunuz?	Kesinlikle **Katılıyorum**	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle **Katılmıyorum**
Gazete ve dergilerden					
İnternet sitelerini ziyaret ederek					
Televizyon izleyerek (örneğin belgesel)					
Okuldan (öğretmen, dersler, ders kitapları)					
Ailemden					
Arkadaşlarımdan					
Şimdiye kadar hiçbir bilgi edinmedim					
Diğer (Lütfen belirtiniz):					

APPENDIX F

GENETICS LITERACY ASSESSMENT INVENTORY

GENETİK OKURYAZARLIK ÖLÇME ENVANTERİ

1. **Yetişkinlerin boy uzunluğu kısmen genler tarafından belirlenir. Çevresel faktörler sabit tutulduğunda (insanların boyları sadece kısa, orta ve uzun olmakla kalmayıp) çeşitlilik gösterir. Boy uzunluğu, aşağıdakilerden hangisinden etkilenmiş olabilir?**
   a. İki alleli olan tek bir genden,
   b. Çekinik tek bir genden,
   c. Baskın tek bir genden,
   d. Birçok genden,
   e. Sadece babadan gelen genlerden,
2. **Moleküler genetik mühendisliği mümkündür;**
   a. Çünkü yaşayan tüm organizmalar, aynı DNA dizilimine sahiptir.
   b. Çünkü yaşayan tüm organizmalar genetik materyal olarak DNA'ya sahiptir.
   c. Çünkü yaşayan tüm organizmalar farklı ancak uyumlu DNA yapılarına sahiptir.
   d. Çünkü DNA dışındaki diğer genetik materyaller bilim insanları tarafından uyumlu hale getirilmiştir.
   e. Sadece bitki türleri arasında ya da sadece hayvan türleri arasında mümkündür, ancak bitki türleri ile hayvan türlerinin birbirleri arasında mümkün değildir.
3. **Mayoz bölünme ile ilgili aşağıdakilerden hangisi yanlıştır?**
   a. Sadece eşeyli üreme gösteren canlı türlerinde meydana gelir.
   b. Üreme hücrelerindeki kromozom sayısı yarıya iner.
   c. Yavrularda genetik varyasyon (çeşitlilik) sağlar.
   d. Bireyin hayatının bir döneminde vücut hücrelerinin çoğunda meydana gelir.
   e. Nesilden nesile kromozom sayısının sabit kalmasını sağlar.
4. **Bazen bir özelliğin bir ailede kaybolduğu ve daha sonraki nesillerde tekrar ortaya çıktığı görülür. Eğer bu özellik, anne-babadan herhangi birinde görülmüyor da yavrulardan bazılarında görülüyorsa, bu özelliğin kalıtımı konusunda ne tür bir sonuca varabilirsiniz?**
   a. Anne ve babanın her ikisi de genin çekinik formunu taşımaktadırlar.
   b. Anne ve babadan sadece biri, genin çekinik formunun 2 kopyasını taşımaktadır.
   c. Anne ve babadan sadece biri, geni baskın olarak taşımaktadır.
   d. Anne ve babadan sadece biri, genin çekinik formunun 1 kopyasını taşımaktadır.
   e. Bu durum, muhtemelen hem annede hem de babada oluşan yeni mutasyonların sonucudur.
5. **Bir bireyin geninde meme kanseri ile ilişkili olan bir mutasyona rastlanmıştır. Bu gen, hangi hücrede bulunmaktadır?**
   a. Sadece kanserin ortaya çıktığı meme hücrelerinde
   b. Sadece her iki meme hücresinde
   c. Sadece dişilerde bulunan hücrelerde
   d. Sadece meme ve yumurtalık hücrelerinde
   e. Bireyin tüm hücrelerinde.
6. **DNA'da oluşan mutasyonlar, insanlar da dahil olmak üzere çoğu organizmada genomlarda gerçekleşir. Bu mutasyonların en önemli sonucu nedir?**
   a. Birey için yeni genler oluştururlar.
   b. Birey için yeni enzimler üretirler.
   c. Birey için yeni hücre kaynakları sağlarlar.
   d. Gelecek nesiller için önemli bir genetik çeşitlilik kaynağı sağlarlar.
   e. Gelecek nesiller için yeni kromozomlar meydana getirirler.
7. **Kanser ve zihinsel bozukluklar gibi kompleks hastalıklar, birden fazla genle ilişkilidir. Bir bireyin bu genler için test edilmesi neyi gösterir?**
   a. Bireyde o hastalığın veya bozukluğun olup olmadığı gösterir.
   b. Bireyin o hastalığa ya da bozukluğa yakalanma riskinin yüksek olup olmadığını gösterir.
   c. Bireyin o hastalığa veya bozukluğa kesin olarak yakalanıp yakalanmayacağını gösterir.
   d. Bireyin çocuklarının o hastalığa veya bozukluğa kesin olarak yakalanıp yakalanmayacağını gösterir.
   e. Eğer birey geni taşıyorsa, hastalığın veya bozukluğun ne kadar ciddi boyutta olacağını gösterir.
8. **Aşağıdakilerden hangisi genetiğin ve genetik teknolojisinin sağlık hizmetlerine uygulanmasının bilinen faydalarından biridir?**
   a. Ortalama insan ömrünü belirgin bir şekilde uzatabilmesi
   b. Kanser gibi kompleks hastalıkları ortadan kaldırabilmesi
   c. Pahalı olmayan ve kolayca uygulanabilen ilaçları üretilebilmesi
   d. Hastalığa yakalanma riski yüksek olan bireylerin belirlenebilmesi
   e. Gen terapisinin rutin olarak genetik hastalıkların tedavisinde kullanılabilmesi.
9. **Bir kadına meme kanseri ile ilişkili bir mutasyon taşıdığının söylenmesi, onun meme kanserine yakalanma olasılığını nasıl etkiler?**
   a. Meme kanseri olma riski, diğer sağlıklı kadınlardan farklı olmayacaktır.
   b. Muhtemelen meme kanseri olmayacaktır.
   c. Meme kanseri olma riski yüksektir.
   d. Kesinlikle meme kanseri olacaktır.
   e. Mutasyona uğramış gen taşıdığından zaten meme kanseri olmuştur.

10. **Genetik uzmanları fare, meyve sineği ve maya gibi organizmaların genetik materyalleri üzerinde araştırma yapmaktadırlar. Bu organizmalardan öğrendiklerini insanlara uygulayabilmektedirler çünkü hemen hemen tüm farklı organizma türleri;**
    a. Genetik materyal olarak DNA'ya sahiptir.
    b. Genetik materyal olarak proteinlere sahiptir.
    c. Aynı miktarda genetik materyale sahiptir.
    d. Genetik materyallerinden protein, yağ ve karbonhidrat üretirler.
    e. Genetik materyal olarak RNA'ya sahiptir.
11. **HIV virüsünün dünya çapında yayıldığı göz önüne alındığında, bazı bireylerin HIV virüsü taşımasına (diğer bir değişle HIV pozitif olmasına) rağmen virüsün etkilerine karşı dayanıklı olduğu bilinmektedir. Bunun nedeni aşağıdakilerden hangisidir?**
    a. Bu bireyler dirençli olmalarını sağlayan genetik farklılıklara sahiptir.
    b. Direnç sağlayan genetik değişiklikler, virüs enfeksiyonuna karşı meydana gelir.
    c. Doğal seleksiyon dirençle sonuçlanan genetik farklıkların oluşmasına yol açar.
    d. Bireyin içerisinde yaşadığı çevre, geliştireceği direnci belirler.
    e. Bireyler arasındaki besleme farklılıkların virüse karşı direnci belirleyeceği bilinmektedir.
12. **Aşağıdakilerden hangisi DNA'daki mutasyonların bir özelliğidir?**
    a. Genellikle etkisini gösterir ve birey için pozitif değişikliklerle sonuçlanır.
    b. Genellikle etkisini gösterir ve birey için belirgin problemlere neden olur.
    c. Anne babanın vücut hücrelerinde gerçekleşen mutasyonlar genellikle çocuklarına aktarılır.
    d. Mutasyonlar genellikle genlerin çoğunda çok yüksek oranlarda görülür.
    e. Mutasyonlar, popülasyon içerisinde bir genin farklı çeşitlerinin oluşmasına neden olur.
13. **Gelişmiş canlılarda, DNA ve kromozomlar arasında nasıl bir ilişki vardır?**
    a. Kromozomlar, DNA'da bulunur.
    b. DNA, kromozomların içinde bulunur.
    c. DNA ve kromozomlar arasında bir farklılık yoktur.
    d. DNA ve kromozomlar tamamen farklı yapılardır.
    e. Kromozomlar, DNA'yı meydana getirir.
14. **Huntington hastalığı, baskın bir genin neden olduğu genetik bir bozukluktur. Belirtiler erişkinlikte başlamakta ve hastalık ölümle sonuçlanmaktadır. Aşağıdakilerden hangisi ebeveynlerden birine Huntington hastalığı teşhisi konulduğunda ortaya çıkan etik bir ikilemdir?**
    a. Huntington hastası ebeveynin hastalık geni için test edilip edilmemesi
    b. Diğer ebeveynin gen için test edilip edilmemesi
    c. Çocuklardan birinin herhangi bir zamanda gen için test edilip edilmemesi
    d. Huntington hastası ebeveynin hastalık için tedavi edilip edilmemesi
    e. Huntington hastası ebeveyne hasta olduğunun söylenip söylenmemesi.
15. **Genetik alanında çalışan uzmanlar, bireylerin genetik yapısının ve yaşadığı çevrenin zeka düzeyi (IQ), akciğer kanseri ve prostat kanseri gibi kompleks özelliklere olan etkisini nasıl açıklamaktadır?**
    a. Çevre, bir özellik için potansiyel oluşturur. Bu potansiyelin ne kadarının gerçekleşeceği bireyin genetik yapısına bağlıdır.
    b. Her bir birey genetik bir potansiyeli miras olarak alır, bu potansiyelin ne kadarının gerçekleşeceği çevreye bağlıdır.
    c. Genetik uzmanları, çoğu özelliğin genetik faktörler tarafından belirlendiğini ve çevrenin kompleks özellikler üzerinde çok az etkisinin olduğunu kabul eder.
    d. Kompleks özelliklerin belirlenmesinde çevre önemli bir rol oynarken genetik faktörler nispeten küçük bir rol oynar.
    e. İnsanlar arasındaki genetik farklıklar o kadar azdır ki aslında bireyler arasında gözlemlenen varyasyonlar, onların yetiştikleri çevreden kaynaklanmaktadır.
16. **Gen ekspresyonu (gen anlatımı) nasıl düzenlenir ya da kontrol edilir?**
    a. Genlerin ekspresyonu düzenlenmez ve kontrol edilemez.
    b. Genler bireyin gelişimi esnasında etkinleşir ve bireyin hayatı boyunca aynı kalırlar.
    c. Genler sadece gelişim esnasında etkinleşir ve etkinliklerini kaybederler
    d. Genler bireyin hayatı boyunca uygun zamanlarda etkinleşir ve etkinliklerini kaybederler.
    e. Gen ekspresyonu sadece dış faktörler tarafından kontrol edilir.
17. **Eğer bir birey belirli bir hastalığa neden olan bir mutasyon için genetik bir test yaptırır ve sonucu <u>pozitif</u> çıkarsa, bu ne anlama gelir?**
    a. Birey, hastalığın baskın veya çekinik mutasyon nedeniyle olup olmadığına bakılmaksızın kesinlikle hastalığı gösterecektir.
    b. Eğer hastalık baskın mutasyondan kaynaklanıyorsa, birey kesinlikle hasta olacaktır.
    c. Mutasyon için yapılan testin sonucunun pozitif çıkması, bireyin zaten hasta olduğunu göstermektedir.
    d. Bu durum, ilgili hastalığa göre değişir. Bazı mutasyonlar için pozitif test sonucu sadece bireyin hastalığa yakalanma riskinin yüksek olduğunu gösterir.
    e. Bireyin gelişimi boyunca yaşadığı çevre, hastalığı gösterip göstermemesinin en önemli belirleyicisidir.
18. **Kas, sinir ve deri hücrelerinizin farklı fonksiyonlara sahip olmasının nedeni aşağıdakilerden hangisidir?**
    a. Bu hücreler, farklı genlere sahiptir.
    b. Bu hücreler, vücudun farklı yerlerinde bulunmaktadır.
    c. Bu hücreler, farklı genleri aktif hale getirir.
    d. Bu hücreler, farklı sayıda gen içerir.
    e. Bu hücreler, farklı mutasyonlara uğramıştır.

19. Çevre, bir bireyin gen ekspresyonunu (gen anlatımı) yaşamı boyunca hangi zamanlarda etkiler?
a. Gebelikten başlayarak, yaşamı boyunca
b. Doğumda başlayarak yaşamı boyunca
c. Doğumda başlayarak ve yetişkinliğe kadar
d. Sadece ergenlik ve menopoz gibi hayatın önemli evrelerinde
e. Çevrenin gen ekspresyonuna çok az etkisi vardır veya hiç etkisi yoktur.

20. Aşağıdakilerden hangisi etnik gruplar arasındaki genetik farklılıklar ile ilgili <u>yanlış</u> bir ifadedir?
a. Etnik gruplar içerisinde, diğer etnik gruplarla aralarında olduğundan daha fazla genetik varyasyon vardır.
b. Görünüş farklılıkları, etnik gruplar arasında sadece daha az genetik farklılıklar gösterir.
c. Orak hücre anemisi gibi genetik hastalıklar bazı etnik gruplarda daha yaygındır.
d. Tüm insanlar arasındaki DNA diziliminin benzerliği %99'dan daha fazladır.
e. Cilt renginden sorumlu olan genetik farklılıklar insan genomunun önemli bir bölümünü temsil etmektedir.

21. Bireylerde etkisini gösteren genler ve özellikler arasındaki ilişki aşağıdakilerden hangisinde belirtilmiştir?
a. Genler, bireysel özelliklerden sorumlu DNA'yı kodlar.
b. Genler, bireysel özelliklerden sorumlu proteinleri kodlar.
c. Genler, bireysel özelliklerden sorumlu kromozomları kodlar.
d. Genler, bireysel özelliklerden sorumlu karbonhidratları kodlar.
e. Genler yerine, bireysel özelliklerden öncelikle çevre sorumludur.

22. Aşağıdakilerden hangisi Charles Darwin tarafından öne sürülen evrimin temel ilkelerini doğru olarak <u>yansıtmamaktadır?</u>
a. Biyolojik türlerin üreme kapasitesi sınırlıdır.
b. Dünyanın sürekli nüfus artışını kaldırabilme kapasitesi sınırlıdır.
c. Bireyler arasındaki farklılıklar, nesilden nesile aktarılır
d. Bazı bireyler, değişen çevre şartlarında hayatta kalma konusunda diğerlerine göre daha iyi donatılmıştır.
e. Doğal seçilim, evrimin itici gücüdür.

23. Aşağıdakilerden hangisi etik bir problem olarak <u>kabul edilemez?</u>
a. Doğum öncesi cinsiyet seçimine izin verilmesi
b. Çiftlere yüksek bakım maliyeti gerektirecek şartlardaki bebekleri dünyaya <u>getirmeme</u> konusunda danışmanlık hizmeti verilmesi
c. Araştırmalar için embriyonik kök hücre kullanılması
d. Sigorta şirketlerine, yüksek risk grubundaki veya genetik hastalığı olduğu bilinen bireylerin sigortasını reddetme hakkının verilmesi
e. 35 yaş ve üstü annelere, kromozom anormalliklerinin doğum öncesi teşhis ettirebilme imkanın sağlanması.

24. Bir bireyin çekinik bir bozukluk olan kistik fibrozis (cystic fibrosis) olması için anormal kistik fibrozis geninin iki kopyasına sahip olması gerekmektedir. Anormal genin bir kopyasına sahip ebeveynleri olan bir çocuğunun hastalığa yakalanma olasılığı nedir?
a. 0% b. 25% c. 50% d. 66% e.75%

25. Bilim ve bilimsel metotla ilgili olarak aşağıdakilerden hangisi doğru bir ifadedir?
a. Bilim ve bilimsel metotlar, nadiren doğal dünya hakkında açıklama sağlayabilir.
b. Bilim ve bilimsel metotlar, doğaüstü dünyayı da içeren açıklamalar sağlayabilir.
c. Bilim ve bilimsel metotlar tekrarlanabilir gözlemler ve test edilebilir hipotezler içeren sorgulama süreçleridir.
d. Bilim ve bilimsel metotların insanların yaşadığı koşulların iyileştirilmesin önemli ölçüde katkıda bulunması olası değildir.
e. Bilim ve bilimsel metotların sonuçları, yeni veriler ve gözlemler ışığında sorgulanmaya açık değildir.

26. İnsan kas hücresi 46 adet kromozom içermektedir. <u>Döllenmemiş</u> insan yumurta hücresi kaç adet kromozom içermektedir?
a. 11 b. 22 c. 23 d.46 e. 92

27. Aşağıdakilerden hangisi, günümüz genetik teknolojilerin <u>beklenilmedik</u> sonuçlarına bir örnektir?
a. Preimplantasyon Genetik Tanı (sağlıklı embriyoların anneye transfer edilmesi) ile erken embriyonik dönemde genetik yapının belirlenmesi,
b. Yeni doğan bir bebeğin genetik yapısının, "yeni doğan genetik tarama programı" ile belirlenmesi,
c. Genetik bozuklukların belirlenmesi amacıyla yapılan testin sonucunda bir çocuğun farklı babaya sahip olduğunun öğrenilmesi,
d. "Yetişkin genetik tarama" talep eden bireylerin taşıyıcı olma durumlarının öğrenilmesi,
e. Prenatal tanı (doğum öncesi tanı) yaptıran annenin taşıdığı fetüste kromozom anormalliği bulunması.

28. Aşağıdakilerden hangisi ülkemizde 2003 yılında yürürlüğe giren "İnsan Hakları ve Biyotıp Sözleşmesi"ne uyum çerçevesinde 2005 yılında yapılandırılan Ceza Muhakemesi Kanunu'nda belirtilen hususlardan biri <u>değildir?</u>
a. Moleküler-genetik incelemeler sadece hakim kararı ile yapılabilir.
b. Genomik özelliklere ait bilgilerin kaydedilmesi yasaklanmıştır.
c. Edinilen genetik bilgilerin saklanmasından DNA bankaları sorumlu tutulmuştur.
d. Yapılan genetik incelemeler eğer kişinin sağlığını bozacak nitelik taşımamalıdır.
e. Yapılan genetik inceleme sonuçlarının amacı dışında kullanılması yasaklanmıştır.

29. Yarasanın kanatları ve köpeğin ön ayakları homolog organlardır. Bu durum aşağıdakilerden hangisine işaret eder?
a. Yarasanın kanatları ve köpeğin ön ayakları aynı göreve sahiptirler.
b. Yarasalar bir köpek soyundan türemiştir.
c. Yarasanın kanatları ve köpeğin ön ayakları ortak ata dolayısıyla birbirine benzerdir.
d. Yarasanın kanatları ve köpeğin ön ayaklarındaki kemikler anatomik olarak birbirine benzerdir.
e. Yarasanın kanatları ve köpeğin ön ayakları farklı atadan gelmektedir fakat aynı fonksiyona sahiptir.

5

30. Aynı türe ait beş kuş türünün yaşamlarının dökümü aşağıda verilmiştir. Evrimsel açıdan en başarılı kuş hangisidir?

a. 5 yıl yaşadı, 12 yumurta bıraktı, bunlardan 4 ü yavru çıkardı.
b. 2 yıl yaşadı, 8 yumurta bıraktı, bunlardan 5 i yavru çıkardı.
c. 6 yıl yaşadı, 2 yumurta bıraktı, bunlardan 2 si yavru çıkardı.
d. 4 yıl yaşadı, 7 yumurta bıraktı, bunlardan 6 si yavru çıkardı.
e. 5 yıl yaşadı, 4 yumurta bıraktı, bunlardan 3 ü yavru çıkardı.

31. Kertenkele popülasyonları yüzlerce kertenkeleden oluşur. Aşağıdaki ifadelerden hangisi bu kertenkelelerin birbirlerine olan benzerliklerini en iyi açıklar?

a. Popülasyondaki tüm kertenkeleler neredeyse aynıdır.
b. Popülasyondaki tüm kertenkelelerin dış görünüşleri aynıdır, fakat iç organlarında, örneğin sindirim olaylarında, farklılıklar vardır.
c. Popülasyondaki tüm kertenkeleler çok sayıda benzerlikler paylaşmaktadırlar, fakat vücut büyüklüğü ve pençe uzunluğu gibi özelliklerinde farklılıklar vardır.
d. Popülasyondaki tüm kertenkeleler tamamen benzersizdir ve diğer kertenkelelerle ortak özellik göstermezler.

Important Note:

* Item 1, Item 3, Item 4, Item 21 and Item 34 were excluded from the Inventory according to the ITEMAN Analysis results in pilot study.

** Item 30 and Item 31 were excluded from the Inventory according to the confirmatory factor analysis results.

F.1. Genetics Literacy Assessment Inventory

Table E.1. *Item difficulty and item discrimination indexes of Turkish version of Genetics Literacy Assessment Inventory*

Item number	Item difficulty index Prop. correct	Item discrimination index (D)
1	0.868	0.101
2	0.297	0.359
3	0.571	0.113
4	0.099	0.041
5	0.593	0.308
6	0.824	0.474
7	0.813	0.495
8	0.692	0.208
9	0.571	0.275
10	0.484	0.433
11	0.462	0.265
12	0.560	0.390
13	0.681	0.210
14	0.560	0.345
15	0.571	0.284
16	0.879	0.341
17	0.374	0.236
18	0.626	0.392
19	0.527	0.315
20	0.451	0.273
21	0.473	0.119

Table F.1 (Continued)

Item number	Item difficulty index Prop. correct	Item discrimination index (D)
22	0.516	0.326
23	0.703	0.267
24	0.253	0.359
25	0.407	0.396
26	0.374	0.309
27	0.418	0.419
28	0.615	0.526
29	0.857	0.434
30	0.747	0.304
31	0.604	0.329
32	0.209	0.216
33	0.341	0.210
34	0.484	0.130
35	0.341	0.226
36	0.769	0.333

Table F.2. Descriptive statistics of Genetics Literacy Assessment Inventory

Item no	N	Range	Min	Max	Mean	SD	Skewness	Kurtosis
1	435	1	0	1	.27	.443	1.059	-.883
2	435	1	0	1	.49	.501	.032	-2.008
3	435	1	0	1	.88	.327	-2.320	3.399
4	435	1	0	1	.82	.386	-1.657	.751
5	435	1	0	1	.59	.493	-.351	-1.885
6	435	1	0	1	.63	.484	-.530	-1.727
7	435	1	0	1	.57	.496	-.265	-1.939
8	435	1	0	1	.35	.477	.634	-1.606
9	435	1	0	1	.66	.474	-.688	-1.534
10	435	1	0	1	.76	.426	-1.243	-.458
11	435	1	0	1	.52	.500	-.078	-2.003
12	435	1	0	1	.53	.499	-.134	-1.991
13	435	1	0	1	.81	.390	-1.618	.620
14	435	1	0	1	.30	.459	.870	-1.249
15	435	1	0	1	.54	.499	-.143	-1.989
16	435	1	0	1	.33	.472	.710	-1.503
17	435	1	0	1	.48	.500	.088	-2.002
18	435	1	0	1	.49	.500	.060	-2.006
19	435	1	0	1	.62	.485	-.509	-1.749
20	435	1	0	1	.22	.412	1.384	-.084
21	435	1	0	1	.31	.464	.811	-1.348
22	435	1	0	1	.33	.470	.732	-1.471
23	435	1	0	1	.34	.474	.688	-1.534
24	435	1	0	1	.69	.463	-.823	-1.329
25	435	1	0	1	.82	.386	-1.657	.751
26	435	1	0	1	.83	.374	-1.780	1.175
27	435	1	0	1	.59	.493	-.351	-1.885
28	435	1	0	1	.15	.359	1.948	1.804
29	435	1	0	1	.26	.438	1.113	-.764
30	435	1	0	1	.42	.495	.313	-1.911
31	435	1	0	1	.80	.404	-1.470	.160

APPENDIX G

ATTITUDES TOWARDS ISSUES IN GENETICS LITERACY SCALE

Yönerge: Verilen ifadeler için aşağıda verilen ölçeği kullanarak görüşünüzü en iyi tanımlayacak seçeneği işaretleyiniz:		Kesinlikle **Katılıyorum**	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle **katılmıyorum**
1	Bilime gereğinden fazla inanıyoruz ama duygu ve inançlara yeterince **inanmıyoruz.**					
2	Genelde modern bilim, yarardan çok zarar getirir.					
3	Ciddi genetik bozukluğu olabilecek bir çocuğa sahip olma riski taşıyan bireylerin aile **kurmaması** gerekir.					
4	İnsan genleri üzerinde yapılan araştırmalar yarardan çok zarar getirecektir.					
5	Modern genetiğin faydaları hakkındaki iddiaların çoğu, oldukça abartılmaktadır.					
6	Hiç kimse, genetik biliminin toplum üzerinde ne gibi bir etkisi olacağını gerçekten **bilmiyor.**					
7	Bilim ve teknoloji, hayatlarımızı daha sağlıklı, daha kolay ve daha rahat hale getirir.					
8	Bilim, yaşam tarzımızı çok hızlı değiştirir.					
9	Hastalıkların genetik tedavileri, insanların acılarını azaltmada çok yardımcı olacaktır.					
10	Yararı ne olursa olsun, bireyin genlerinin değiştirilmesi fazlasıyla risklidir.					
11	Hastalıkları, insanların genlerini değiştirmeden tedavi etmeye çalışmak daha iyidir.					
12	İnsanların genleri üzerinde yapılan araştırmalar, nihayetinde bize zarardan çok yarar sağlayacaktır.					
13	İnsanların genlerini değiştirmeyi hiç bilmesek daha iyi olurdu.					
14	İnsanlar, genlerinin değiştirilmesinin riskleri hakkında çok fazla endişeleniyorlar.					
15	İnsanların genlerine asla müdahale **etmemeliyiz.**					
16	Dünyanın aşırı kalabalıklaşmasından dolayı, bilim insanları genetik tedaviler **aramamalıdır.**					
17	Doğaya bir müdahale olduğundan dolayı, genlerin değiştirilmesi **yasaklanmalıdır.**					
18	Engelli insanların genlerini değiştirmekten ziyade, onların hayatını kolaylaştıracak imkanlar sağlamalıyız.					
19	Yeni geliştirilen genetik tedavilerin, çocuklar üzerinde test edilmesine izin verilmelidir.					

Yönerge: İnsanlar, gelecekte ciddi bir genetik hastalığa yakalanma olasılıkları olup olmadığını öğrenmek için genetik test yaptırabileceklerdir. Aşağıdaki cümlelerden hangisi sizin bu konudaki fikrinizi yansıtmaktadır?	Kesinlikle katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle katılmıyorum
Sigorta şirketleri, genetik testleri hayat sigorta poliçelerini kabul veya reddetme amacıyla kullanmalıdır.					
İşverenler, genetik test sonuçlarını görme hakkına sahip olmalıdır.					
İşverenler, iş başvurusu yapanlardan genetik test yaptırmalarını isteme hakkına sahip olmalıdır.					
İşverenler, iş başvurusu yapanlardan özellikle işyerinde kullanılabilecek kimyasallara karşı hassasiyetleri olup olmadığını öğrenmek için genetik test yaptırmalarını isteme hakkına sahip olmalıdır.					

Yönerge: Bir kadının çocuğunun aşağıda belirtilen durumlarda doğma olasılığı varsa, o kadının yasal kürtaj yaptırmak konusunda hakkı,
(1) Her zaman olmalıdır. (2) Bazen olmalıdır. (3) Hiçbir zaman olmamalıdır.

Durumlar: Çocuğun,	(1)	(2)	(3)
Ciddi bir zihinsel engelle doğması ve asla bağımsız bir yaşam sürdüremeyecek olması.			
Bağımsız bir yaşam sürdüremeyecek fiziksel bir engelle doğması.			
20'li veya 30'lu yaşlarına kadar sağlıklı olacak ancak bu yaşlarda ölmesine sebep olacak bir durumla doğması.			
Sağlıklı ancak boyunun 8 yaşındaki birinden daha uzun olamayacağı bir durumla doğması.			

Yönerge: Çiftlerin, ciddi sağlık problemleri olmayan çocuklara sahip olmalarının bir yolu daha vardır: Kadının yumurtası, eşinin spermi ile vücudunun dışında döllenir ve genetik olarak test edilir. Sadece sağlıklı yumurtalar kadının rahmine konur ve sonra bu yumurtalardan bebek oluşabilir.
Aşağıdaki durumlarda doğabilecek bebekleri olma riski taşıyan bir ailenin, böyle bir uygulamaya başvurmasının doğruluğu konusunda ne düşünüyorsunuz?
(1) Her zaman doğrudur. (2) Bazen doğrudur. (3)Hiçbir zaman doğru değildir.

Durumlar: Çocuğun,	(1)	(2)	(3)
Ciddi zihinsel bir engelle doğacak olması.			
Ciddi fiziksel bir engelle doğacak olması.			
Sağlıklı yaşayacak ancak 20'li veya 30'lu yaşlarda ölecek olması.			
Sağlıklı ancak boyunun 8 yaşındaki birinden daha uzun olamayacak olması.			

Yönerge: Bir bireyin genlerinin değiştirilebileceğinin keşfedildiğini varsayın. Bu keşfin, aşağıda belirtilen durumları oluşturmak için kullanılmasına izin verilip verilmesi konusunda ne düşünüyorsunuz? **Durumlar,**		Kesinlikle izin verilmeli	Muhtemelen izin verilmeli	Muhtemelen izin verilmemeli	Kesinlikle izin verilmemeli
1	Bireyi daha uzun veya kısa yapmak.				
2	Bireyi daha zeki yapmak.				
3	Eşcinsel olmayan bireyler yapmak.				
4	Bireyin kalp hastası olma olasılığını belirlemek.				
5	Bireyin meme kanseri olma olasılığını azaltmak.				
6	Bireyin fazla kilolu olmasındansa, ortalama bir kiloda olmasını sağlamak.				
7	Doğmamış bir bebeğin cinsiyetini belirlemek.				
8	Bireyin kel olmasındansa, gür saçlı olmasını sağlamak.				
9	Bireyin şizofren olmasını engellemek.				
10	Bireyi daha az öfkeli ve saldırgan yapmak.				

Yönerge: Bireyin genlerinin enjeksiyon yolu ile değiştirilebileceğinin keşfedildiğini varsayın. Aşağıda belirtilen **3 durum için** gen terapisinin kullanılmasına izin verilip verilmemesi konusunda ne düşünüyorsunuz?

DURUM 1: Bu yeni genler, bu bireylerin sahip olabilecekleri çocuklara aktarılmayacaklar.

	Kesinlikle izin **verilmeli**	Muhtemelen izin verilmeli	Muhtemelen izin **verilmemeli**	Kesinlikle izin **verilmemeli**	Verilen bilgiler karar vermem için yeterli değildir
20'li yaşlarda ciddi kalp rahatsızlıkları olan bireyler.					
20'li yaşlarda kel olan ve bundan utanan bireyler.					
Kistik fibrozis ile doğan 20'li yaşlardaki bireyler					

DURUM 2: Şimdi, bu yeni genlerin bireylerin gelecekteki çocuklarına aktarılacağını düşünün.

	Kesinlikle izin **verilmeli**	Muhtemelen izin verilmeli	Muhtemelen **izin verilmemeli**	Kesinlikle izin **verilmemeli**	Verilen bilgiler karar vermem için yeterli değildir
Bireyin gelecekteki çocuklarının, 20'li yaşlarda ciddi kalp rahatsızlığı geçirme olasılığını daha da azaltmak.					
Bireyin gelecekteki çocukları 20'li yaşlarda kel **kalmayacaklar.**					
Bireyin gelecekteki çocukları Kistik fibrozis **olmayacaklar.**					

DURUM 3: Şimdi ise, bireyin genlerinin henüz ana rahminde iken yani birey daha doğmadan tedavi ile değiştirilebileceğini varsayın. Yeni genler, bireylerin daha sonra sahip olacakları çocuklarına geçmeyecektir.

	Kesinlikle izin **verilmeli**	Muhtemelen izin verilmeli	Muhtemelen izin **Verilmemeli**	Kesinlikle izin **verilmemeli**	Verilen bilgiler karar vermem için yeterli değildir
Bireyler in 20'li yaşlarda ciddi kalp rahatsızlığı geçirme olasılığını azaltmak.					
Bireyler 20'li yaşlarda kel **kalmayacaklar.**					
Bireyler Kistik fibrozis **olmayacaklar.**					

G.1. Attitudes towards Issues in Genetics Literacy Scale

Table F.1. Data screening for Attitudes towards Issues in Genetics Literacy scale from pilot study

	Valid Cases		Missing Cases		Total	
	N	Percent (%)	N	Percent (%)	N	Percent (%)
gen_att1	95	100	0	0	95	100
gen_att2	95	100	0	0	95	100
gen_att3	95	100	0	0	95	100
gen_att4	95	100	0	0	95	100
gen_att5	90	94.7	5	5.3	95	100
gen_att6	94	98.9	1	1.1	95	100
gen_att7	95	95	0	0	95	100
gen_att8	95	95	0	0	95	100
gen_att9	94	98.9	1	1.1	95	100
gen_att10	95	95	0	0	95	100
gen_att11	94	98.9	1	1.1	95	100
gen_att12	95	95	0	0	95	100
gen_att13	93	97.9	2	2.1	95	100
gen_att14	95	95	0	0	95	100
gen_att15	93	97.9	2	2.1	95	100
gen_att16	95	95	0	0	95	100
gen_att17	95	95	0	0	95	100
gen_att18	95	95	0	0	95	100
gen_att19	95	95	0	0	95	100
use_gen_1	92	96.8	3	3.2	95	100
use_gen_2	92	96.8	3	3.2	95	100
use_gen_3	92	96.8	3	3.2	95	100
use_gen_4	93	97.9	2	2.1	95	100
abort_1	90	94.7	5	5.3	95	100
abort_2	90	94.7	5	5.3	95	100
abort_3	90	94.7	5	5.3	95	100
abort_4	90	94.7	5	5.3	95	100
pre_IG_1	91	95.8	4	4.2	95	100
pre_IG_2	91	95.8	4	4.2	95	100
pre_IG_3	91	95.8	4	4.2	95	100
pre_IG_4	91	95.8	4	4.2	95	100
gene_ther_1	93	97.9	2	2.1	95	100
gene_ther_2	93	97.9	2	2.1	95	100

Table G.1. (Continued)

	Valid Cases	Missing Cases	Total		Valid Cases	Missing Cases
	N	Percent (%)	N		N	Percent (%)
gene_ther_3	93	97.9	2	2.1	95	100
gene_ther_4	93	97.9	2	2.1	95	100
gene_ther_5	93	97.9	2	2.1	95	100
gene_ther_6	93	97.9	2	2.1	95	100
gene_ther_7	93	97.9	2	2.1	95	100
gene_ther_8	93	97.9	2	2.1	95	100
gene_ther_9	93	97.9	2	2.1	95	100
gene_ther_10	93	97.9	2	2.1	95	100
g_thr_sit_1_1	92	96.8	3	3.2	95	100
g_thr_sit_1_2	92	96.8	3	3.2	95	100
g_thr_sit_1_3	92	96.8	3	3.2	95	100
g_thr_sit_2_1	92	96.8	3	3.2	95	100
g_thr_sit_2_2	92	96.8	3	3.2	95	100
g_thr_sit_2_3	92	96.8	3	3.2	95	100
g_thr_sit_3_1	92	96.8	3	3.2	95	100
g_thr_sit_3_2	92	96.8	3	3.2	95	100
g_thr_sit_3_3	92	96.8	3	3.2	95	100

Table G.2. Descriptive statistics of Attitudes towards Issues in Genetics Literacy scale for pilot study

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
gen_att1	95	4	1	5	2,69	1.238	.262	-1.095
gen_att2	95	4	1	5	1.82	.967	1.306	1.200
gen_att3	95	4	1	5	2.69	1.230	.467	-.598
gen_att_4	95	4	1	5	2.31	1.102	.729	-.170
gen_att_5	90	4	1	5	2.64	.975	.177	-.834
gen_att6	94	4	1	5	3.31	.995	-.591	-.513
gen_att7	95	4	1	5	4.12	.921	-1.153	1.520
gen_att8	95	4	1	5	3.96	1.081	-1.257	1.190
gen_att9	94	4	1	5	4.04	.879	-.764	.501
gen_att10	95	4	1	5	3.53	1.060	-.316	-.531
gen_att11	94	4	1	5	3.82	1.016	-.571	-.461
gen_att12	95	4	1	5	3.31	1.053	-.644	-.269

Table G.2. (Continued)

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
gen_att13	93	4	1	5	2.46	1.128	.536	-.278
gen_att14	95	4	1	5	3.28	1.078	-.177	-.964
gen_att15	93	4	1	5	2.86	1.185	.397	-.740
gen_att16	95	4	1	5	2.09	1.063	1.112	1.017
gen_att17	95	4	1	5	2.78	1.265	.170	-.994
gen_att18	95	4	1	5	3.58	1.190	-.520	-.717
gen_att19	95	4	1	5	1.82	1.072	1.320	1.073
use_gen_1	92	4	1	5	2.11	1.271	.909	-.429
use_gen_2	92	4	1	5	2.17	1.263	.768	-.715
use_gen_3	92	4	1	5	2.10	1.196	.872	-.417
use_gen_4	93	4	1	5	3.58	1.271	-1.045	-.037
abort_1	90	2	1	3	1.79	.868	.427	-1.546
abort_2	90	2	1	3	1.98	.779	.039	-1.338
abort_3	90	2	1	3	2.31	.744	-.578	-.975
abor_4	90	2	1	3	2.49	.723	-1.056	-.282
pre_IG_1	91	2	1	3	1.53	.705	.972	-.346
pre_IG_2	91	2	1	3	1.65	.721	.646	-.820
pre_IG_3	91	2	1	3	1.88	.758	.206	-1.219
pre_IG_4	91	2	1	3	1.97	.823	.062	-1.520
gene_ther_1	93	3	1	4	2.84	1.066	-.275	-1.275
gene_ther_2	93	3	1	4	2.65	1.129	-.185	-1.352
gene_ther_3	93	3	1	4	2.51	1.039	-.015	-1.148
gene_ther_4	93	3	1	4	1.69	.872	1.160	.586
gene_ther_5	93	3	1	4	1.67	.913	1.243	.579
gene_ther_6	93	3	1	4	2.05	1.146	.602	-1.124
gene_ther_7	93	4	1	5	3.20	1.017	-.931	-.202
gene_ther_8	93	4	1	5	2.51	1.148	.141	-1.268
gene_ther_9	93	3	1	4	1.67	.925	1.224	.447
gene_ther_10	93	3	1	4	2.19	1.106	.493	-1.083
g_thr_sit_1_1	92	4	1	5	1.77	.973	1.208	.800
g_thr_sit_1_2	92	4	1	5	2.46	1.063	.172	-.971
g_thr_sit_1_3	92	4	1	5	1.86	1.065	1.238	.952
g_thr_sit_2_1	92	4	1	5	1.78	1.025	1.202	.521
g_thr_sit_2_2	92	4	1	5	2.34	1.122	.347	-1.065
g_thr_sit_2_3	92	4	1	5	1.76	.999	1.313	1.241

Table G. 2. (Continued)

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
g_thr_sit_3_1	92	4	1	5	1.66	.998	1.608	2.038
g_thr_sit_3_2	92	4	1	5	2.25	1.125	.529	-.743
g_thr_sit_3_3	92	4	1	5	1.72	1.020	1.549	2.035

Table G.3. Descriptive statistics of Attitudes towards Issues in Genetics Literacy scale after imputation for pilot study

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
gen_att1	95	4	1	5	2.69	1.238	.262	-1.095
gen_att2	95	4	1	5	1.82	.967	1.306	1.200
gen_att3	95	4	1	5	2.69	1.230	.467	-.598
gen_att_4	95	4	1	5	2.31	1.102	.729	-.170
gen_att_5	95	4	1	5	2.64	.958	.190	-.784
gen_att6	95	4	1	5	3.30	.993	-.569	-.532
gen_att7	95	4	1	5	4.12	.921	-1.153	1.520
gen_att8	95	4	1	5	3.96	1.081	-1.257	1.190
gen_att9	95	4	1	5	4.02	.904	-.780	.421
gen_att10	95	4	1	5	3.53	1.060	-.316	-.531
gen_att11	95	4	1	5	3.83	1.018	-.580	-.461
gen_att12	95	4	1	5	3.31	1.053	-.644	-.269
gen_att13	95	4	1	5	2.46	1.128	.526	-.313
gen_att14	95	4	1	5	3.28	1.078	-.177	-.964
gen_att15	95	4	1	5	2.86	1.177	.400	-.722
gen_att16	95	4	1	5	2.09	1.063	1.112	1.017
gen_att17	95	4	1	5	2.78	1.265	.170	-.994
gen_att18	95	4	1	5	3.58	1.190	-.520	-.717
gen_att19	95	4	1	5	1.82	1.072	1.320	1.073
use_gen_1	95	4	1	5	2.08	1.260	.946	-.344
use_gen_2	95	4	1	5	2.15	1.255	.805	-.642
use_gen_3	95	4	1	5	2.14	1.208	.806	-.584
use_gen_4	95	4	1	5	3.56	1.286	-1.020	-.133
abort_1	95	2	1	3	1.78	.865	.448	-1.525
abort_2	95	2	1	3	1.96	.771	.073	-1.301
abort_3	95	2	1	3	2.31	.745	-.564	-.990

Table G. 3 (Continued)

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
abor_4	95	2	1	3	2.46	.712	-.953	-.408
pre_IG_1	95	2	1	3	1.53	.712	.988	-.354
pre_IG_2	95	2	1	3	1.65	.711	.620	-.805
pre_IG_3	95	2	1	3	1.87	.747	.210	-1.169
pre_IG_4	95	2	1	3	1.99	.819	.020	-1.507
gene_ther_1	95	3	1	4	2.86	1.068	-.310	-1.269
gene_ther_2	95	3	1	4	2.65	1.128	-.185	-1.351
gene_ther_3	95	3	1	4	2.51	1.030	-.014	-1.125
gene_ther_4	95	3	1	4	1.68	.866	1.167	.629
gene_ther_5	95	3	1	4	1.66	.906	1.250	.626
gene_ther_6	95	3	1	4	2.06	1.156	.592	-1.157
gene_ther_7	95	4	1	4	3.22	1.012	-.963	-.143
gene_ther_8	95	4	1	4	2.49	1.147	.143	-1.264
gene_ther_9	95	3	1	4	1.65	.920	1.255	.527
gene_ther_10	95	3	1	4	2.21	1.110	.477	-1.106
g_thr_sit_1_1	95	4	1	5	1.76	.964	1.234	.894
g_thr_sit_1_2	95	4	1	5	2.47	1.060	.152	-.979
g_thr_sit_1_3	95	4	1	5	1.84	1.055	1.267	1.055
g_thr_sit_2_1	95	4	1	5	1.77	1.015	1.230	.618
g_thr_sit_2_2	95	4	1	5	2.35	1.128	.322	-1.106
g_thr_sit_2_3	95	4	1	5	1.77	.994	1.280	1.162
g_thr_sit_3_1	95	4	1	5	1.67	1.015	1.570	1.783
g_thr_sit_3_2	95	4	1	5	2.25	1.111	.528	-.699
g_thr_sit_3_3	95	4	1	5	1.69	1.011	1.594	2.188

Table G.4. Data screening for Attitudes towards Issues in Genetics Literacy Scale from main study

	Valid Cases		Missing Cases		Total	
	N	Percent (%)	N	Percent (%)	N	Percent (%)
gen_att1	435	100	0	0	435	100
gen_att2	434	98.8	1	.2	435	100
gen_att3	435	100	0	0	435	100
gen_att_4	434	99.8	1	.2	435	100
gen_att_5	429	98.6	6	1.4	435	100

Table G. 4 (Continued)

	Valid Cases	Missing Cases	Total		Valid Cases	Missing Cases
	N	Percent (%)	N		N	Percent (%)
gen_att6	433	99.5	2	.5	435	100
gen_att7	435	100	0	.0	435	100
gen_att8	435	100	0	.0	435	100
gen_att9	432	99.3	3	.7	435	100
gen_att10	432	99.3	3	.7	435	100
gen_att11	434	99.8	1	.2	435	100
gen_att12	434	98.8	1	.2	435	100
gen_att13	433	99.5	2	.5	435	100
gen_att14	434	99.8	1	.2	435	100
gen_att15	433	99.5	2	.5	435	100
gen_att16	434	99.8	1	.2	435	100
gen_att17	434	99.8	1	.2	435	100
gen_att18	435	100	0	.0	435	100
gen_att19	435	100	0	.0	435	100
use_gen_1	432	99.3	3	.7	435	100
use_gen_2	432	99.3	3	.7	435	100
use_gen_3	431	99.1	4	.9	435	100
use_gen_4	433	99.5	2	.5	435	100
abort_1	429	98.6	6	1.4	435	100
abort_2	430	98.9	5	1.1	435	100
abort_3	429	98.6	6	1.4	435	100
abor_4	430	98.9	5	1.1	435	100
pre_IG_1	431	99.1	4	.9	435	100
pre_IG_2	431	99.1	4	.9	435	100
pre_IG_3	431	99.1	4	.9	435	100
pre_IG_4	431	99.1	4	.9	435	100
gene_ther_1	433	99.5	2	.5	435	100
gene_ther_2	433	99.5	2	.5	435	100
gene_ther_3	432	99.3	3	.7	435	100
gene_ther_4	433	99.5	2	.5	435	100
gene_ther_5	433	99.5	2	.5	435	100
gene_ther_6	433	99.5	2	.5	435	100
gene_ther_7	433	99.5	2	.5	435	100
gene_ther_8	433	99.5	2	.5	435	100
gene_ther_9	433	99.5	2	.5	435	100
gene_ther_10	432	99.3	3	.7	435	100
g_thr_sit_1_1	432	99.3	3	.7	435	100
g_thr_sit_1_2	432	99.3	3	.7	435	100
g_thr_sit_1_3	432	99.3	3	.7	435	100

Table G. 4 (Continued)

	Valid Cases	Missing Cases	Total		Valid Cases	Missing Cases
g_thr_sit_2_1	N	Percent (%)	N		N	Percent (%)
g_thr_sit_2_2	432	99.3	3	.7	435	100
g_thr_sit_2_3	432	99.3	3	.7	435	100
g_thr_sit_3_1	432	99.3	3	.7	435	100
g_thr_sit_3_2	432	99.3	3	.7	435	100
g_thr_sit_3_3	432	99.3	3	.7	435	100

Table G.5. Descriptive statistics of Attitudes towards Issues in Genetics Literacy Scale for main study

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
gen_att1	435	4	1	5	2.74	1.230	.271	-1.065
gen_att2	434	4	1	5	1.82	.880	1.349	2.124
gen_att3	435	4	1	5	2.91	1.287	.166	-1.048
gen_att_4	434	4	1	5	2.07	1.019	.957	.464
gen_att_5	429	4	1	5	2.37	.995	.568	-.339
gen_att6	433	4	1	5	3.27	1.082	-.366	-.859
gen_att7	435	4	1	5	4.13	.897	-1.241	1.762
gen_att8	435	4	1	5	4.09	.998	-1.348	1.593
gen_att9	432	4	1	5	4.14	.833	-1.145	1.913
gen_att10	432	4	1	5	3.34	.945	-.053	-.391
gen_att11	434	4	1	5	3.54	1.010	-.404	-.485
gen_att12	434	4	1	5	3.39	1.014	-.370	-.391
gen_att13	433	4	1	5	2.27	1.010	.743	.275
gen_att14	434	4	1	5	3.49	.959	-.414	-.555
gen_att15	433	4	1	5	2.61	1.011	.658	-.006
gen_att16	434	4	1	5	2.02	.974	1.269	1.589
gen_att17	434	4	1	5	2.52	1.079	.506	-.308
gen_att18	435	4	1	5	3.41	1.133	-.329	-.873
gen_att19	435	4	1	5	1.91	1.095	1.178	.684
use_gen_1	432	4	1	5	2.14	1.172	.832	-.284
use_gen_2	432	4	1	5	2.02	1.110	1.032	.234
use_gen_3	431	4	1	5	1.94	1.029	1.132	.774
use_gen_4	433	4	1	5	3.58	1.158	-.930	.056

Table G. 5 (Continued)

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
abort_1	429	2	1	3	1.61	.811	.817	-.993
abort_2	430	2	1	3	1.82	.803	.330	-1.375
abort_3	429	2	1	3	2.08	.800	-.148	-1.424
abor_4	430	2	1	3	2.32	.792	-.627	-1.131
pre_IG_1	431	2	1	3	1.49	.750	1.142	-.271
pre_IG_2	431	2	1	3	1.57	.768	.913	-.709
pre_IG_3	431	2	1	3	1.74	.798	.512	-1.250
pre_IG_4	431	2	1	3	1.88	.841	.236	-1.550
gene_ther_1	433	3	1	4	2.75	1.041	-.122	-1.275
gene_ther_2	433	3	1	4	2.56	1.112	.007	-1.360
gene_ther_3	432	3	1	4	2.36	1.072	.205	-1.207
gene_ther_4	433	3	1	4	1.67	.859	1.252	.912
gene_ther_5	433	3	1	4	1.58	.838	1.482	1.563
gene_ther_6	433	3	1	4	2.09	1.042	.607	-.812
gene_ther_7	433	3	1	4	3.15	1.041	-.804	-.760
gene_ther_8	433	3	1	4	2.61	1.100	-.052	-1.338
gene_ther_9	433	3	1	4	1.55	.810	1.469	1.504
gene_ther_10	432	3	1	4	2.18	1.076	.474	-1.038
g_thr_sit_1_1	432	4	1	5	1.67	.978	1.711	2.609
g_thr_sit_1_2	432	4	1	5	2.47	1.156	.349	-.874
g_thr_sit_1_3	432	4	1	5	1.81	1.152	1.536	1.548
g_thr_sit_2_1	432	4	1	5	1.54	.882	1.844	3.117
g_thr_sit_2_2	432	4	1	5	2.35	1.176	.455	-.939
g_thr_sit_2_3	432	4	1	5	1.71	1.105	1.685	2.056
g_thr_sit_3_1	432	4	1	5	1.51	.856	2.029	4.284
g_thr_sit_3_2	432	4	1	5	2.24	1.166	.590	-.748
g_thr_sit_3_3	432	4	1	5	1.65	1.042	1.862	2.927

Table G.6. Descriptive statistics of Attitudes towards Issues in Genetics Literacy Scale after imputation for main study

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
gen_att1	435	4	1	5	2.74	1.230	.271	-1.065
gen_att2	435	4	1	5	1.81	.879	1.352	2.135
gen_att3	435	4	1	5	2.91	1.287	.166	-1.048
gen_att_4	435	4	1	5	2.07	1.018	.956	.468
gen_att_5	435	4	1	5	2.36	.992	.589	-.314
gen_att6	435	4	1	5	3.27	1.082	-.364	-.866
gen_att7	435	4	1	5	4.13	.897	-1.241	1.762
gen_att8	435	4	1	5	4.09	.998	-1.348	1.593
gen_att9	435	4	1	5	4.13	.840	-1.131	1.793
gen_att10	435	4	1	5	3.33	.948	-.044	-.409
gen_att11	435	4	1	5	3.54	1.009	-.408	-.481
gen_att12	435	4	1	5	3.39	1.013	-.368	-.386
gen_att13	435	4	1	5	2.26	1.011	.736	.273
gen_att14	435	4	1	5	3.49	.958	-.415	-.549
gen_att15	435	4	1	5	2.61	1.009	.659	.001
gen_att16	435	4	1	5	2.02	.973	1.267	1.591
gen_att17	435	4	1	5	2.52	1.078	.504	-.305
gen_att18	435	4	1	5	3.41	1.133	-.329	-.873
gen_att19	435	4	1	5	1.91	1.095	1.178	.684
use_gen_1	435	4	1	5	2.14	1.174	.830	-.299
use_gen_2	435	4	1	5	2.01	1.107	1.039	.256
use_gen_3	435	4	1	5	1.94	1.027	1.140	.803
use_gen_4	435	4	1	5	3.59	1.157	-.933	.066
abort_1	435	2	1	3	1.61	.808	.834	-.961
abort_2	435	2	1	3	1.82	.802	.331	-1.373
abort_3	435	2	1	3	2.09	.801	-.159	-1.426
abor_4	435	2	1	3	2.32	.790	-.639	-1.114
pre_IG_1	435	2	1	3	1.49	.751	1.135	-.288
pre_IG_2	435	2	1	3	1.57	.769	.909	-.718
pre_IG_3	435	2	1	3	1.73	.799	.517	-1.249
pre_IG_4	435	2	1	3	1.88	.841	.238	-1.549
gene_ther_1	435	3	1	4	2.75	1.043	-.116	-1.277
gene_ther_2	435	3	1	4	2.57	1.114	-.001	-1.365

Table G. 6 (Continued)

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
gene_ther_3	435	3	1	4	2.36	1.076	.209	-1.213
gene_ther_4	435	3	1	4	1.67	.859	1.258	.928
gene_ther_5	435	3	1	4	1.58	.837	1.489	1.583
gene_ther_6	435	3	1	4	2.09	1.041	.603	-.813
gene_ther_7	435	3	1	4	3.15	1.039	-.807	-.751
gene_ther_8	435	3	1	4	2.62	1.099	-.058	-1.336
gene_ther_9	435	3	1	4	1.55	.809	1.475	1.525
gene_ther_10	435	3	1	4	2.18	1.073	.475	-1.034
g_thr_sit_1_1	435	4	1	5	1.67	.975	1.712	2.630
g_thr_sit_1_2	435	4	1	5	2.47	1.154	.349	-.874
g_thr_sit_1_3	435	4	1	5	1.80	1.150	1.546	1.580
g_thr_sit_2_1	435	4	1	5	1.54	.880	1.842	3.127
g_thr_sit_2_2	435	4	1	5	2.35	1.177	.448	-.949
g_thr_sit_2_3	435	4	1	5	1.72	1.114	1.665	1.970
g_thr_sit_3_1	435	4	1	5	1.51	.854	2.026	4.291
g_thr_sit_3_2	435	4	1	5	2.24	1.170	.580	-.775
g_thr_sit_3_3	435	4	1	5	1.65	1.040	1.868	2.960

APPENDIX H

PERCEPTIONS OF TEACHING ISSUES IN GENETICS LITERACY SCALE

8

Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği

	Yönerge: Verilen ifadeler için aşağıda verilen ölçeği kullanarak görüşünüzü en iyi tanımlayacak seçeneği işaretleyiniz:	Kesinlikle **Katılıyorum**	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle **Katılmıyorum**
1.	Genetik okuryazarlıkla ilgili eğitim ve öğretim materyalleri geliştirmek isterim.					
2.	Ders zamanın sınırlı olması genetik okuryazarlık konusunu anlatırken beni sıkıntıya sokuyor.					
3.	Ne kadar çok çaba harcasam da genetik okuryazarlık konusunu, fen bilgisi dersindeki diğer konular kadar iyi **öğretemiyorum.**					
4.	Genetik okuryazarlık konusu ilgili materyal elde edebilirsem, sınıfımda kullanıyorum					
5.	Genetik okuryazarlık konusunu anlatırken çeşitli öğretim yöntemleri kullanıyorum					
6.	Öğretmenlerin genetik okuryazarlık konusunu anlamalarına yardım amacı ile hazırlanmış programlara katılmak isterim.					
7.	Öğrencilerimin genetik okuryazarlık konusunu anlamak için yeterince hazır **olmadıklarına** inanıyorum.					
8.	Genetik okuryazarlık konusunun öğrencilerimin ilgisini çekeceğini pek **zannetmiyorum**.					
9.	Öğrencilerin genetik okuryazarlık konusundaki yetersiz önbilgileri giderilmelidir.					
10.	Genetik okuryazarlık konusu genellikle başarılı öğrencileri ilgilendiriyor.					
11.	Genetik okuryazarlık konusu öğrencilerin bilime karşı ilgisini artırıyor.					
12.	Genetik okuryazarlık konusunu yeterince anlayabiliyorum.					
13.	Genetik okuryazarlık konusuyla ilgili eğitim ve öğretim materyalleri geliştirme konusunda kendime güveniyorum.					
14.	Genetik okuryazarlık konusu öğrencinin kendi değer yargıları hakkında kafasını karıştırabilir.					
15.	Sınıf ortamında genetik okuryazarlık konusu çeşitli öğretim yöntemleri (rol oynama, grup etkinlikleri) kullanarak işlemek neredeyse hiç mümkün **değildir**.					
16.	Etkili bir şekilde öğretecek kadar genetik okuryazarlık kavramlarından iyi anlıyorum					
17.	Genetik okuryazarlık konusunun öğretimi fen bilgisi dersinde yer alan diğer konularının öğretimi kadar önemli **değildir**.					
18.	Genetik okuryazarlık konusunun öğretimi çaba ve zaman harcamaya **değmez**.					
19.	Genetik okuryazarlık konularına ortaöğretim müfredatında yer verilmesinin daha uygun olduğunu düşünüyorum.					
20.	Genetik okuryazarlık konusu mutlaka fen derslerinde verilmelidir.					

Çalışmama katkıda bulunduğunuz için en derin teşekkürlerimi sunarım.

Important Note:

***** Item 3, Item 5 and Item 19 were removed from the Scale according to the explanatory factor analysis results.

H.1. Perceptions of Teaching Issues in Genetics Literacy Scale

Table H.1. Item-total statistics and inter-item correlation for teachers' perceptions of teaching genetics literacy issues scale

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
perc_1	29.21	16.922	.676	.546	.823
perc_3	29.23	18.187	.625	.483	.830
perc_4	29.13	17.499	.729	.589	.818
perc_7	28.95	19.953	.412	.240	.853
perc_9	29.24	17.204	.695	.544	.821
perc_15	29.19	18.579	.543	.522	.839
perc_16	28.94	19.259	.554	.468	.839
perc_17	29.26	17.479	.527	.301	.845

Table H.2. Item-total statistics for teachers' perceptions of the factors that impede addressing genetics literacy issues in their classrooms

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
perc_5	10.85	12.738	.385	.169	.783
perc_6	11.68	10.786	.635	.429	.703
perc_8	11.19	10.506	.597	.412	.716
perc_12	12.18	11.281	.634	.438	.708
perc_13	11.56	11.032	.507	.333	.750

Table H.3. Item-total statistics for teachers' personal science teaching efficacy beliefs regarding genetics literacy issues

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
perc_2	10.48	4.209	.575	.367	.703
perc_10	10.81	4.027	.662	.461	.656
perc_11	10.82	3.868	.643	.487	.664
perc_14	10.80	4.817	.392	.180	.795

Table H. 4. Inter-item correlations

	Mean	Min	Max	Range	Max / Min	Variance	N of Items
Necessity of addressing genetics literacy issues in their classes	4.163	4.043	4.370	.326	1.081	.017	8
The factors that impede addressing genetics literacy issues in their classrooms	2.873	2.183	3.516	1.333	1.611	.255	5
Teachers' personal science teaching efficacy beliefs regarding genetics literacy issues	3.575	3.484	3.817	.333	1.096	.026	4

Table H.5. Data screening for teachers' perceptions of teaching genetics literacy issues scale

	Valid Cases		Missing Cases		Total	
	N	Percent (%)	N	Percent (%)	N	Percent (%)
perc_1	430	98.9	5	1.1	435	100
perc_2	433	99.5	2	.5	435	100
perc_3	432	99.3	3	.7	435	100
perc_4	431	99.1	4	.9	435	100
perc_5	433	99.5	2	.5	435	100
perc_6	433	99.5	2	.5	435	100
perc_7	432	99.3	3	.7	435	100
perc_8	432	99.3	3	.7	435	100
perc_9	432	99.3	3	.7	435	100
perc_10	433	99.5	2	.5	435	100
perc_11	432	99.3	3	.7	435	100
perc_12	433	99.5	2	.5	435	100
perc_13	433	99.5	2	.5	435	100
perc_14	430	98.9	5	1.1	435	100
perc_15	433	99.5	2	.5	435	100
perc_16	432	99.3	3	.7	435	100
perc_17	433	99.5	2	.5	435	100

Table H.6. Descriptive statistics of teachers' perceptions of teaching genetics literacy issues scale for main study

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
perc_1	430	4	1	5	4.07	.843	-.818	.397
perc_2	433	4	1	5	2.46	1.009	.683	-.119
perc_3	432	3	2	5	4.08	.740	-.992	1.568
perc_4	431	4	1	5	4.13	.788	-1.113	1.922
perc_5	433	4	1	5	3.37	1.142	-.333	-.953
perc_6	433	4	1	5	2.20	.999	.924	.534
perc_7	432	4	1	5	4.27	.689	-1.176	3.090

Table H.6 (Continued)

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
perc_8	432	4	1	5	2.86	1.249	.212	-1.138
perc_9	432	4	1	5	4.17	.749	-.914	1.273
perc_10	433	4	1	5	3.84	.777	-.723	1.108
perc_11	432	4	1	5	3.38	.829	.041	-.447
perc_12	433	4	1	5	3.06	1.039	.001	-.914
perc_13	433	4	1	5	2.75	1.056	.410	-.676
perc_14	430	4	1	5	3.46	.875	-.406	-.095
perc_15	433	4	1	5	1.79	.791	1.326	2.656
perc_16	432	4	1	5	1.59	.685	1.337	3.144
perc_17	433	4	1	5	4.08	.994	-1.220	1.331

Table H.7. Descriptive statistics of teachers' perceptions of teaching genetics literacy issues scale after imputation for main study

Item	N	Range	Min	Max	Mean	S.D.	Skewness	Kurtosis
perc_1	435	4	1	5	4.07	.840	-.812	.404
perc_2	435	4	1	5	2.46	1.012	.674	-.142
perc_3	435	3	2	5	4.08	.745	-1.001	1.546
perc_4	435	5	1	5	4.13	.788	-1.094	1.916
perc_5	435	4	1	5	3.37	1.143	-.322	-.969
perc_6	435	4	1	5	2.20	.997	.929	.552
perc_7	435	4	1	5	4.27	.687	-1.171	3.106
perc_8	435	4	1	5	2.87	1.251	.201	-1.145
perc_9	435	4	1	5	4.16	.749	-.905	1.251
perc_10	435	4	1	5	3.84	.776	-.719	1.101
perc_11	435	4	1	5	3.39	.827	.036	-.442
perc_12	435	4	1	5	3.06	1.039	-.008	-.917
perc_13	435	4	1	5	2.75	1.054	.413	-.669
perc_14	435	4	1	5	3.46	.872	-.407	-.083
perc_15	435	4	1	5	1.79	.790	1.327	2.666
perc_16	435	4	1	5	1.59	.684	1.339	2.161
perc_17	435	4	1	5	4.08	.991	-1.222	1.349

APPENDIX I

DECISION MAKING INTERVIEW PROTOCOLS

I. 1. Fetal Tissue Transplantation Scenario

Senaryo 1: Fetüs Doku Transferi

Son yıllarda yapılan bilimsel araştırmalar sonucunda, kürtajla alınan fetüsten başka bir insana doku transferinde başarı sağlanmıştır. "Fetüs doku transferi" olarak adlandırılan bu yöntemin; diyabet, Parkinson ve Alzheimer gibi hastalıklara sahip bireylerin iyileşme olasılığını arttırması umulmaktadır.

Senaryo:

Ahmet ve Suzan 30'lu yaşların sonlarına yaklaşan ve iki ergen çocukları olan evli bir çifttir. Yakın zamanda, Suzan'ın babasına Parkinson Hastalığı teşhisi konuldu. Bu hastalık, titreme ve kas sertliği gibi belirtiler göstermektedir. Suzan'ın babasının hastalığı yavaş ilerleme göstermesine rağmen, doktoru, babasının zamanla daha da güçsüz ve aciz kalacağını açıkladı.

Babasının hastalığını öğrendiği günlerde Suzan; yerel gazetede, bir devlet üniversitesi tarafından Parkinson hastaları ile yürütülen araştırma projesi hakkında bir yazı okumuştu. Bu habere göre, Dr. Acar yürütücülüğündeki araştırma grubu, çalışmaları için gerekli izinleri almışlardı. Hastalık hakkında daha fazla bilgi almak için Dr. Acar'la görüşen Suzan; fetüs beyin hücrelerinin hastanın beynine nakledilmesiyle, Parkinson hastalığının ilerlemesinin yavaşlatılabileceğini öğrendi. Bu görüşmeden iki ay sonra Suzan hamile olduğunu öğrendi. Üçüncü çocuk istemeyen çift, hamileliği sonlandırmayı düşündü. Ancak Suzan'ın babasının hastalığının ilerlemesi üzerine Ahmet ve Suzan fetüs doku transferini alternatif bir tedavi seçeneği olarak düşünmeye başladı.

Sorular

1. Deneysel bir araştırma olduğu düşünüldüğünde "Fetüs doku transferi" yöntemini Suzan ve Ahmet, Suzan'ın babasının tedavisi için düşünmeli mi? Neden?
2. Eğer Suzan ve Ahmet, fetüsü aldırmaya karar verirlerse; bu fetüs dokularını, doku nakli için bağışlamalarına izin verilmeli mi? Neden?
3. Suzan ve Ahmet'in, doku transferi için Suzan'ın babasını "alıcı" olarak belirlemesine izin verilmeli mi? Neden?
4. Suzan'ın kürtajı istemesindeki asıl amacı babasına doku kaynağı sağlamak olsaydı yine de Suzan'ın kürtaj yaptırmasına izin verilmeli miydi?
5. Sizce, Dr. Acar'a, Parkinson hastalığının tedavisi için fetüs beyin doku transferiyle ilgili çalışmasına devam etmesi için izin verilmeli mi? Neden?

I. 2. Cystic Fibrosis Scenario

Senaryo 2: Kistik fibrozis

Sık görülen hastalıklardan biri olan Kistik fibrosiz (Cystic Fibrosis, CF) otozomal çekinik bir genetik hastalıktır. Bu hastalık, Amerika Birleşik Devletleri'nde ve İngiltere'de 2000 yeni doğandan birini etkilemekte ve her 20 kişiden biri taşıyıcı olmaktadır. Kistik fibrozis; dış salgı bezlerinin yetersiz çalışmasına neden olarak terdeki tuz miktarında yüksek artışa, sindirim bozukluklarına ve solunum sisteminde çok miktarda mukus üretimine sebep olmaktadır. Salgılanan mukus, sıklıkla görülen akciğer enfeksiyonlarına yol açmaktadır. Her enfeksiyon uzun vadede akciğerlere zarar verir. Dolayısıyla hastalık ölümcüldür ve hastalar 40'lı yaşlardan sonra nadiren hayatta kalırlar.

Kistik fibrozis hastalığından sorumlu genin yeri belirlenmiştir. Gen terapisi üzerinde çalışan farklı ülkelerden bilim insanları, iki farklı yöntem üzerinde durmaktadır: Birinci yöntemde; normal bir geni, akciğer dokusunda bulunan deforme olmuş genle değiştirmek amaçlanmıştır. Akciğerlerin karmaşık olan yapısı, epitel hücrelerinin çıkarılmasını ve gen değişiminden sonra bu hücrelerin geri konulmasını imkansız hale getirmesine karşın, 1992 yılında bir grup araştırmacı, bir farenin akciğerlerindeki epitel hücrelerine genleri yerleştirmeyi başarmış ve bu genler, 6 hafta boyunca fonksiyonlarını sürdürmüştür. İkinci yöntemde ise normal genler içeren bir sprey geliştirilmesi hedeflenmiş ve bu normal genlerin, "taşıyıcılara" yerleştirilerek, normal genlerin hücrelere taşınması amaçlanmıştır. Bu spreyi kullanan Kistik fibrozis hastalarının hücrelerinde, bu normal genlerin çalışacakları umulmaktadır. Ancak, tüm bu çabalara rağmen Kistik fibrozis hastalığının genetik tedavisinin uygulanabilmesi için uzun bir zaman gerekmektedir.

Senaryo:

1. Otozomal çekinik özellik gösteren Kistik fibrozis hastası erkek kardeşleri olan Reyhan ve Semih evli bir çifttir. Reyhan hamiledir. Bu çift embriyoyu aldırmalı mıdır? Neden?
2. Yapılan genetik testler sonucunda, Reyhan ve Semih'in her ikisinin de Kistik fibrozis taşıyıcısı olduğu ve embriyonun da Kistik fibrozis hastası olduğunu belirlenmiştir. Sizce yapılan testin sonuçlarına göre, Reyhan ve Semih kürtaja karar vermeli mi? Neden?

I. 3. Huntington Disease Scenario

Senaryo 3: Huntington Hastalığı

Huntington hastalığı, baskın genetik bir hastalıktır. İlgili allelin bulunduğu taşıyıcılar, hayatlarının bir döneminde hastalığın belirtilerini göstermektedir. Tipik başlangıç belirtileri, 35-45 yaşları arasında görülmektedir. Hastalarda, irade dışı kol ve bacak titremeleri ve kişilik değişimleri (birden bire meydana gelen ağlamalar, açıklanamayan öfke nöbetleri, hafıza kaybı ve bazen şizofren davranışlar) görülür. Hastalığın farklı evrelerindeki belirtilerin şiddeti, bir hastadan diğerine farklılık göstermektedir. Bu hastalık ölümcüldür ve ölüm 50 yaş civarında gerçekleşmektedir. Hastalar son evrelerinde, hastalar bitkisel hayata girmektedir.

Senaryo:

28 yaşında olan Lale, kısa bir süre önce evlenmiştir. Lale'nin babası, 50 yaşındadır ve son beş yıldır Huntington hastasıdır. Huntington hastalığı genini taşıyıp taşımadığını öğrenmek için genetik test yaptırmayı istemeyen Lale, hamile olduğunu öğrenince, fetüsün taşıyıcı olup olmadığını öğrenme ihtiyacı hissetti. Lale'nin yaptırdığı genetik testler, fetüsün gerçekten de Huntington hastalığı taşıyıcısı olduğunu gösterdi.

Lale kürtaj yaptırmalı mı? Neden?

1. Ortalama yaşam süresinin 75 yıl olduğu ve Huntigton hastalarının 50'li yaşlara kadar normal bir hayat sürdüğü düşünüldüğünde, aradaki 25 yıllık bu fark Lale'nin kürtajı düşünmesi sizce ne derece doğrudur?
2. Huntington hastalığı ile belirtileri doğumla başlayan diğer hastalıklar arasında bir fark olduğunu düşünüyor musunuz? Neden?
3. Huntington hastalarının ilerleyen zamanda çekeceği acılar düşünüldüğünde, bu acılar, Lale'nin kürtaja karar vermesinde bir neden olabilir mi?

I. 4. Gene Therapy Scenario

Senaryo 4: Gen terapisinin Huntington hastalığında kullanılması

Germline gen terapisi, insanlarda henüz kullanılmaya başlanmamış bir genetik teknolojidir. Germline gen terapisi, bir bireyin üreme (yumurta veya sperm) hücrelerinde bulunan veya döllenmeden hemen sonra oluşan embriyonun bir geninin değiştirilmesi esasına dayanır. Germline gen terapisinin amacı, istenmeyen geni istenilen bir genle değiştirmektir. Gen terapisi sonucunda oluşan üreme hücresi ya da embriyo "yeni" geni içerecek ve istenmeyen "eski" gen yok olacaktır.

Senaryo 4.a: Huntington Hastalığı

Huntington hastalığı tek bir gen tarafından kontrol edilmektedir. Bu nedenle, germline gen terapisi bu hastalığın tedavisinde kullanılabilir.

Üreme hücrelerinden Huntington hastalığı genini yok etmek suretiyle, yeni nesiller oluşturulmasında gen terapisi kullanılmalı mı?

Sizi bu şekilde düşünmeye sevk eden faktörler nelerdir? Açıklar mısınız?

1.a. Şimdi, kendinizi Huntington hastası bir çocuğu olan ebeveynin yerine koyun. Yine aynı kararı verir miydiniz?

1.b. Şimdi ise, kendinizi Huntington hastalığı genini taşıyan çocuğun yerine koyun. Yine aynı kararı verir miydiniz?

Gen terapisinin herhangi bir ahlaki kural veya prensiple ilişkili olduğunu düşünüyor musunuz? Neden?

Ebeveyne çocuğunun genlerini değiştirme hakkı verilmeli mi? Neden?

2.a. Gen terapisi yapılan çocuğun geleceğini düşündüğünüzde yine aynı karar verir miydiniz? Neden?

2.b. Gen terapisi yapılmayan geleceğini düşündüğünüzde yine aynı karar verir miydiniz? Neden?

Senaryo 4.b: Gen terapisinin zeka üzerinde kullanılması

İnsan zekasının, içinde çevresel ve genetik etkilerin de bulunduğu bir çok faktör tarafından kontrol edildiği bilinmektedir. Bir bireyin zekasını tam anlamıyla belirleyebilen ne genetik ne de çevresel tek bir faktör vardır. Dolayısıyla, bireyin zekasında, birkaç genin katkısının olması olasıdır. Bununla birlikte, bilim insanlarının bir kişinin zekasına en azından katkısı olan bir gen bulmaları mümkündür.

Eğer bilim, insan zekasını önemli ölçüde belirleyen bir geni izole edebilirse; bu gen gelecek nesillerin zeka düzeyini arttırmak için gen terapisinde kullanılmalıdır?

1. Sizi böyle düşünmeye sevk eden faktörler nelerdir? Açıklar mısınız?
    a) Zekasının düzeyi arttırılan çocuğun ebeveynlerinin duygu ve sorumlulukları açısından,
    b) Zeka düzeyi arttırılan bir çocuğun duyguları ve hakları açısından,
    c) Gen terapisi yapılan çocuğun ve gen terapisi yapılmayan çocuğun geleceği açısından,
2. Bu olayda uygulanan gen terapisinin, herhangi bir ahlaki kural veya prensiple ilişkili olduğunu düşünüyor musunuz? Neden?
3. Ebeveynlere, çocuğunun zeka düzeyini arttırmak adına onun genlerini değiştirme hakkı verilmeli mi? Neden?

Bu bölümde öğretmenlere, daha önce okumuş oldukları gen terapisinin Huntington hastalığının tedavisinde ve zeka düzeyinin arttırılmasında kullanılması ile ilgili ortak sorular sorulacaktır:

4. Huntington hastalığının tedavisi ve zeka düzeyinin arttırılması ile ilgili gene terapisi uygulamalarını gerçekleştirecek doktorların görev ve sorumlulukları neler olmalıdır? Her iki durumda da doktorların görev ve sorumlulukları aynı mıdır? Neden?
5. Sizce kimler gen terapisi yaptırmalı? Neden böyle düşünüyorsunuz?

6. Huntington hastalığı genini taşıyan ebeveynler mi yoksa çocuğunun zeka düzeyini arttırmak isteyen ebeveynler mi?
7. Gen terapisiyle ilgili sizi en çok neler endişelendirmektedir?
8. Gen terapisiyle ilgili sizi endişelendiren teknolojik konular var mı? Varsa bu konular nelerdir?

APPENDIX J

CANONICAL CORRELATION ANALYSIS ASSUMPTIONS

J.1. Missing Data Analysis

Table J.1. Missing Data Analysis

	Valid Cases		Valid Cases		Total	
	N	(%)	N	Percent (%)	N	Percent (%)
gender	435	100	0	0	435	100
Teaching experience	433	99.5	2	0.5	435	100
Int_gen	435	100	0	0	435	100
Know_gen	435	100	0	0	435	100
GLAI	435	100	0	0	435	100
General attitude	435	100	0	0	435	100
Use of genetic information	435	100	0	0	435	100
Abortion	435	100	0	0	435	100
Pre-implementation genetic diagnosis	435	100	0	0	435	100
Gene therapy	435	100	0	0	435	100
Gene therapy applications	435	100	0	0	435	100
Necessity of genetics literacy issues	435	100	0	0	435	100
Impeding factors	435	100	0	0	435	100
Teaching efficacy beliefs	435	100	0	0	435	100

J.2. Normality

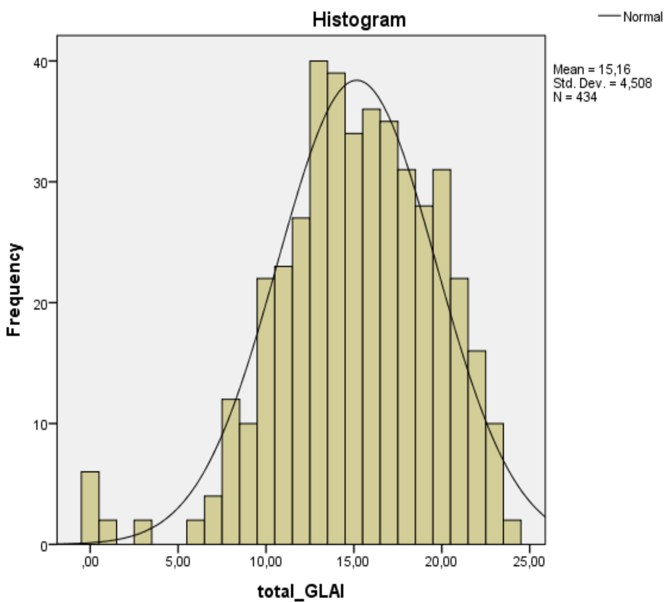


Figure J.2.1. Histogram of total score of the GLAI

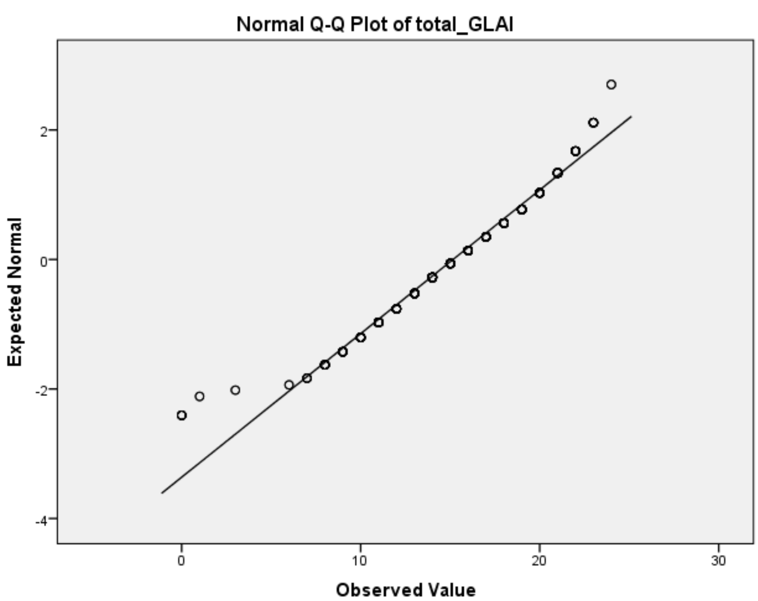


Figure J. 2.2. Q-Q Plot of total score of the GLAI

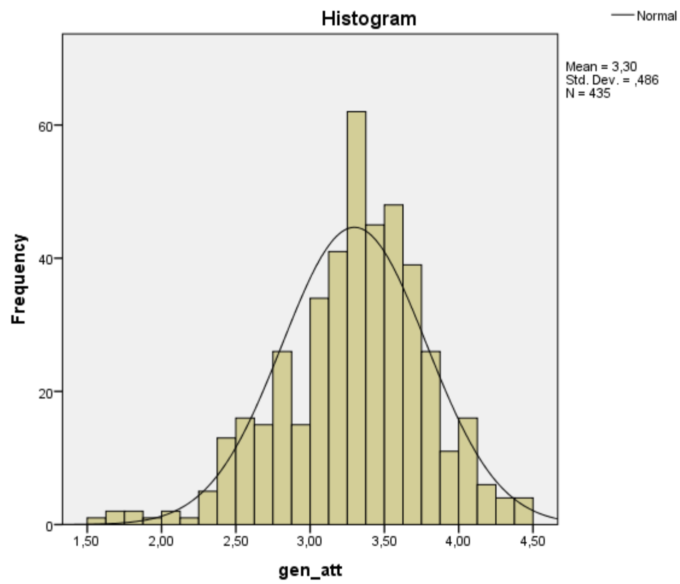


Figure J. 2.3. Histogram of total score of general attitude

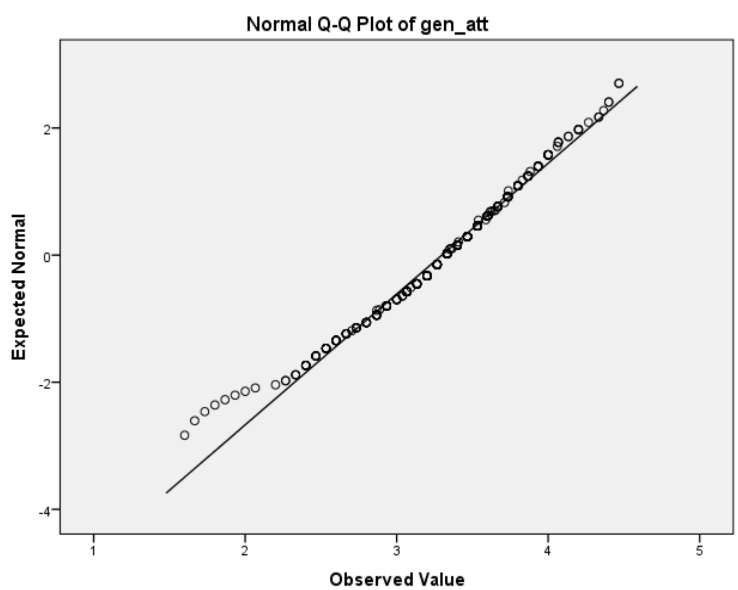


Figure J. 2.4. Q-Q Plot of total score of general attitude

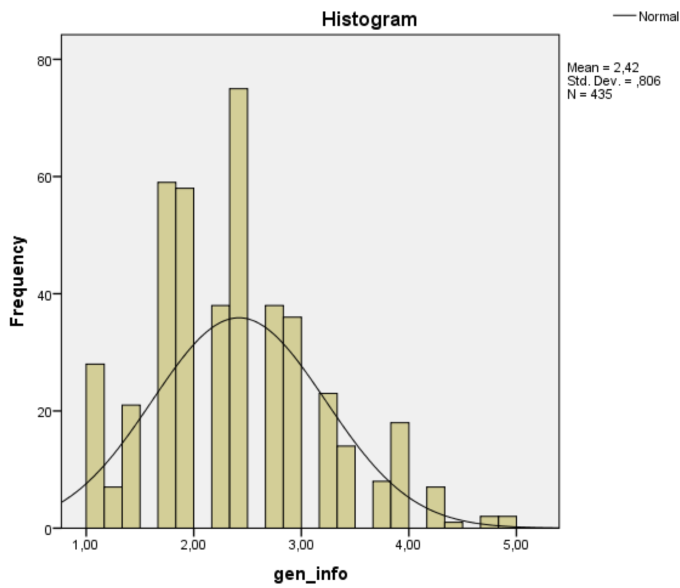


Figure J. 2.5. Histogram of total score of use of genetic information

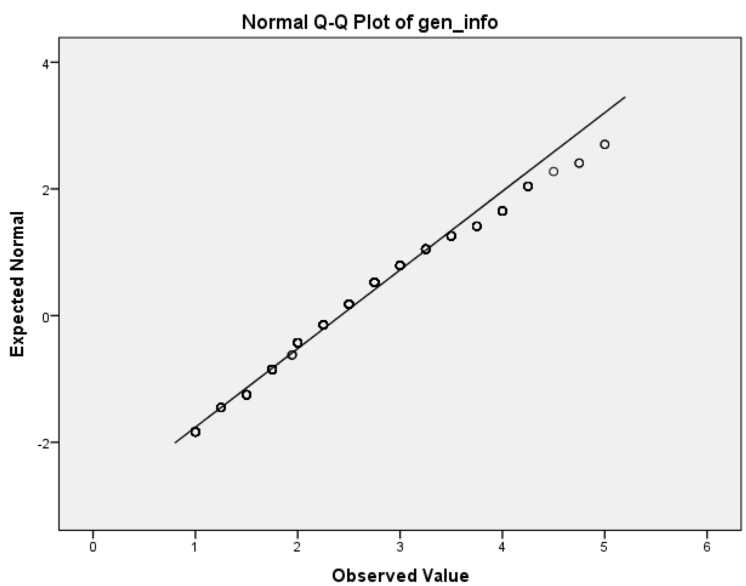


Figure J.2.6. Q-Q Plot of total score of use of genetic information

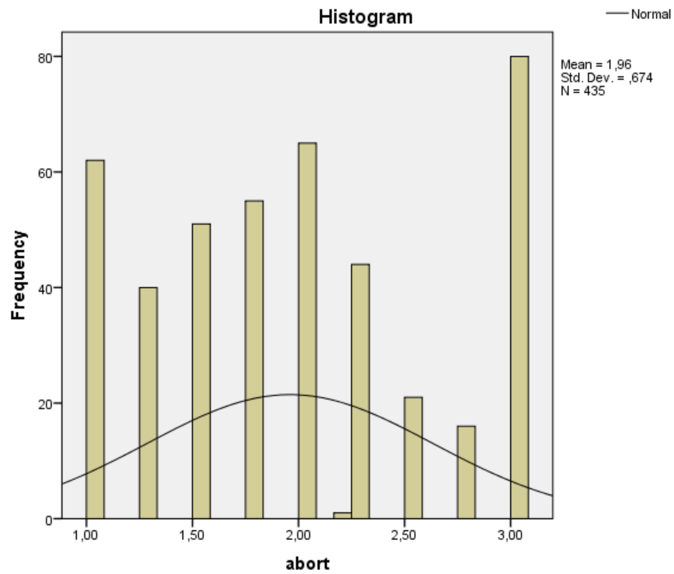


Figure J. 2.7. Histogram of total score of abortion

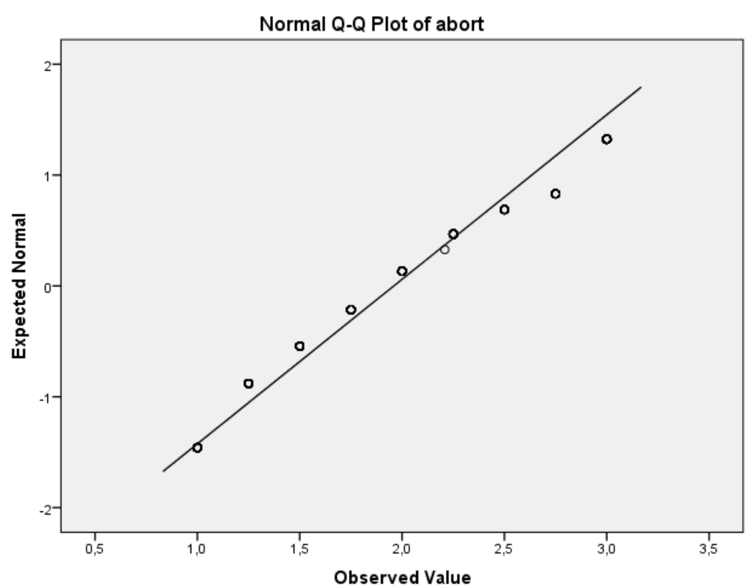


Figure J. 2.8. Q-Q Plot of total score of abortion

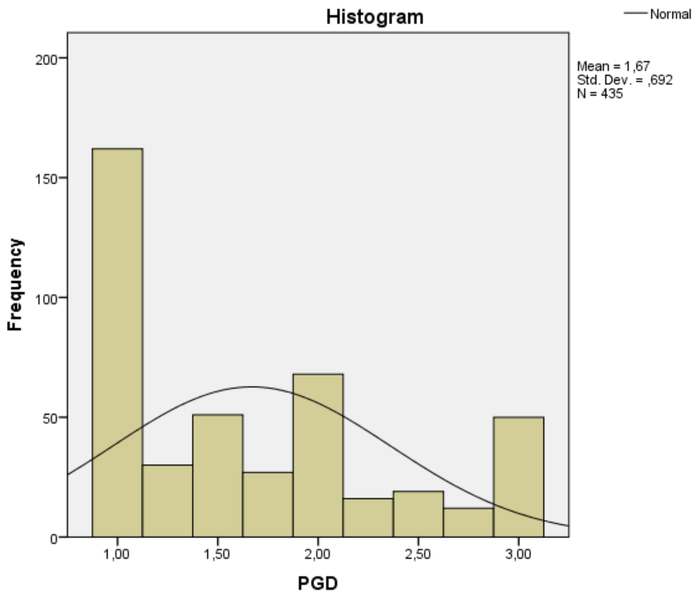


Figure J.2.9. Histogram of total score of Pre-implementation genetic diagnosis

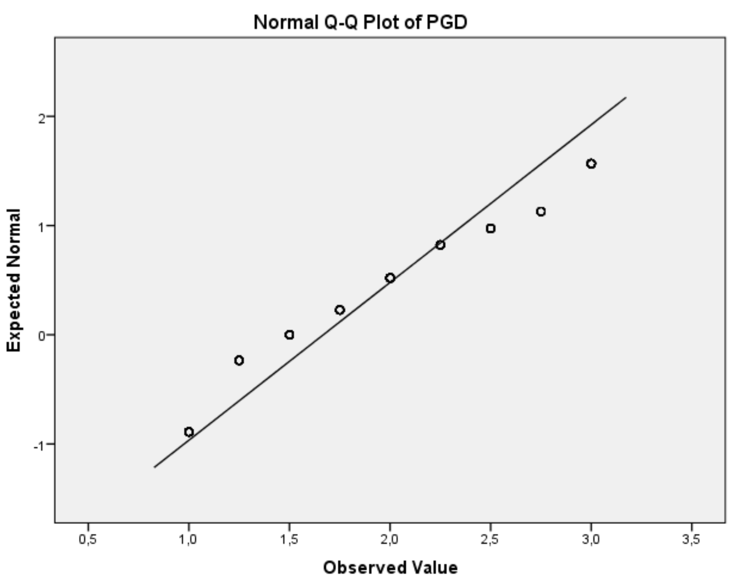


Figure J.2.10. Q-Q Plot of total score of Pre-implementation genetic diagnosis

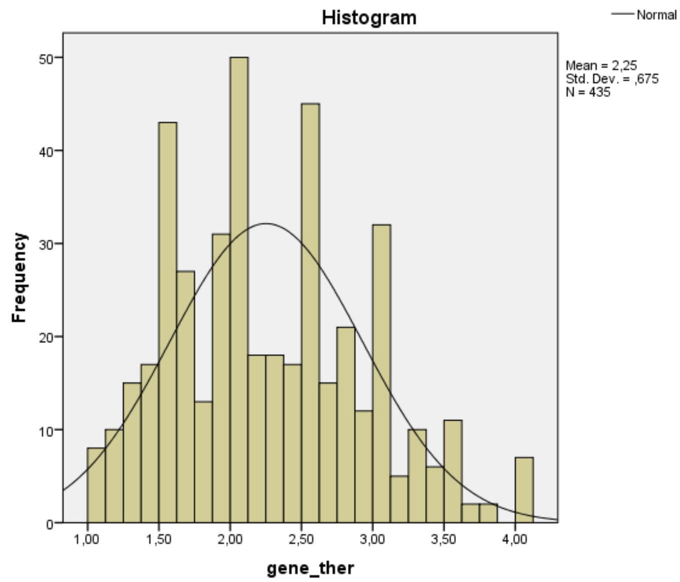


Figure J.2.11. Histogram of total score of gene therapy

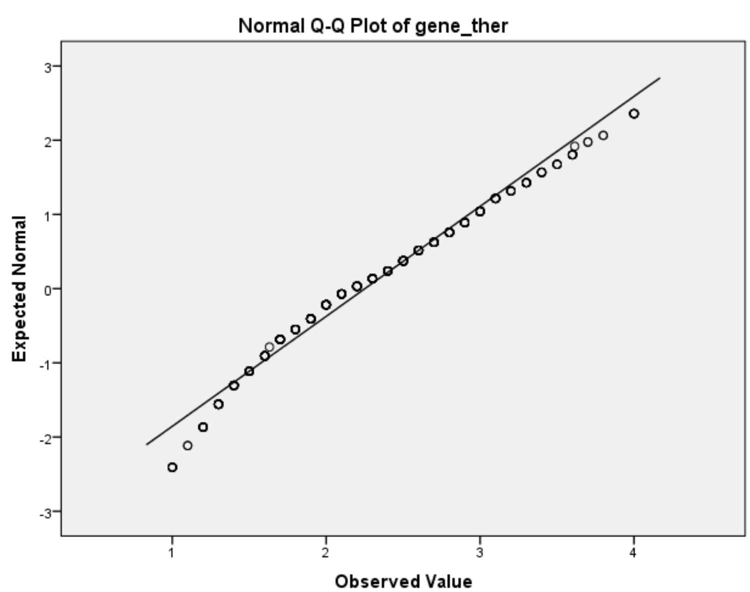


Figure J.2.12. Q-Q Plot of total score of gene therapy

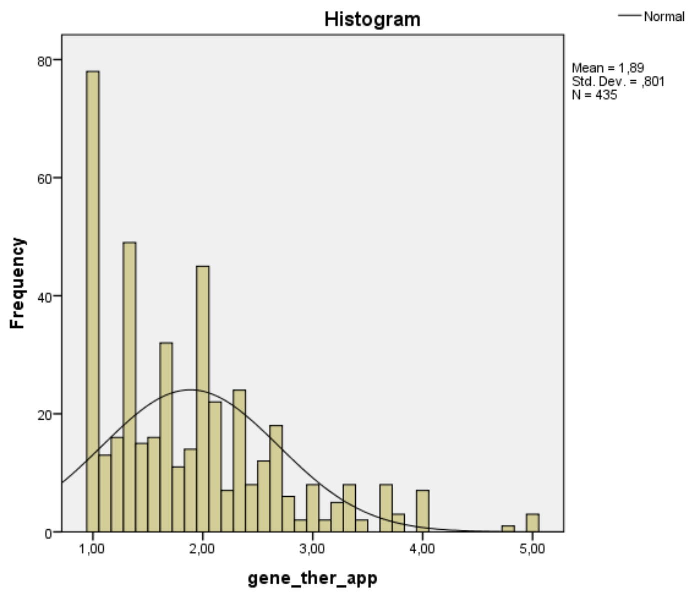


Figure J.2.13. Histogram of total score of gene therapy applications

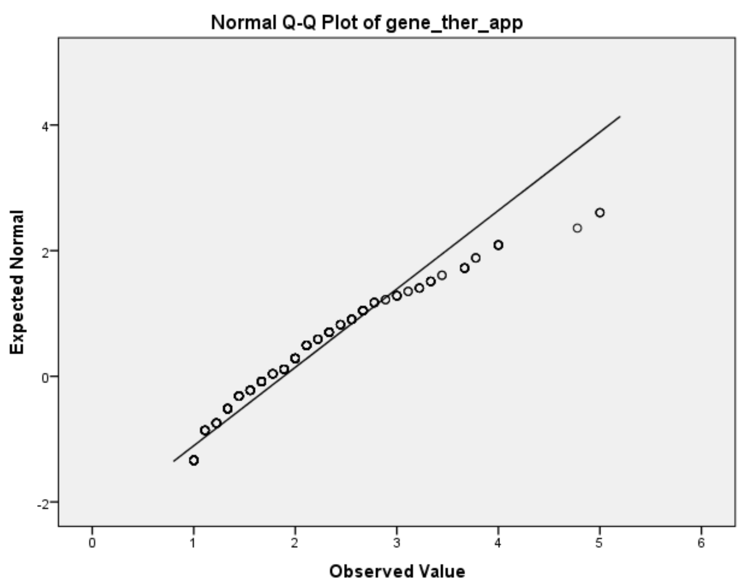


Figure J.2.14. Q-Q Plot of total score of gene therapy applications

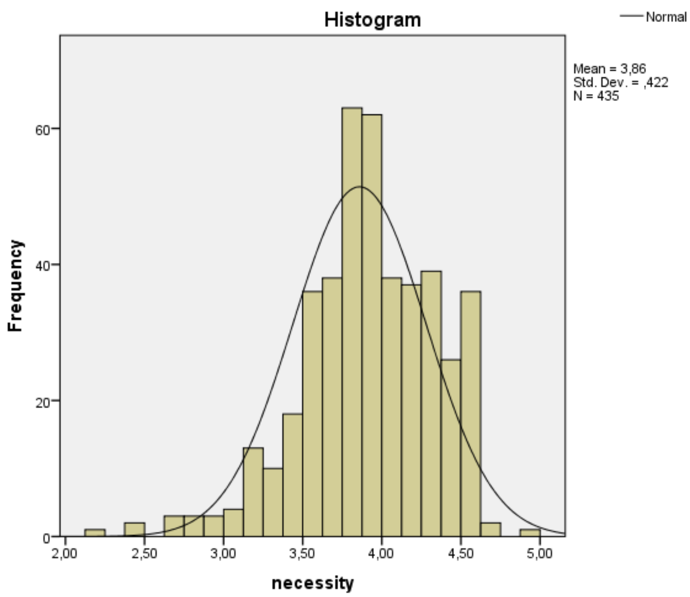


Figure J.2.15. Histogram of total score of necessity of introducing genetics literacy

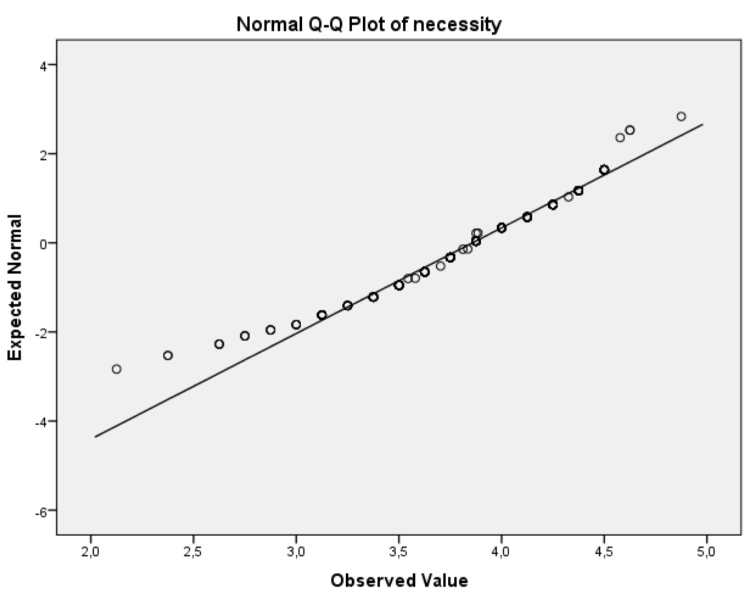


Figure J.2.16. Q-Q Plot of total score of necessity of introducing genetics literacy

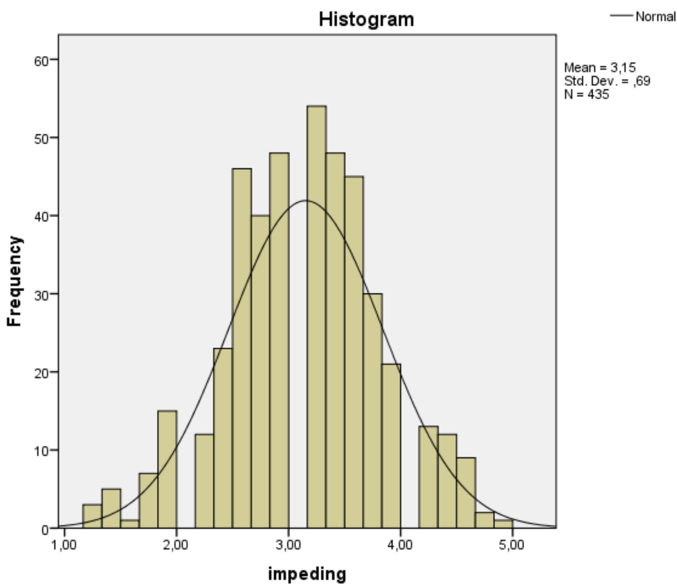


Figure J.2.17. Histogram of total score of impeding factors

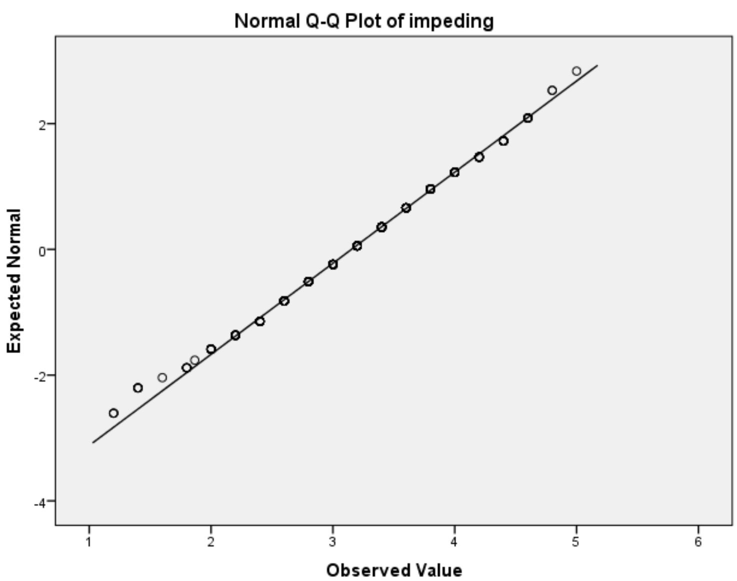


Figure J.2.18. Q-Q Plot of total score of impeding factors

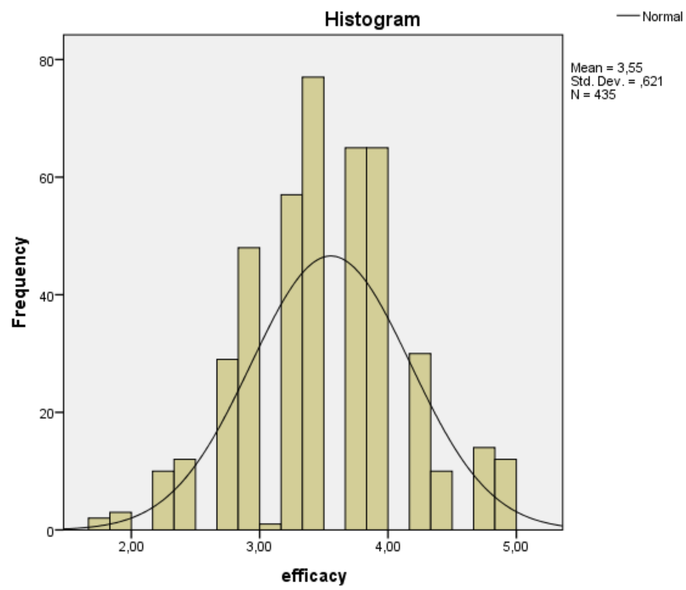


Figure J.2.19. Histogram of total score of self-efficacy beliefs

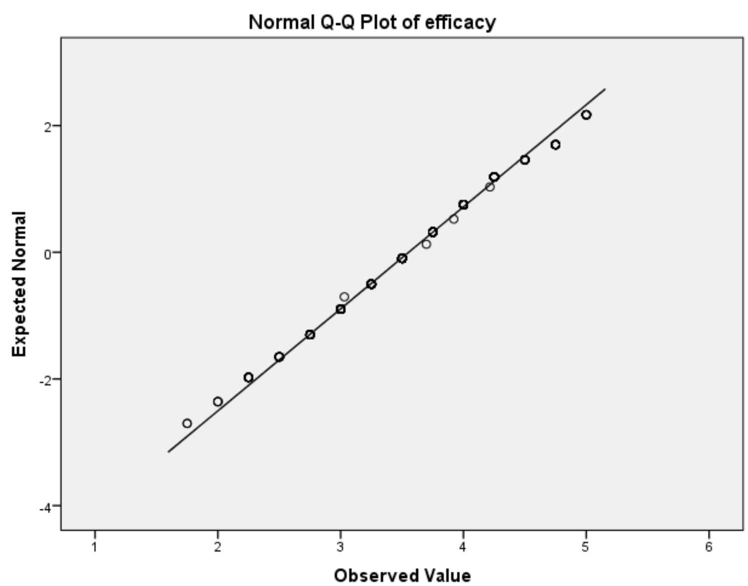


Figure J.2.20. Q-Q Plot of total score of self-efficacy beliefs

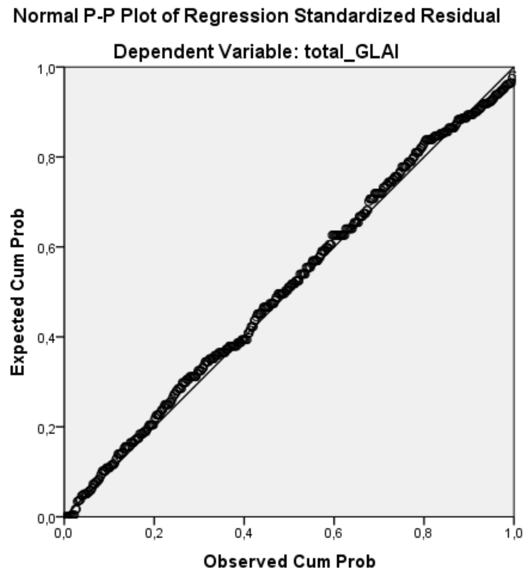


Figure J.2.21. P-P Plot of total score of the GLAI

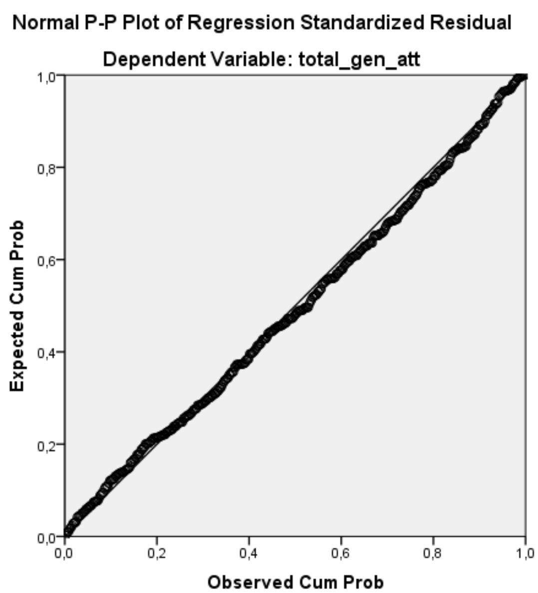


Figure J.2.22. P-P Plot of total score of general attitude

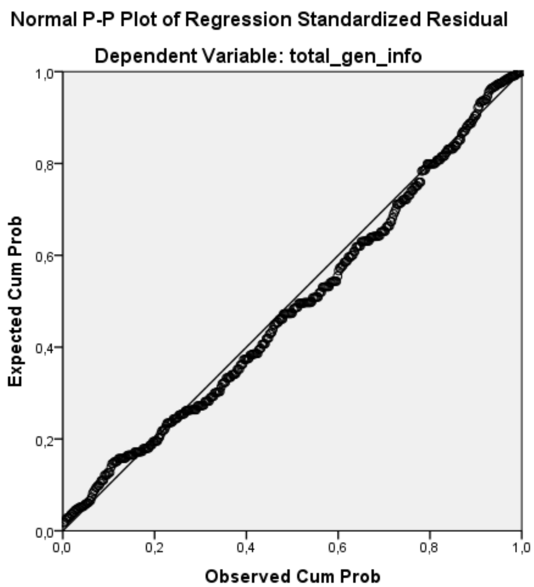


Figure J.2.23. P-P Plot of total score of use of genetic information

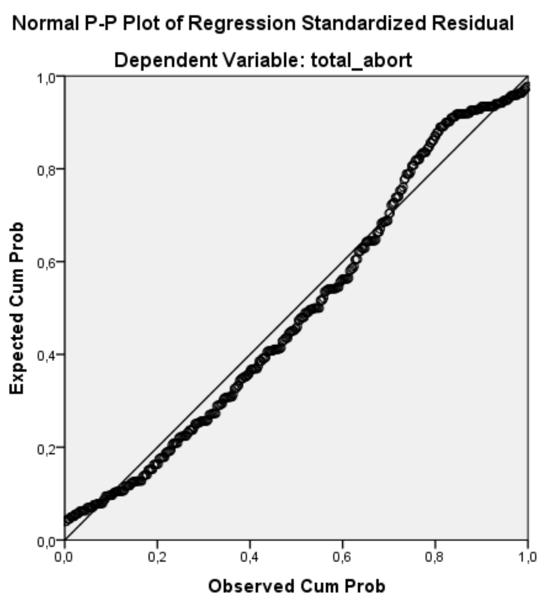


Figure J.2.24. P-P Plot of total score of abortion

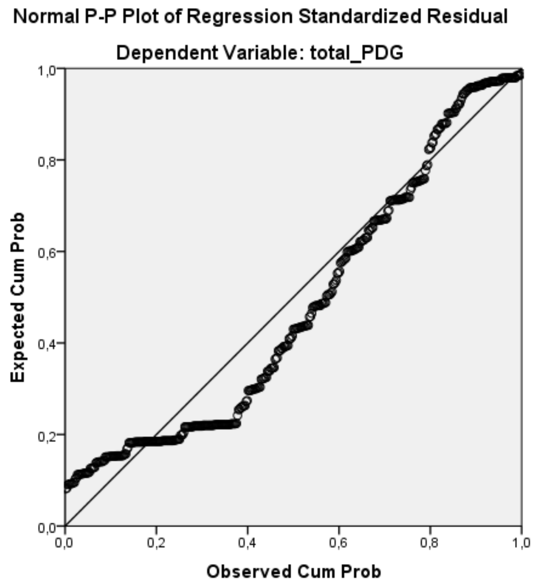


Figure J.2.25. P-P Plot of total score of pre-implementation genetic diagnosis

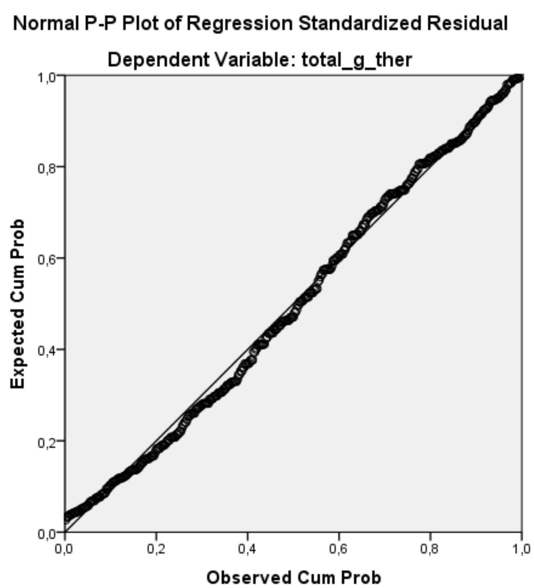


Figure J.2.26. P-P Plot of total score of gene therapy

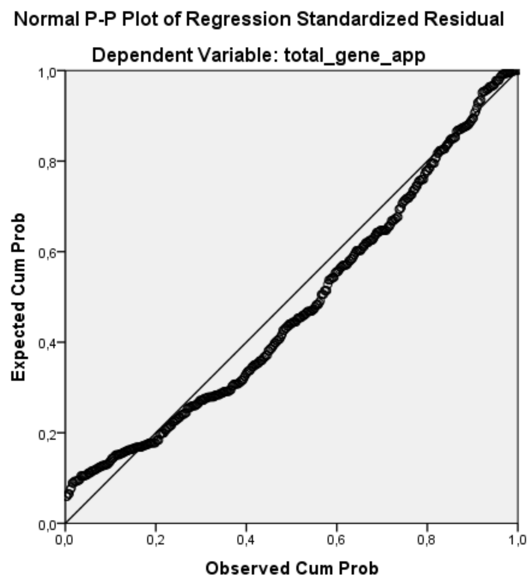


Figure J.2.27. P-P Plot of total score of gene therapy applications

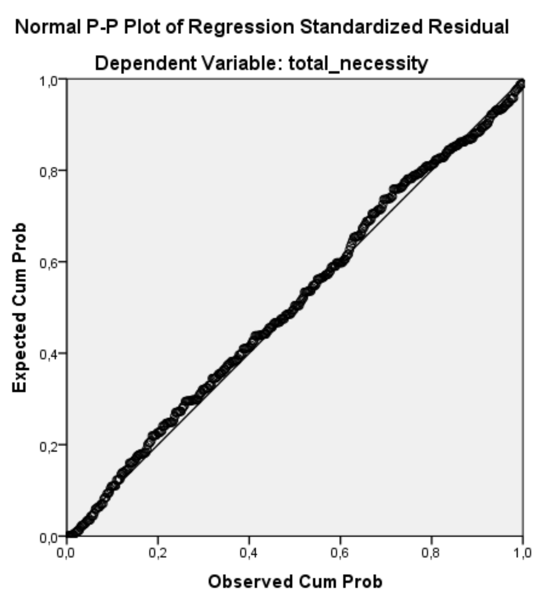


Figure J.2.28. P-P Plot of total score of necessity of introducing genetics literacy

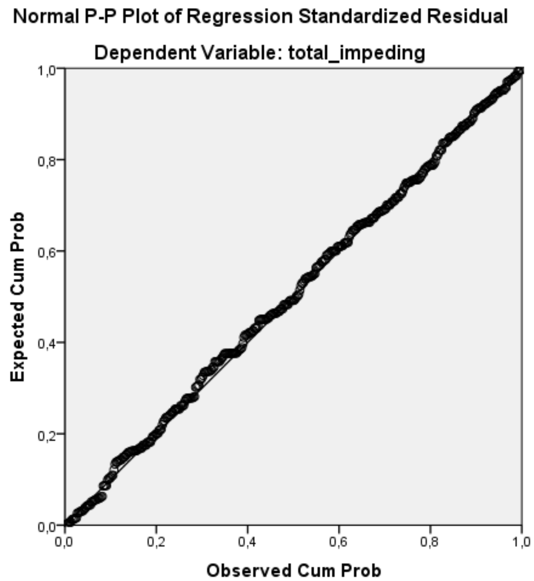


Figure J.2.29. P-P Plot of total score of impeding factors

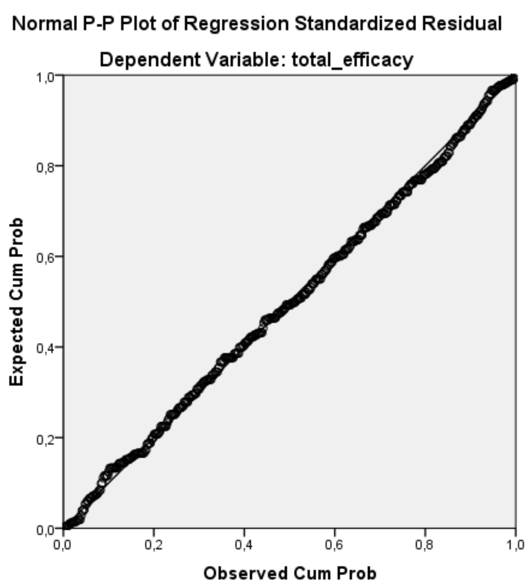


Figure J.2.30. P-P Plot of total score of self-efficacy beliefs

J. 3. Linearity

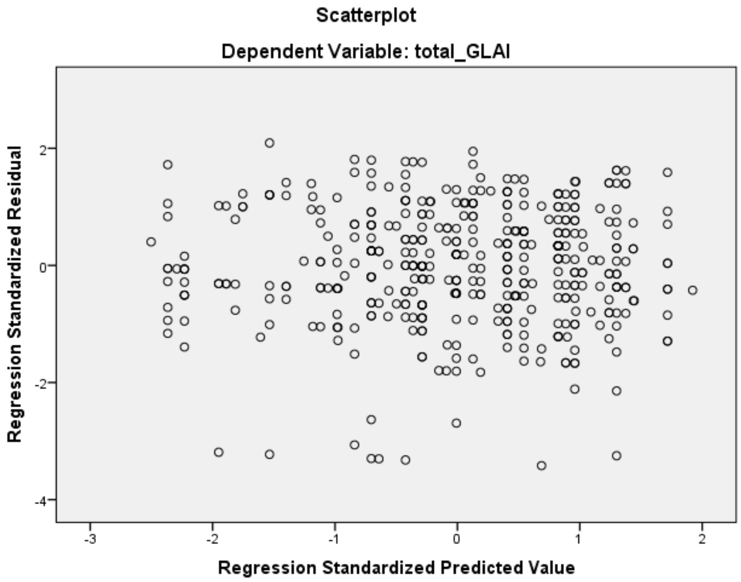


Figure J.3.1: Scatterplot of the standardized residuals for GLAI

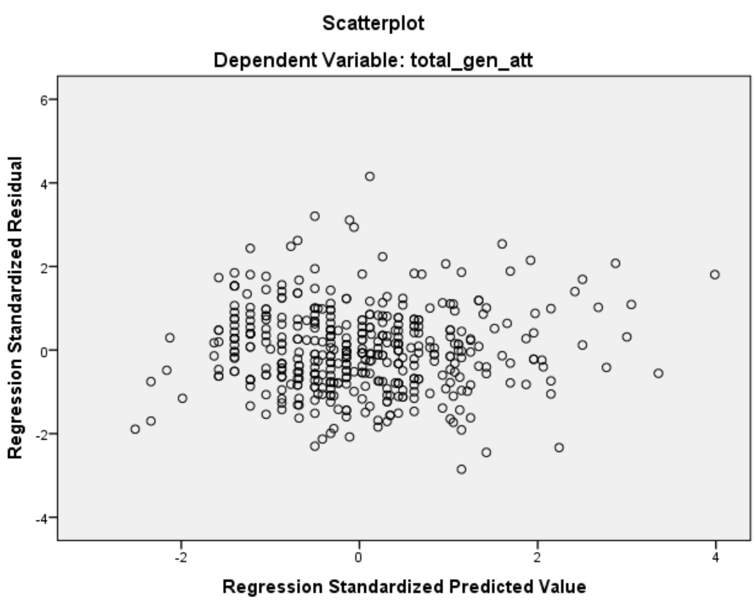


Figure J.3.2: Scatterplot of the standardized residuals for general attitude

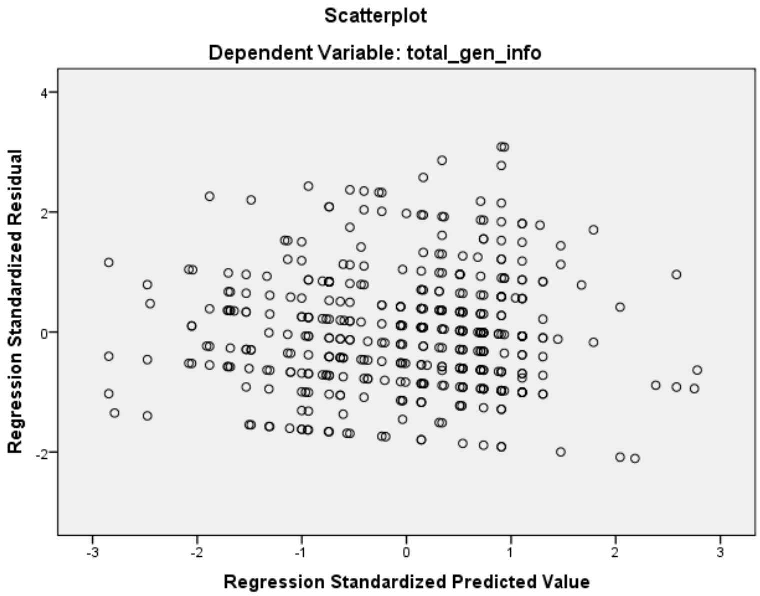


Figure J.3.3: Scatterplot of the standardized residuals for use of genetic information

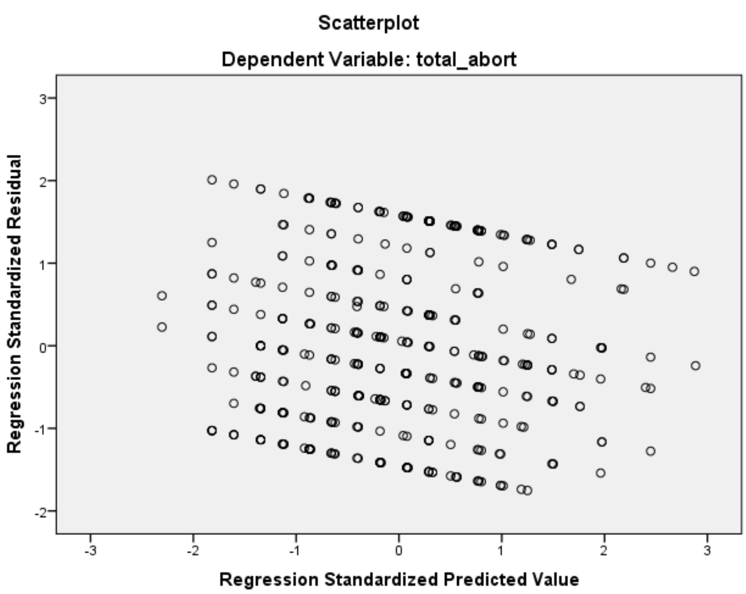


Figure J.3.4: Scatterplot of the standardized residuals for abortion

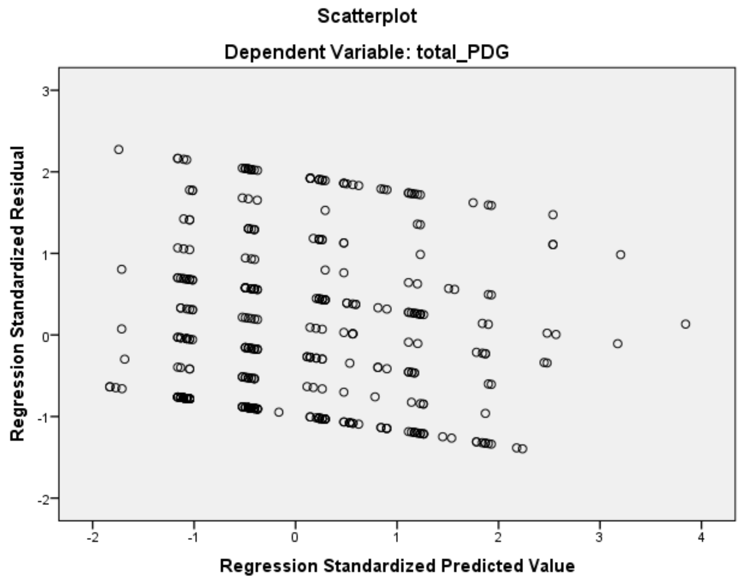


Figure J.2.3: Scatterplot of the standardized residuals for pre-implementation genetic diagnosis

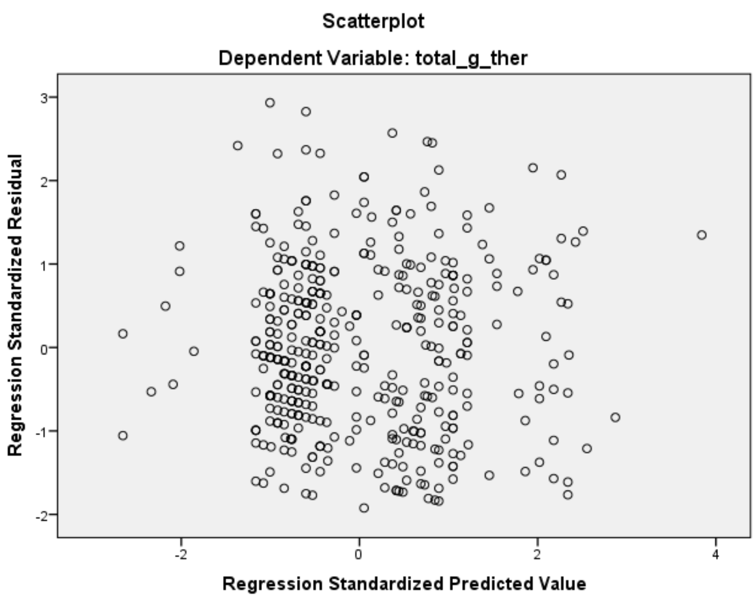


Figure J.3.6: Scatterplot of the standardized residuals for gene therapy

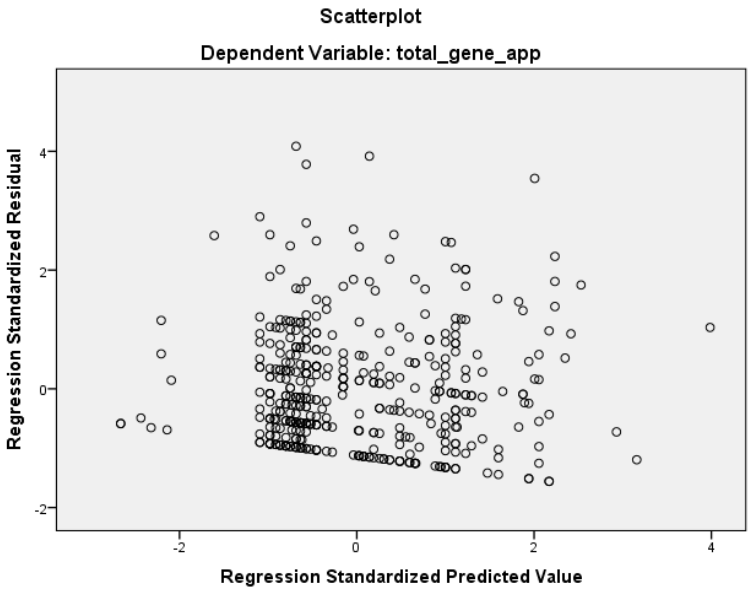


Figure J.3.7: Scatterplot of the standardized residuals for gene therapy applications

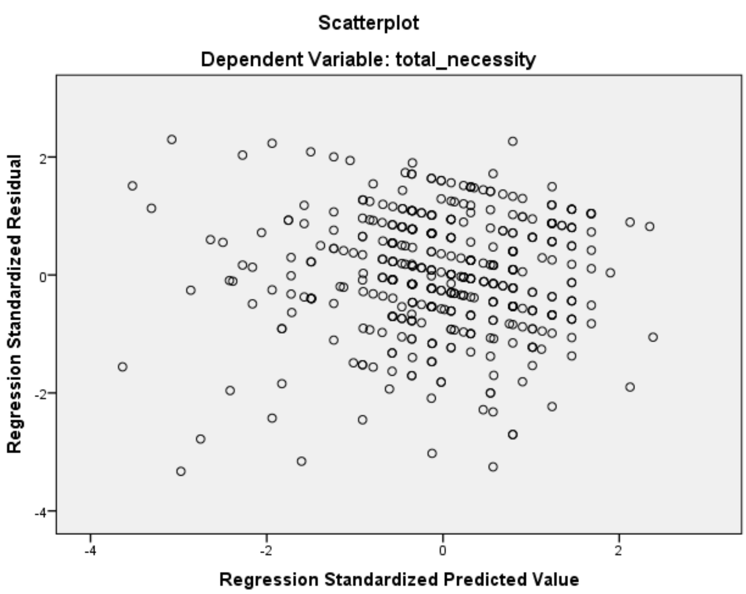


Figure J.3.8: Scatterplot of the standardized residuals for necessity of introducing genetics literacy issues

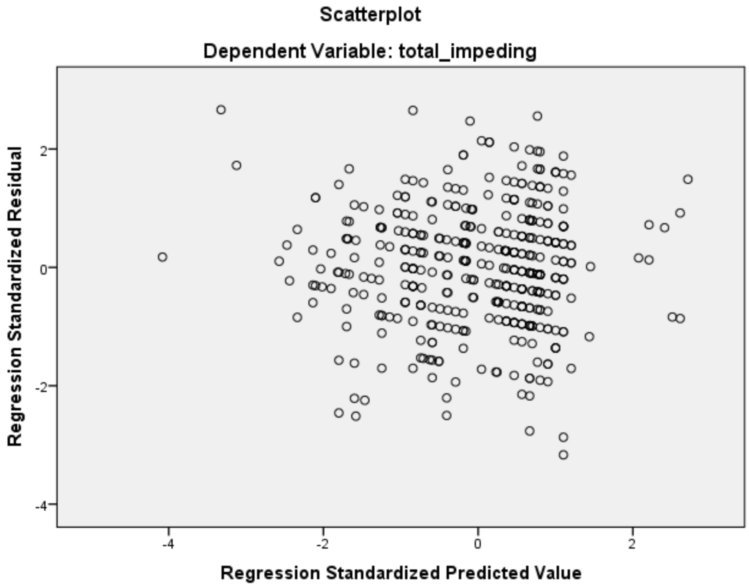


Figure J.3.9: Scatterplot of the standardized residuals for impeding factors

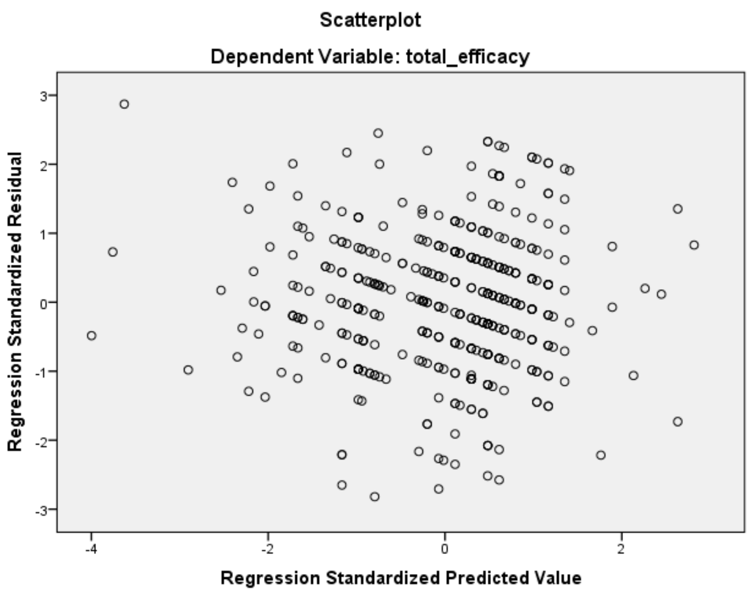


Figure J.3.10: Scatterplot of the standardized residuals for teachers' teaching efficacy beliefs regarding genetics literacy

APPENDIX K

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Cebesoy, Ümran Betül
Nationality: Turkish (TC)
Date and Place of Birth: 14 August 1985, Istanbul
Marital Status: Single
Phone: +90 312 210 4065
Fax: +90 312 210 7984
email: betulcebesoy@yahoo.com

EDUCATION

Degree	**Institution**	**Year of Graduation**
MS	Marmara University Elementary Science Education	2009
BS	Istanbul University Elementary Science Education	2007
High School	Bagcilar Super High School, Istanbul	2003

WORK EXPERIENCE

Year	**Place**	**Enrollment**
2010- Present	METU- Elementary Education	Research Assistant
2008-2010	Usak University- Elementary Science Education	Research Assistant

FOREIGN LANGUAGES

Advanced English

WORSHOPS

Participant of NWU-Essen Research Group & Graduate School Teaching & Learning Science Winter School (12-14 Feb, 2013), University of Duisburg Essen, Germany

Participant of Genetics Education for the 21st Century Workshop (14-16 March, 2013), Utrecht, Netherlands.

PROJECTS

Research Associate **-** Investigating Pre-Service Science Teachers' Genetic Literacy Levels and their attitudes towards Genetics Literacy (Jan 2012 - Dec 2012)

Research Associate **-**Investigating In-Service Science Teachers' Genetic Literacy Levels, attitudes towards genetics literacy issues and their perceptions of teaching genetics literacy (Jan 2013-Dec 2013)

PUBLICATIONS

Journal Article

Cebesoy, Ü. B. & Dönmez-Şahin, M. (2010). İlköğretim II. Kademe Fen ve Teknoloji Programının Çevre Eğitimi Açısından Karşılaştırmalı İncelenmesi [Comparison of elementary science curriculum in terms of environmental education], *BİBAD Biyoloji Bilimleri Araştırma Dergisi, 3*(2), 159-168.

Cebesoy, Ü. B., & Tekkaya, C. (2012). Pre-service science teachers' genetic literacy level and attitudes towards genetics. *Procedia - Social and Behavioral Sciences,* 31, 56-60.

Cebesoy, Ü. B., & Akinoglu, O. (2012). The effectiveness of elaboration and organizational strategies in science education on students' academic achievement, attitude and concept learning. *Energy Education Science and Technology Part B, 5(1),* 207-220.

Cebesoy, Ü. B., & Dönmez-Şahin, M. (2013). Fen Bilgisi Öğretmen Adaylarının Sosyobilimsel Konulara Yönelik Tutumlarının Çeşitli Değişkenler Açısından İncelenmesi. [Investigating pre-service science teachers' attitudes towards socioscientific issues in terms of gender and class level]. *Journal of Atatürk Education Faculty, 37,* 100-117.

Cebesoy, Ü. B. (2013). Pre-Service science teachers' perceptions of self-regulated learning in physics. *Turkish Journal of Education, 2*(1), 4-18.

Cebesoy, Ü. B., & Yeniterzi, B. (2014). Investigation of science and technology exam questions in terms of mathematical knowledge. *Procedia - Social and Behavioral Science,*116, 2711-2716

International Conference Papers

Cebesoy, Ü. B., & Dönmez-Şahin, M. (2009, September) *Fen bilimleri alanındaki öncü Türk bilim kadınları*. [Leading Turkish women scientist working in the field of science] International Multidisciplinary Women Congress, Izmir, Turkey

Dönmez Şahin, M., & **Cebesoy, Ü. B**. (2009, September) *Botanik (flora ve vejetasyon) alanında çalışan kadın bilim insanının karşılaştığı sorunlar.* [The problems of women scientists working in the field of botany (flora and vegetation)]. International Multidisciplinary Women Congress, Izmir, Turkey

Cebesoy, Ü. B. (2011, April). *Fen Eğitiminde Öğrenme Stratejilerinin Kullanımı.* [The usage of learning strategies in science education]. 2nd International Conference on New Trends in Education and Their Implications, Antalya, Turkey

Cebesoy, Ü. B., & Akınoğlu, O. (2011, April). *Fen Eğitiminde Kullanılan Anlamlandırma ve Örgütleme Stratejilerinin Öğrencilerin Akademik Başarılarına Etkisi* [The effectiveness of using Elaboration and organization strategies on students' academic achievement]. 2nd International Conference on New Trends in Education and Their Implications, Antalya, Turkey.

Güçyeter, Ş., & **Cebesoy, Ü. B.** (2011, July). *Investigation of Recent Research Studies in Gifted Education.* Excellence in Education 2011: Giftedness-Creativity-Development, Istanbul, Turkey

Cebesoy, Ü. B., & Akınoğlu, O. (2011, September). *The Comparative Effects of Elaboration and Organization Strategies on Students' Academic Achievement and Attitudes in Science Education.* World Conference on New Trends in Science Education (WCNTSE), Aydin, Turkey.

Cebesoy, Ü. B., & Tekkaya, C. (2011, September). *Identification of pre-service science teachers' genetics literacy level.* Paper presented at The World Conference of New Trends in Science Education (WCNTSE), Aydin, Turkey.

Cebesoy, Ü. B., & Tekkaya, C. (2011, October). *Pre-service science teachers' genetic literacy level and attitudes towards genetics.* Paper presented at World Conference on Learning, Teaching and Administration, Istanbul, Turkey.

Cebesoy, Ü. B. (2012, May). *Pre-Service Science Teachers' Perceptions of Self-Regulated Learning in Physics: Usak University Case.* Paper presented at IV. International Congress of Educational Research, Istanbul, Turkey

Cebesoy, Ü. B., & Tekkaya, C**.** (2012, September). *Are in-service science teachers genetically literate? Some preliminary findings*. Poster presented at Applied Education Congress (APPED), Ankara, Turkey.

Cebesoy, Ü. B., & Yeniterzi, B. (2013, February). *Investigation of Science and Technology Exam Questions in Terms of Mathematical Knowledge.* Paper presented at 5th World Conference on Educational Sciences, Rome, Italy.

Cebesoy, Ü. B. Öztekin-Tekkaya, C. (2013, March). *Genetics Literacy: Insights from Turkish Science Teachers' Knowledge, Attitude and Teaching Perceptions*. Poster presented at Genetics education for the 21st century workshop, Utrecht, Netherlands.

Yeniterzi, B., & **Cebesoy, Ü. B.** (2013, September). *Middle School Students' Mathematical Difficulties in Force and Motion Unit.* Paper presented at European Conference on Educational Research, Istanbul, Turkey.

Cebesoy, Ü. B. & Öztekin C. (2014, July). *Looking from Gender Perspective into Genetics Literacy: Pre-service Science Teachers in Turkey*. Paper presented at Twenty-First International Conference on Learning, New York, USA

National Conference Papers

Cebesoy, Ü. B. ve Dönmez-Şahin, M. (2009- October). *Ilköğretim II. kademe fen ve teknoloji programının çevre eğitimi açısından karşılaştırmalı incelenmesi,* [Investigating middle school science and technology curriculum in terms of environmental education]. IX. National Ecology and Environment Congress, Nevşehir, Turkey.

Cebesoy, Ü. B. & Dönmez-Şahin, M. (2010-September). I*lköğretim I. kademe fen ve teknoloji programının çevre eğitimi açısından karşılaştırmalı incelenmesi,* [Investigating primary school science and technology curriculum in terms of environmental education]. IX. National Science and Mathematics Education Congress, İzmir, Turkey.

Cebesoy, Ü. B., & Dönmez-Şahin, M**.** (2012, September). Fen bilgisi öğretmen adaylarının sosyobilimsel konulara yönelik tutumlarının çeşitli değişkenler açısından incelenmesi. [Investigating pre-service science teachers' attitudes towards socioscientific issues in terms of gender and class level]. 21. National Educational Sciences Congress, İstanbul, Turkey

MEMBERSHIP

Membership of European Science Education Research Association (ESERA)

AWARD S& SCHOLARSHIPS

Scholarship of the Scientific and Technological Research Council of Turkey (TUBITAK) for Master Degree, Turkey (2007-2009)

Scholarship of the Scientific and Technological Research Council of Turkey (TUBITAK) for PhD Degree, Turkey (2010-2014)

Scientific and Technological Research Council of Turkey (TUBITAK) Travel Award – 2014

Phd Graduate Scholar Award Winner of Twenty-First International Conference on Learning

HOBBIES

Swimming, Jogging, Calligraphy, Movies

APPENDIX L

TURKISH SUMMARY

1. Giriş

Bilimsel okuryazarlık düzeyinin arttırılması, fen eğitiminin önemli ve temel amaçları arasındadır (Bybee, 1997; National Research Council [NRC], 1996). Bilimsel okuryazar bireyler yetiştirilmesi Fen ve Teknoloji Öğretim Programının temel amaçları arasında yer almakla birlikte, "bilimsel ve teknolojik okuryazar bireylerin yetiştirilmesi" olarak programın vizyonunda da yer almaktadır (Milli Eğitim Bakanlığı [MEB], 2006; s. 5).

Yaşanan teknolojik gelişmeler, toplumu genetik biliminde ve genetik teknolojilerinde yaşanan yeniliklerle yüz yüze getirmektedir (Bowling ve ark., 2008; Jennings, 2004). Örneğin; genetik testler, genetiği değiştirilmiş gıdalar, pre-implemantayon genetik tanı, klonlama ve kök hücre çalışmaları, gene terapisi ve uygulamaları bireylerin günlük yaşantılarında sıklıkla karşılaştıkları durumlar haline gelmiştir (Klop & Severiens, 2007; Sadler, Amirshokoohi, Kezampouri ve Allspaw, 2006; Sadler & Zeidler, 2004; Sadler, 2004; Reis & Galvão, 2004; Sturgis, Cooper & Fife-Schaw, 2005). Bu konuların öneminin giderek artıyor olması, toplumun bilimsel gelişmeleri takip edebilecek ve anlayabilecek bilimsel okuryazar bireylere olan ihtiyacını da arttırmıştır. (Duncan, Rogat & Yarden, 2009; Tsui & Treagust, 2010). Bilimsel okuryazar bu bireyler, toplumdaki bu rollerinin yanında DNA ve gen gibi genetik yapıların hayatlarındaki işlevlerini de kavramışlardır (Miller, 1998; Tsui ve Treagust, 2010). Dolayısıyla genetik, bilimsel okuryazarlığın ayrılmaz bir parçası haline gelmiştir (Duncan et al., 2009; Tsui & Treagust, 2010). Klop, Severiens, Knippels, van Mil ve Ten Dam'a (2010) göre, bilimsel okuryazar bireyler; genetik ile ilgili doğru temel bilgilere sahip olmalarının yanı sıra genetik uygulamaları konusundaki davranış ve kararlarında net fikirlere sahiptir. Klop ve arkadaşlarının (2010) vurguladığı üzere bireylerin günlük hayatlarında karşılaştıkları genetik uygulamaları hakkında bilgi sahibi olmaları ve karar verme süreçlerine aktif olarak katılmaları, onların genetik okuryazarı olmalarını gerektirmektedir. Genetik okuryazarı bireyler, genetik ile ilgili konularda kişisel sağlıkları için gerekli kararlar konusunda yeterli bilgiye ve genetikle ilgili karar verme süreçlerinde aktif bir şekilde rol almaları için gerekli bilgi donanımına sahiptir (Bowling et al., 2008). Geleceğin toplumunu oluşturacak genetik okuryazar bireylerin yetiştirilmesi ve öğrencilerin genetik okuryazarlık düzeylerinin arttırılması için öğretmenlerin genetik okuryazar olması gerekmektedir. Bunun yanı sıra öğretmenlerin genetik okuryazarlığa yönelik tutumları ve genetik okuryazarlığın öğretimine yönelik algıları da, genetik okuryazar bireylerin yetiştirilmesi ve öğrencilerin genetik okuryazarlık düzeylerinin arttırılmasında etkilidir.

Genetik okuryazarlık kavramı dünyada ve ülkemizde yeni gelişen bir çalışma alanıdır ve dolayısıyla bu alanda yapılan çalışma sayısı azdır (Acra, 2006; Bowling, 2007; Bowling et al., 2008; Cebesoy & Tekkaya, 2011a, 2011b, 2012; ve Moskalik, 2007). Bu çalışmada öngörülen genetik okuryazarlık ölçme envanteri, genetik okuryazarlık konularına yönelik tutum ölçeği ve öğretmenlerin genetik okuryazarlık konularını öğretimine yönelik algılarını belirlemeye yönelik bu denli kapsamlı bir çalışma ilgili literatürde bulunmamaktadır. Alanda var olan bu eksikliği gidermek adına gerçekleştirilen bu çalışmada, aşağıdaki sorulara cevap aranmıştır:

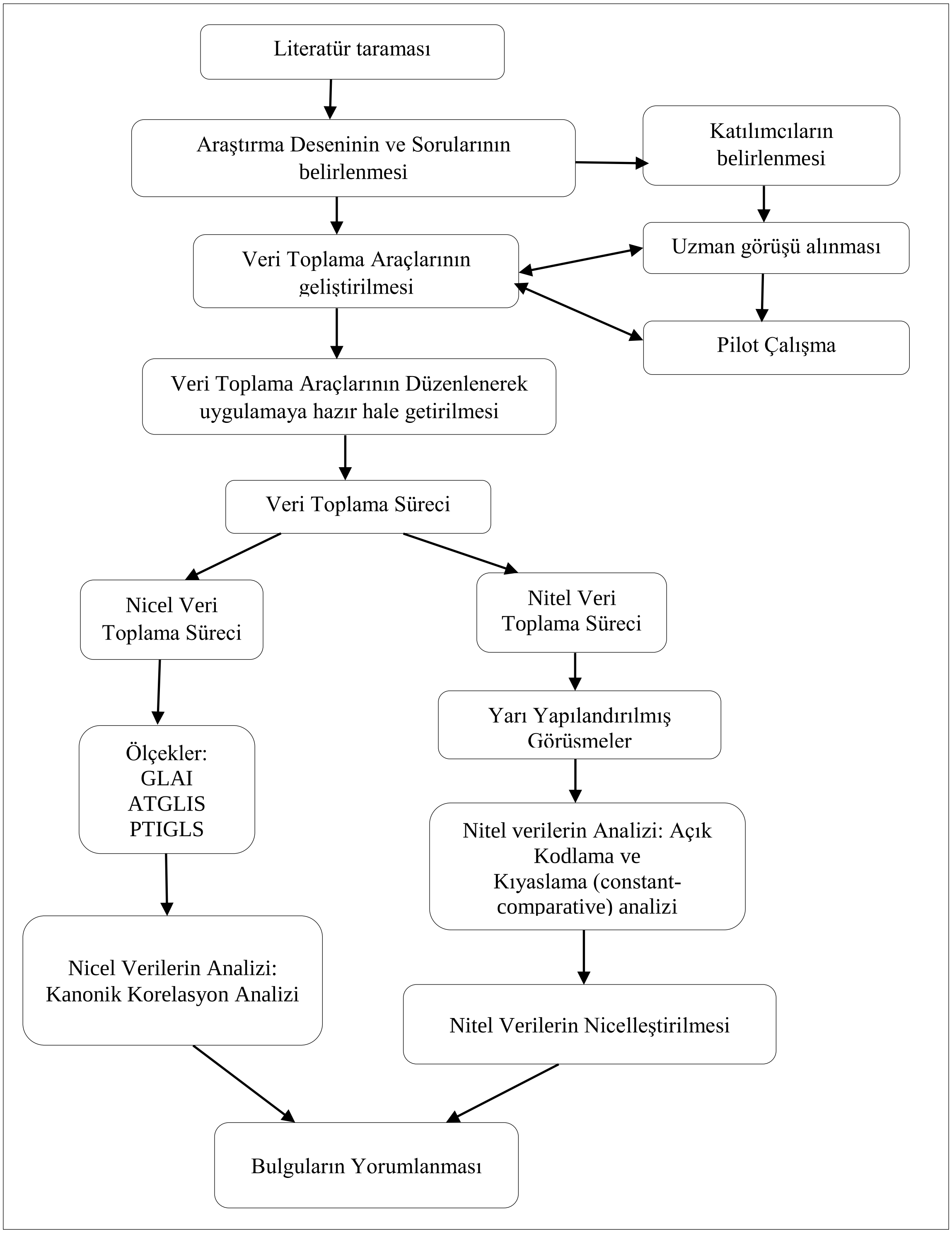
1. Fen bilimleri öğretmenlerinin genetik okuryazarlık düzeylerinin, genetik okuryazarlık konularına yönelik tutumlarının ve genetik okuryazarlık öğretimine yönelik algıları nelerdir?
2. Fen bilimleri öğretmenlerinin genetik okuryazarlık düzeyleri, genetik okuryazarlık konularına yönelik tutumları ve genetik okuryazarlık öğretimine yönelik algıları ile çeşitli demografik bilgileri (cinsiyet, mesleki deneyim, mezun olunan bölüm, genetik okuryazarlığa yönelik ilgi ve genetik okuryazarlığın öğrenildiği bilgi kaynakları) arasında nasıl bir ilişki vardır?
3. Fen bilimleri öğretmenlerinin, çeşitli genetik okuryazarlık konularında karar verme süreçlerini etkileyen faktörler nelerdir?

Bu çalışmada elde edilecek sonuçların; fen bilimleri öğretmenlerinin genetik okuryazarlık seviyelerinin, genetik okuryazarlığa yönelik tutumlarının ve genetik okuryazarlık öğretimine yönelik algılarının ve genetik okuryazarlığa etki eden faktörlerin belirlenmesine yardımcı olacağı öngörülmektedir. Yine gerçekleştirilecek yarı yapılandırılmış mülakatlar ile öğretmenlerin genetik okuryazarlık ile ilgili hazırlanan farklı örnek olaylarda kullandıkları karar verme süreçlerini etkileyen faktörler incelenecektir. Ayrıca sonuçların, genetik okuryazar öğretmen yetiştirilmesi konusunda mevcut hizmet içi eğitim programlarının etkililiği hakkında fikir vereceği umulmaktadır.

2. Yöntem

Bu araştırmada, karma araştırma yöntemlerinden *sıralı açıklayıcı tasarım* kullanılmıştır. Bu tasarıma göre, önce nicel verilerini toplanması gerçekleştirilmiştir. Bunun devamında ise nitel veriler toplanmıştır (Creswell & Plano-Clark, 2011; Fraenkel et al., 2011).

Araştırmanın deseni ve araştırma sürecine ait basamaklar Şekil 1'de sunulmuştur:



Şekil 1: Araştırmanın deseni ve araştırma sürecine genel bakış

3. Örneklem

Bu araştırmanın nicel kısmının örneklemini, Ankara'ya bağlı merkez ilçelerde (Çankaya, Keçiören, Mamak, Etimesgut, Sincan) görev yapmakta olan 435 fen bilimleri öğretmenleri oluşturmaktadır.

ODTU Etik Kurulu, Milli Eğitim Bakanlığı ve Ankara İl Milli Eğitim Müdürlüğü'nden gerekli izinler alınarak Ankara genelinde 200 ilk ve ortaokulu araştırmacı tarafından gidilmiştir. Araştırmanın nicel kısmına, 435 fen ve teknoloji öğretmeni katılmıştır. Araştırmaya katılan öğretmenlerin 324'ü (%74.5) bayan ve 111'ini ise erkek katılımcılar oluşturmaktadır (%25.5). Araştırmaya katılan öğretmenlerin demografik özellikleri (öğretmenlik deneyimi mezun olunan branş ve mezun olunan fakülte) Tablo 1'de sunulmuştur:

Tablo 1:

Araştırmaya katılan fen bilimleri öğretmenlerinin demografik özellikleri

Demografik özellik		N	Yüzde (%)
	1 yıldan daha az	43	9.9
	1-5 yıl	106	24.4
Öğretmenlik Deneyimi	6-10 yıl	91	20.9
	11-15 yıl	69	15.9
	16-20 yıl	64	14.7
	20 yıldan daha fazla	60	14.2
	Fen bilimleri öğretmeni	327	75.2
	Biyoloji öğretmeni	63	14.5
Branş	Fizik öğretmeni	13	3.0
	Kimya öğretmeni	32	7.3
	Eğitim Fakültesi	300	69.0
Mezun olunan fakülte	Fen-Edebiyat Fakültesi	109	25.1
	Eğitim Enstitüsü (3 yıl)	24	5.5
	Mühendislik Fakültesi	2	0.4

Tablo 1 incelendiğinde, araştırmaya katılan öğretmenlerin nerdeyse yarısının 1-10 yıl arası mesleki deneyime sahip olduğu görülmektedir. Öğretmenlerin %15.9'u 11-15 yıl arası mesleki deneyime sahipken, %14.7'si ise 16-20 yıl arası mesleki deneyime sahiptir. Katılımcıları %9.9'unu oluşturan 43 öğretmen ise 1 yıldan daha az öğretmenlik deneyimine sahiptir. Bununla birlikte, katılımcıların %14.2'si ise 20 yıldan daha fazla öğretmenlik deneyimine sahiptir. Araştırmaya katılan öğretmenlerin branşlara göre dağılımları incelendiğinde, katılımcı öğretmenlerin büyük bir çoğunluğunun (%75.2) fen bilimleri öğretmeni olduğu görülmektedir. Bunun yanı sıra, katılımcılardan bir kısmının fizik, kimya ve biyoloji öğretmeni olduğu görülmüştür. Katılımcıların mezun olunan fakültelere göre dağılımı incelendiğinde katılımcıların büyük çoğunluğunun (%69) Eğitim Fakültesi mezunu oldukları ve %25.1'inin ise Fen-Edebiyat Fakültesi mezunu olduğu görülmektedir. Bununla birlikte katılımcıların %5.5'inin ise 1973 yılında açılan ve 1989 yılındaki yasa değişikliği ile Eğitim Fakültesi bünyesine dahil edilen Eğitim Enstitüsü'nü bitirdikleri görülmüştür (Çakıroğlu & Çakıroğlu, 2003; Gürşimsek, Kaptan, & Erkan, 1997). Sadece 2 öğretmen, Mühendislik Fakültesi mezunu olduğunu belirtmiştir.

Araştırmanın **nitel kısmında** ise gidilen okullardaki öğretmenler ile mesleki deneyim ve gönüllülük esasına dayalı olarak yarı yapılandırılmış görüşmeler gerçekleştirilmiştir. Bu görüşmeler, 45-70 dakika arasında sürmüş, öğretmenin bilgisi dahilinde ses kaydına alınmıştır. Yarı yapılandırılmış görüşmelere katılan fen ve teknoloji öğretmenlerinin 13 tanesi bayan (%72.3) ve 5 tanesi ise erkektir (%27.7).

Öğretmenler mesleki deneyimlerine göre 3 gruba (1-4 yıl arasında mesleki deneyime sahip öğretmenler, 5-9 yıl arasında mesleki deneyime sahip öğretmenler ve 10 yıldan fazla mesleki deneyime sahip öğretmenler) ayrılmıştır. Katılımcıların mesleki deneyimlerine göre dağılımları Tablo 2'de sunulmuştur:

Tablo 2:

Yarı-yapılandırılmış görüşmelere katılan öğretmenlerin mesleki deneyimlerine göre sınıflandırılması

Gruplar	Mesleki deneyim (yıl)
2-5 yıl arası deneyimi olan öğretmenler	5
6-10 yıl deneyimi olan öğretmenler	8
10 yıldan fazla deneyimi olan öğretmenler	5

4. Veri toplama Araçları

Bu araştırma ile öğretmenlerin genetik okuryazarlık düzeyleri, genetik okuryazarlığa yönelik tutumları ve genetik okuryazarlık öğretimine yönelik algıları belirlenmesi ve genetik okuryazarlığa etki eden faktörlerin incelenmesi (cinsiyet, mesleki deneyim, mezun olunan bölüm, genetik okuryazarlığa yönelik ilgi ve genetik okuryazarlığın öğrenildiği bilgi kaynakları) hedeflenmektedir. Bunula birlikte, öğretmenlerin genetik okuryazarlık ile ilgili farklı konularda karar verme süreçlerini etkileyen faktörler incelenmesi amaçlanmaktadır. Bu amaçla aşağıdaki ölçme araçları kullanılmıştır:

1. Kişisel Bilgi Formu
2. Genetik Okuryazarlık Ölçme Envanteri
3. Genetik Okuryazarlığa Yönelik Tutum Ölçeği
4. Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği
5. Genetik Okuryazarlık Konularına yönelik geliştirilen görüşme soruları

Çalışmanın gerçekleştirilmesi için ODTU Etik Kurul izni alındıktan sonra Milli Eğitim Bakanlığı ve Ankara İl Milli Eğitim Müdürlüğü'nden gerekli izinler alınmıştır.

4.1. *Kişisel Bilgi Formu*

Araştırmanın katılacak öğretmen adaylarının demografik özelliklerini belirlemek üzere "Kişisel Bilgi Formu" hazırlanmıştır. Bu form, öğretmen adaylarının cinsiyet, mesleki deneyim, mezun olunan bölüm, pedagojik formasyon alıp almadığının belirlenmesine yönelik maddeler; genetiğe olan ilgi ve bilgisini belirlemeye yönelik çeşitli bilgiler ve genetik okuryazarlık kaynakları ile ilgili bilgiler içermektedir.

4.2. Genetik Okuryazarlık Ölçme Envanteri

Bu ölçek, lisans öğrencilerinin genetik okuryazarlık düzeylerini belirlemek üzere Bowling ve arkadaşları (2008) tarafından geliştirilmiş olup, 31 madde ve 6 boyuttan oluşmaktadır. Bu boyutlar; Tablo 3'de sunulmuştur:

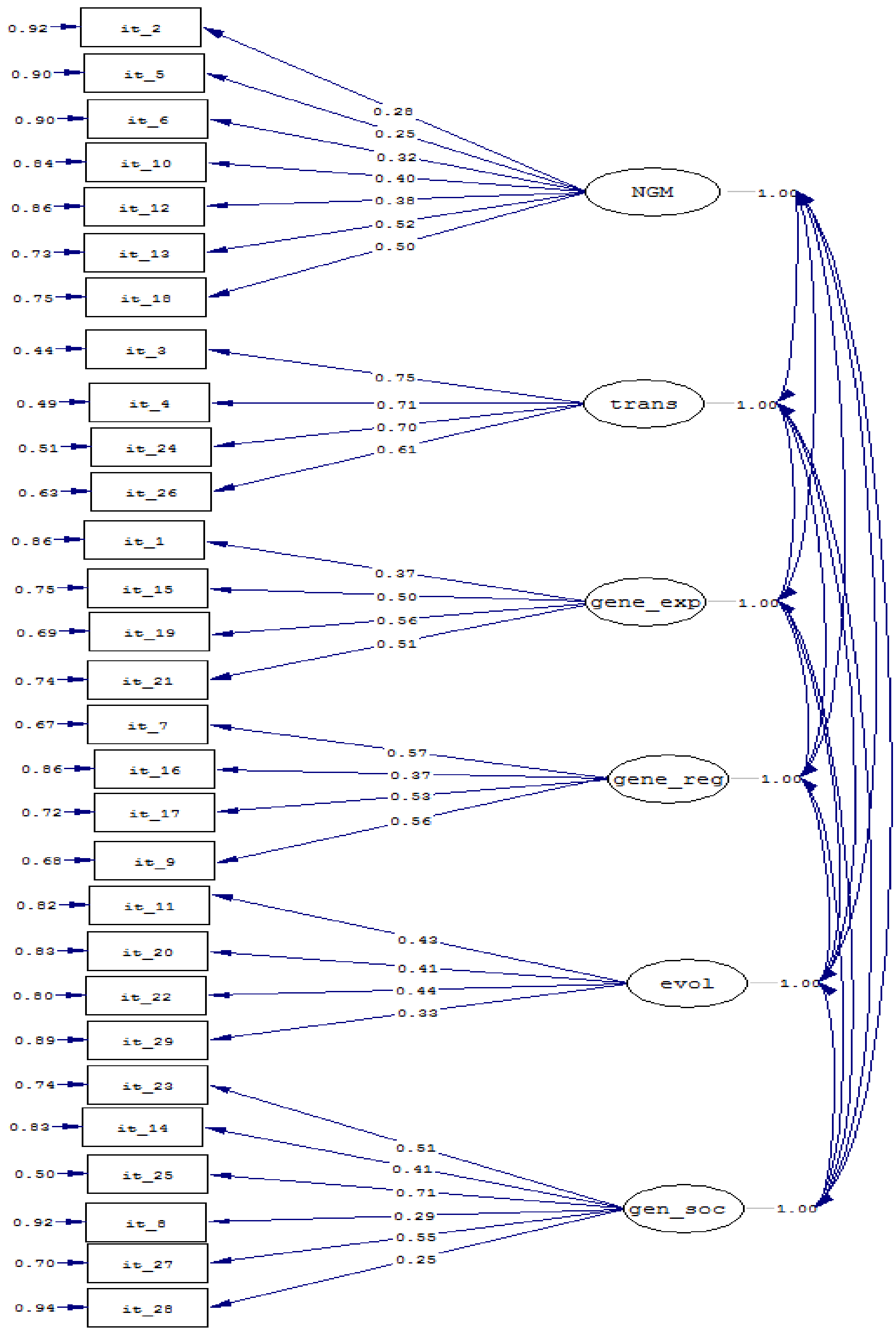
Tablo 3:

Genetik Okuryazarlık Ölçme Envanteri'nin boyutları ve boyutlarda bulunan madde sayıları

Boyutlar	Madde Sayısı
Genetik Maddenin Yapısı	8
Transmisyon	4
Gen ekspresyonu	6
Gen regülasyonu	4
Evrim	3
Genetik ve Toplum	6

Genetik Okuryazarlık Ölçme Envanterini Türkçeye uyarlama ve adaptasyon çalışması, Cebesoy ve Tekkaya (2011a) tarafından başlatılmıştır. Türk kültürüne uygun olmayan maddeler çıkarılarak Türkiye'de 2006 yılında yürürlüğe giren İnsan Hakları ve Biyotıp Sözleşmesine yönelik 2 madde eklenmiştir. Böylelikle oluşturulan "Genetik ve Toplum" boyutunda 8 madde bulunmaktadır. Bunun yanı sıra Rutledge ve Warden (2000) tarafından geliştirilen ve Deniz, Donnelly ve Yılmaz (2008) tarafından Türkçeye uyarlanan Evrim Kavram Testi'nden 4 madde "Evrim" boyutuna eklenmiştir. Böylelikle elde edilen Genetik Okuryazarlık Ölçme Envanteri'nde 36 madde bulunmaktadır. Türkçeye uyarlama ve adaptasyon çalışması yapılan Genetik Okuryazarlık Ölçme Envanterinin geçerlik - güvenilirlik çalışmaları 95 fen bilimleri öğretmeni ile gerçekleştirilmiştir. Yapılan ITEMAN analizi sonucunda madde ayırt edicilik indeksi düşük olan 5 maddenin D1= 0.10, D3=0.11, D4=0.04, D21=0.11 and D34=0.13) ölçekten çıkarılmasına karar verilmiştir. 31 maddelik ölçeğin ortalama ayırt edicilik indeksinin 0.33 olduğu ve iyi sorulardan oluştuğu görülmüştür. Ayrıca, bu ölçeğin ortalama güçlük indeksinin ise 0.55 olduğu ve ortalama güçlükte bir test olduğu sonucuna ulaşılmıştır. 31 maddelik ölçeğin Cronbach alpha içgüvenilirlik katsayısı 0.70 olarak bulunmuştur. 31 maddelik ölçek, daha sonra, 435 fen bilimleri öğretmenine uygulanmış olup, edilen veriler, doğrulayıcı faktör analizi yöntemiyle incelenmiştir. Yapılan analizler sonucunda, Evrim altboyutunda yer alan 30 ve 31. maddelerin standart madde yüklerinin çok düşük olduğu görülmüştür (30. madde için 0.00 ve 31.madde için 0.09). Bu maddelerin analizden çıkarılmasının model-veri uyumunu arttırılacağı umulmuştur. 29 maddelik ölçekle yapılan doğrulayıcı faktör analizi sonucunda, Ki-kare uyum indeksi değerinin anlamlı bulunmuştur ($p<.05$). Ancak birden fazla parametre söz konusu olduğu için Ki-kare değerinin serbestlik derecesine olan bağımlılığını düzeltmek amacıyla Kline (1998)'in önerdiği düzeltme kullanılmıştır. Buna göre Ki-kare değerinin serbestlik derecesine bölündüğünde, elde edilen sonuç (χ^2/df) model-veri uyumuna işaret etmektedir. Bu değerin 3'ten küçük olması mükemmel model-veri uyumuna işaret etmektedir. 2 maddenin çıkarılmasıyla elde edilen 29 maddelik ölçeğin, χ^2/df değeri 1,38 olarak bulunmuştur. Model-veri uyumuna ilişkin değerlerin tamamı dikkate alındığında (RMSEA= .03, CFI= .98, SRMR= .80, and GFI= .95), kurulan modelin veriyle iyi uyum gösterdiği, bu nedenle ölçeğin yapısal geçerliğe sahip olduğu sonucuna ulaşılmıştır.

29 maddelik Genetik Okuryazarlık Ölçme Envanteri'ne ilişkin doğrulayıcı faktör analizi diyagramı şekil 2'de sunulmuştur:



Şekil 2: 29 maddelik Genetik Okuryazarlık Ölçme Envanterine ait Model-Veri Uyum Diyagramı

4.3. Genetik Okuryazarlık Konularına Yönelik Tutum Ölçeği

Genetik Okuryazarlığa Yönelik Tutum Ölçeği “British Social Attitude Survey” (2000) ve “Wellcome Trust Consultive Panel on Gene Therapy” (1999) ölçeklerinden alınan maddeler ile oluşturulmuştur. Genetik uygulamalarına yönelik bu maddelerin dağılımı şu şekildedir:

Tablo 4:

Genetik Okuryazarlığa Yönelik Tutum Ölçeği ve alındığı orijinal ölçeğe göre madde sayıları

Genetik Okuryazarlık Konularına Yönelik Tutum Ölçeği Altboyutları	Alındığı orijinal ölçek	Madde Sayısı	Likert Tipi
Genel tutum maddeleri	British Social Attitude Survey Wellcome Trust Consultive Panel on Gene Therapy	19	5’li
Genetik Bilginin kullanılması	British Social Attitude Survey	4	5’li
Kürtaj	British Social Attitude Survey	4	3’lü
Pre-İmplementasyon Genetik Tanı	British Social Attitude Survey	4	3’lü
Gen Terapisi	British Social Attitude Survey	10	4’lü
Gen Terapisi Uygulamaları	Wellcome Trust Consultive Panel on Gene Therapy	9	5’li

Genetik Okuryazarlığa Yönelik Tutum Ölçeği toplam 50 madde içermektedir çoklu Likert tipinde farklı altboyutlardan oluşmaktadır. “Genel tutum” ve “genetik bilginin kullanılması” altboyutları 5’li Likert tipinde olup 1 ‘kesinlikle katılmıyorum’ ve 5 ‘kesinlikle katılıyorum’ şeklinde kodlanırken; “Kürtaj” ve “Pre-implementasyon Genetik Tanı” altboyutları 3’lü Likert tipi maddelerden oluşmakta olup, 1 ‘her zaman doğrudur’ ve 3 ‘hiçbir zaman doğru değildir’ şeklinde kodlanmıştır. “Gen terapisi” altboyutu 4’lü Likert tipinde olup, 1 ‘kesinlikle izin verilmeli’ ve 4 ‘kesinlikle izin verilmemeli’ şeklide kodlanmıştır. Bununla birlikte “Gen Terapisi Uygulamaları” altboyutu ise 5’li Likert tipi maddelerden oluşmaktadır ve "'kesinlikle izin verilmeli' ve 4 'kesinlikle izin verilmemeli' şeklinde kodlanmıştır. Buna ek olarak 5 'karar verebilmem için daha fazla bilgi gereklidir' şeklinde kodlanmıştır.

Yapılan pilot çalışma sonucunda elde edilen verilerin analizi, ölçeğin altboyutlarının içgüvenilirlik katsayılarının .77- .95 arasında olduğu göstermektedir (Bak. Tablo 5).

Tablo 5:

Genetik Okuryazarlığa Yönelik Tutum Ölçeği'ne ilişkin iç güvenilirlik katsayıları

Genetik Okuryazarlık Konularına Yönelik Tutum Ölçeği Altboyutları	İç güvenilirlik katsayıları (α)
Genel tutum maddeleri	0.77
Genetik Bilginin kullanılması	0.75
Kürtaj	0.84
Pre-İmplementasyon Genetik Tanı	0.86
Gen Terapisi	0.89
Gen Terapisi Uygulamaları	0.90

Daha sonra, 435 fen bilimleri öğretmeni ile gerçekleştirilen asıl uygulama sonucunda elde edilen veriler, doğrulayıcı faktör analizi yardımıyla incelenmiştir. Her bir boyut farklı Likert tipi maddelerden oluştuğu için her bir boyut için ayrı doğrulayıcı faktör analizi gerçekleştirilmiş olup, model-veri uyumuna ilişkin değerler incelenmiştir. Model-veri uyumuna ilişkin değerlerin tamamı dikkate alındığında, her bir boyut için kurulan modelin veriyle kabule edilebilir bir uyum gösterdiği, bu nedenle ölçeğin yapısal geçerliğe sahip olduğu bulgusuna ulaşılmıştır.

4.4. Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği

Fen bilimleri öğretmenlerinin genetik okuryazarlık öğretimine yönelik algılarını ölçmek amacıyla Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği kullanılacaktır. Bu ölçek, daha önce Lee, Abd-El Khalick ve Choi (2006), Pedretti, Bencze, Hewitt, Romkey ve Jivraj (2008) ve Riggs ve Enochs (1990) tarafından geliştirilen ölçeklerden yararlanılarak geliştirilmiş olup, 5'li Likert tipte 20 maddeden oluşmaktadır. Yapılan Açımlayıcı faktör analizi sonucunda 3 maddenin ölçekten çıkarılmasına karar verilmiştir ve 17 madde 3 alt boyutta toplanmıştır. Açımlayıcı faktör analizi sonuçları, Tablo 6'da sunulmuştur:

Tablo 6:

Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği Altboyutlarının Açımlayıcı Faktör Analizi Sonuçları

Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği Altboyutları	Madde no	Faktör 1	Faktör 2	Faktör 3
Öğretmenlerin genetik okuryazarlık konularına fen müfredatında yer verilmesinin gerekliliğine yönelik algıları	1	.831		
	4	.840		
	6	.813		
	9	.466		
	11	.694		
	17	.657		
	18	.508		
	20	.615		
Öğretmenlerin genetik okuryazarlık konularına fen müfredatında yer verilmesini engelleyen faktörlere yönelik algıları	7		.750	
	8		.708	
	10		.627	
	14		.534	
	15		.784	
Öğretmenlerin genetik okuryazarlık öğretimine yönelik özyeterlik algıları	3			.417
	12			.486
	13			.663
	16			.592
Eigen Değerleri		6.53	2.18	1.70
Açıklanan varyans		32.64	10.90	8.43

Daha sonra, ölçeğin altboyutlarının iç güvenilirlik katsayıları (Cronbach α) hesaplanmıştır ve Tablo 7'de sunulmuştur:

Tablo 7:

Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği Altboyutlarının İç güvenilirlik katsayıları

Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği Altboyutları	Madde sayıları	İç güvenilirlik katsayıları (α)
Öğretmenlerin genetik okuryazarlık konularına fen müfredatında yer verilmesinin gerekliliğine yönelik algıları	8	0.85
Öğretmenlerin genetik okuryazarlık konularına fen müfredatında yer verilmesini engelleyen faktörlere yönelik algıları	5	0.78
Öğretmenlerin genetik okuryazarlık öğretimine yönelik özyeterlik algıları	4	0.77

Yapılan pilot çalışma sonucunda elde edilen verilerin analizi, ölçeğin altboyutlarının içgüvenilirlik katsayılarının .77- .85 arasında olduğu göstermektedir. Asıl çalışmada elde edilen veriler, doğrulayıcı faktör analizi yöntemiyle incelenmiştir. Ki-kare uyum indeksi değerinin anlamlı bulunmuştur ($p<.05$). Ancak birden fazla parametre söz konusu olduğu için Ki-kare değerinin serbestlik derecesine olan bağımlılığını düzeltmek amacıyla Kline (1998)'in önerdiği düzeltme kullanılmıştır. Buna göre Ki-kare değerinin serbestlik derecesine bölündüğünde, elde edilen sonuç (χ^2/df) model-veri uyumuna işaret etmektedir. Bu değerin 3'ten küçük olması mükemmel model-veri uyumuna işaret etmektedir. Araştırmada χ^2/df değeri 3.65 olarak bulunmuştur. Model-veri uyumuna ilişkin değerlerin tamamı dikkate alındığında indices (RMSEA= .078, CFI= .90, SRMR= .64, and GFI= .90), kurulan modelin veriyle kabul edilebilir uyum gösterdiği, bu nedenle ölçeğin yapısal geçerliğe sahip olduğu sonucuna ulaşılmıştır.

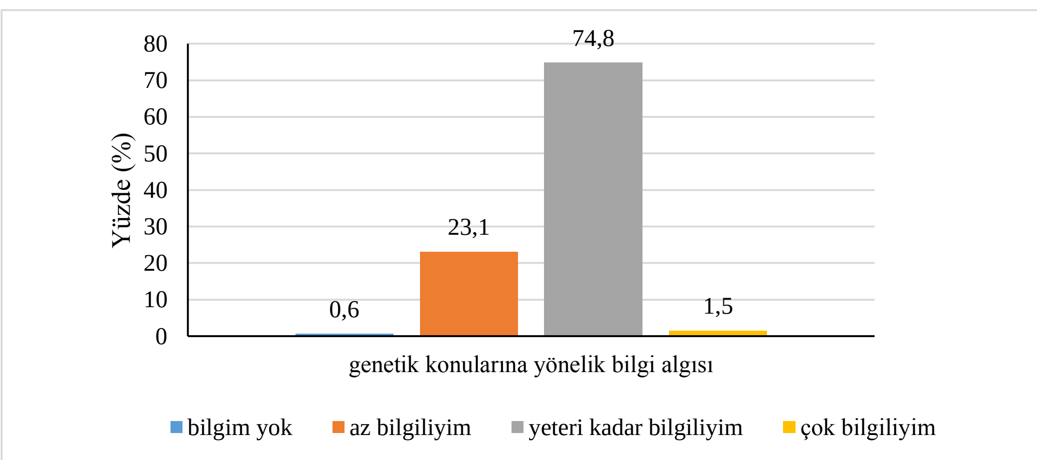
4.5. Genetik Okuryazarlık Konuları ile ilgili görüşme soruları

Araştırmada, fen bilimleri öğretmenlerinin genetik okuryazarlıkla ilgili çeşitli konularda karar verme süreçlerini ve bu süreçlere etki eden faktörleri belirlemek üzere yarı-yapılandırılmış mülakatlar geçekleştirilmiştir. Bu amaçla, gönüllük esasına dayanarak çalışamaya katılan fen bilimleri öğretmenleri belirlenmiş olup, daha önceden hazırlanan ve pilot uygulaması yapılan 4 farklı örnek olay kullanılmıştır. Örnek olayların hazırlanmasında, Bell ve Lederman (1999), Sadler ve Zeidler (2004) ve Zohar ve Nemet'in (2002) geliştirdikleri örnek olaylardan yararlanılmıştır. Öğretmenlerin seçilmesinde mesleki deneyim ölçütü ve gönüllülük kriteri göz önünde bulundurulmuştur.

5. Bulgular

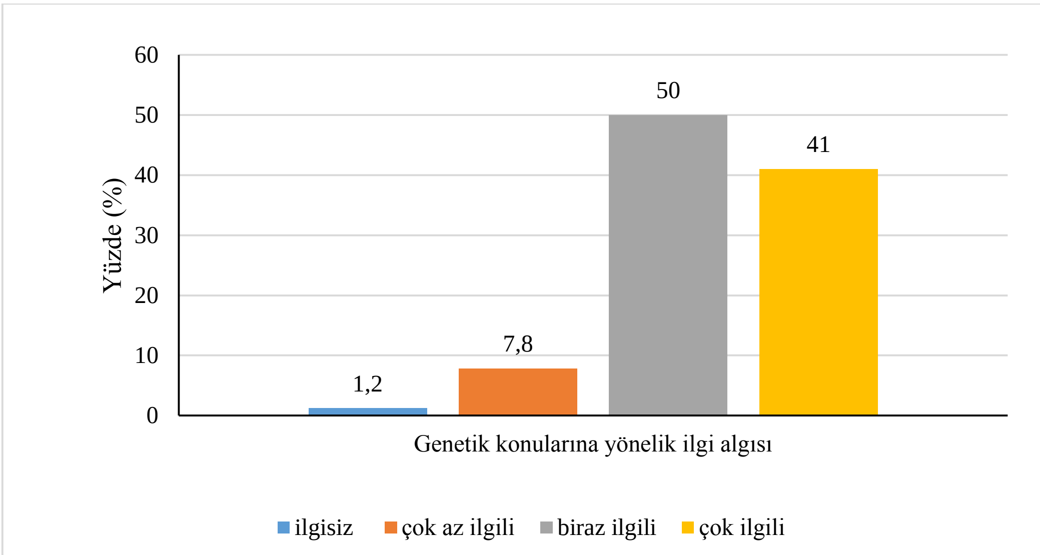
5.1.Öğretmenlerin Demografik verilerine İlişkin Bulgular

Bu bölümde, araştırmaya katılan öğretmenlerin genetik konularına yönelik ilgi ve bilgilerine ait bulgular ve genetik okuryazarlık kaynakları hakkında hangi kaynaklardan bilgi edindiklerine yönelik bulgular sunulmuştur. Öğretmenlerin genetik konularında ne kadar bilgili olduklarına yönelik verdikleri cevaplar incelendiğinde, öğretmenlerin büyük bir kısmı (%75) kendilerinin genetik konusunda "yeteri kadar" bilgili olduklarını ifade ederken, %23'ü ise kendilerinin "biraz" bilgili olduklarını belirtmiştir. Öğretmenlerin sadece %1.5'i kendilerini "çok bilgili" olarak nitelendirirken %0.6'sı ise kendilerini "bilgim yok" şeklinde ifade etmişlerdir (Bak. Şekil 3).



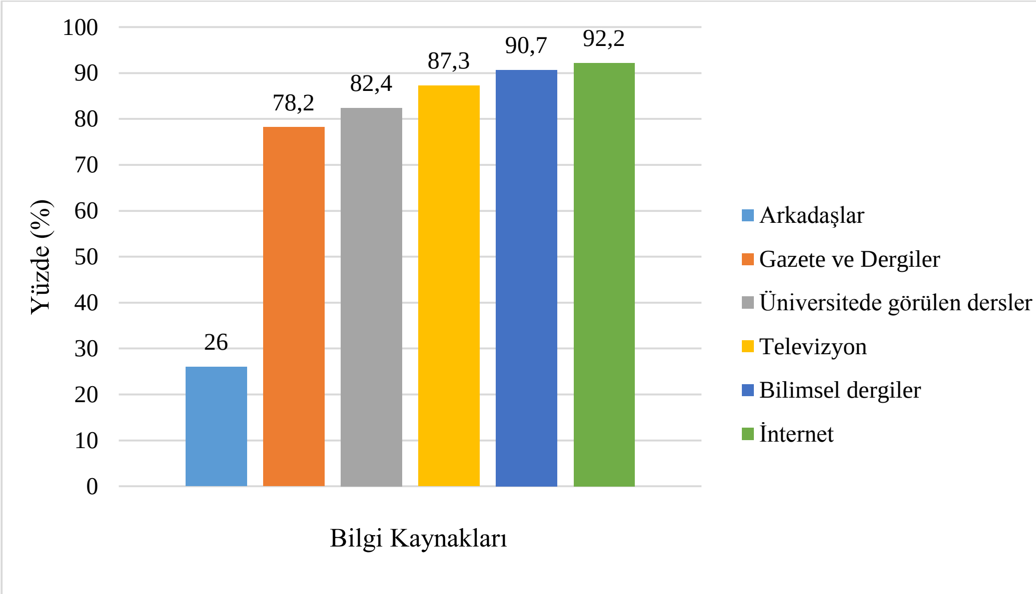
Şekil 3. Fen bilimleri öğretmenlerinin genetik konularına yönelik ilgilerini gösteren frekans değerleri

Öğretmenlere genetik okuryazarlık konuları ile ne kadar ilgili oldukları sorulduğunda, katılımcıların yarısı (50%) "biraz ilgili" olduklarını belirtirken %14'ü ise "çok ilgili" olduklarını ifade etmişlerdir. Bununla birlikte, öğretmenlerin %7.8'i "çok az ilgili" oldukları ifade ederken sadece %1.2'si kendilerini genetik konularına "ilgisiz" olarak tanımlamışlardır (bk. Şekil 4).



Şekil 4. Fen bilimleri öğretmenlerinin genetik konularına yönelik bilgi düzeylerini gösteren frekans değerleri

Öğretmenlerin genetik okuryazarlık konularına ait bilgi kaynakları incelendiğinde, öğretmenlerin bu bilgileri, sırasıyla internetten (%92.2), bilimsel dergilerden (%90.7), televizyondan (%87.3) ve üniversite derslerinden (%82.4), gazete-dergilerden (%78.2) elde ettiği ve arkadaşlarından (%26) öğrendiği görülmüştür (Bak. Şekil 5).



Şekil 5: Fen Bilimleri Öğretmenlerinin Bilgi Kaynakları

5.2. Fen Bilimleri Öğretmenlerinin Genetik Okuryazarlık Düzeyleri

Çalışmaya katılan öğretmenlerin 29 maddelik ölçekte yer alan soruların yaklaşık yarısına doğru cevap verdikleri (*M*=14.54, *SS*=4.06) görülmüştür. Buna dayanılarak, çalışmaya katılan öğretmenlerin genetik okuryazarlık düzeylerinin orta seviyede olduğu sonucuna ulaşılmıştır.

5.3.Fen Bilimleri Öğretmenlerinin Çeşitli Genetik Okuryazarlık Konularındaki Tutumları

Fen bilimleri öğretmenlerinin Genetik Okuryazarlık Konularına Yönelik Tutum Ölçeğinin altboyutlarına verilen cevaplar incelendiğinde, öğretmenlerin genel tutum altboyutunda yer alan maddeler hakkında genellikle kararsız kaldıkları görülmüştür (*M*=3.28, *SS*=0.40). Örneğin; bu boyutta yer alan maddelere katılımcıların verdikleri cevaplar incelendiğinde, katılımcıların yarıya yakının bireyin genlerinin değiştirilmesi konusunda kararsız oldukları (%40) oldukları görülmüştür. Yine katılımcılar, yapılan genetik araştırmaların insanlığa yarar mı zarar mı getireceği konusunda ve genlere yapılan müdahaleler konusunda kararsız kalmışlardır (sırasıyla %30 ve %28.5). Benzer şekilde katılımcılar, hastalıkların tedavisinde gen terapisi kullanılması konusunda (%25.5) ve gen terapisi uygulamalarının riskleri konusunda kararsız kaldıkları görülmüştür (%23.4).

Öğretmenlerin genetik bilginin kullanılması altboyutuna verdikleri cevaplar incelendiğinde, öğretmenlerin genetik bilginin sigorta şirketleri veya işverenler tarafından kullanılması konusunda olumsuz bir tutuma sahip oldukları görülmüştür (*M*=2.42, *SS*=0.81). Örneğin; bu boyutta yer alan maddelere katılımcıların verdikleri cevaplar incelendiğinde, katılımcıların büyük çoğunluğunun sigorta şirketlerinin genetik testleri hayat sigorta poliçelerini kabul veya reddetme amacıyla kullanmasına (%69.1), işverenlerin genetik test sonuçlarını görmelerine (%75.6) ve işverenlerin çalışanlarından genetik test yaptırmalarını istemelerine karşı çıkmıştır (%68.2). Bununla birlikte, katılımcıların büyük çoğunluğu (%68), işverenlerin çalışanlarından işyerinde kullanılabilecek kimyasallara karşı hassasiyetin belirlenmesine yönelik genetik test yaptırması fikrine ise olumlu yaklaşmışlardır.

Öğretmenlerin kürtaj altboyutuna verdikleri cevaplar incelendiğinde, katılımcılar kürtaj konusuna “bazı durumlarda” izin verilmesi gerektiğini belirtmişlerdir (*M*=1.95, *SS*=0.67). Örneğin, katılımcıların önemli bir çoğunluğu; çocuğun ciddi bir zihinsel engelle doğması durumunda (%79.2), ve bağımsız bir hayat sürdüremeyecek fiziksel bir engelle doğması durumunda (75.3%) kürtaja *izin verilmesi* gerektiğini belirtmiştir. Bununla birlikte, katılımcıların yarısından fazlası ise çocuğun sağlıklı ancak cüce olarak doğması durumunda kürtaja *izin verilmemesi* yönünde görüş belirtmişlerdir (%51.9).

Benzer şekilde katılımcılar, Pre-implemantasyon Genetik Tanı yönteminin “bazı durumlarda” kullanılmasına izin verilmesi gerektiğini ifade etmişlerdir (*M*=1.67, *SS*=0.69). Örneğin katılımcıların önemli bir kısmı, çocuğun ciddi bir zihinsel engelle doğması durumunda (%84.2) ve ciddi bir fiziksel engelle doğması durumunda (%82.9) Pre-implemantasyon Genetik Tanı yönteminin kullanılması gerektiğini belirtmiştir.

Öğretmenlerin Genetik Okuryazarlık Konularına Yönelik Tutum Ölçeği’ne ait diğer bir altboyut olan gen terapisine verilen cevaplar incelendiğinde, katılımcıların gen terapisi uygulamalarına muhtemelen izin verilmesi gerektiği konusunda fikir belirtmişlerdir (*M*=2.25, *SS*=0.67). Öğretmenlerin bu boyutta yer alan her bir maddeye verdikleri cevaplar incelendiğinde, katılımcılarının büyük çoğunluğu, gene terapisine bireyin kalp hastası olması durumunda (%86.2), meme kanseri olması durumunda (%87.3), ve bireyin şizofren olmasını engellemek amacıyla (%87.8) izin verilmesi gerektiğini belirtmiştir. Bununla birlikte, katılımcılar, cinsiyetin belirlenmesi (%71), bireyin boyunun uzun veya kısa olarak belirlenmesi (%54.3), bireyin kellik durumunun giderilmesi (%50.7) ve bireyi daha zeki yapmak amacıyla kullanılması (%48.5) durumlarında gen terapisi uygulamasına izin verilmemesi gerektiği yönünde fikir belirtmiştir.

Tutum ölçeğinin son alt boyutu olan "gen terapisi uygulamaları" altboyutunda katılımcılara değiştirilen genlerin gelecek nesillere aktarılıp aktarılmaması konusundaki görüşleri sorulmuştur. Bu altboyuta katılımcıların verdikleri cevaplar incelendiğinde, katılımcılar gen terapisi uygulamalarına "muhtemelen izin verilmesi" gerektiği belirtmiştir (*M*=1.89, *SS*=0.80). Bu boyutta yer alan maddeler incelendiğinde katılımcıların gen terapisi kullanılacak "duruma" değiştirilen genler bir sonraki nesile aktarılıp aktarılmamasından daha fazla önem verdikleri görülmüştür. Örneğin; katılımcıların büyük çoğunluğu gen terapisi uygulamalarının bireylerin kalp hastası olmaları (%85.9) ve Kistik Fibrozis hastası olmaları (%80.9) durumlarında gen terapisi uygulamalarının kullanılmasına izin verilmesi gerektiği yönünde fikir belirtmişlerdir. Bununla birlikte bu uygulamaların kellik durumunda kullanılması konusunda bireylerin daha az bir kısmı olumlu görüş belirtmiştir (%56).

5.4. Fen Bilimleri Öğretmenlerinin Genetik Okuryazarlık Öğretimine Yönelik Algıları

Bir sonraki aşamada, Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği altboyutlarına verdikleri cevaplar incelenmiştir. Öğretmenlerin "genetik okuryazarlık konularına fen müfredatında yer verilmesinin gerekliliğine yönelik algıları"nın olumlu olduğu ve öğretmenlerin bu konuların fen bilimleri derslerinde yer verilmesi gerektiğini düşündükleri görülmüştür (*M*=3.85, *SS*=0.42). Örneğin; bu boyutta yer alan maddelere katılımcıların verdikleri cevaplar incelendiğinde, katılımcıların büyük çoğunluğunun genetik okuryazarlık konusunu anlamalarına yardımcı olmak amacıyla geliştirilen programlara katılmak istedikleri (%86.9), genetik okuryazarlık konusunun öğrencilerin bilime karşı ilgisini arttırdığına inandıkları (%85.2) ve derslerinde genetik okuryazarlık konusu ile ilgili materyal kullanmak istedikleri (%87.9) belirtmişlerdir.

Algı ölçeğinin diğer bir altboyutu olan "Öğretmenlerin genetik okuryazarlık konularına fen müfredatında yer verilmesini engelleyen faktörlere yönelik algıları"na verilen cevaplar incelendiğinde, öğretmenlerin genel olarak kararsız bir tutum içinde oldukları bulgusuna ulaşılmıştır (*M*=3.15, *SS*=0.69). Bu boyutta yer alan maddelere öğretmenlerin verdikleri cevaplar incelendiğinde, öğretmenler, genetik okuryazarlık konularının öğrencilerin kendi değer yargıları konusunda kafalarını karıştırabileceği düşünmektedir (%35.3). Bununla birlikte katılımcıların önemli bir kısmı bu konuda kararsız kalmıştır (%25.9). Öğretmenlerin yarısından fazlası, öğrencilerin genetik okuryazarlık konusunu anlamak için yeterince hazır olduklarına inanmamakla birlikte (%55.5), katılımcıların büyük çoğunluğu, genetik okuryazarlık konusunun öğrencilerin ilgisini çekeceğini düşünmektedir (%72.2). Benzer şekilde, öğretmenlerin neredeyse yarısı, genetik okuryazarlık konuşlarının sadece başarılı öğrencilerin ilgisini çekeceğine inanmamaktadır (%48.9). Aynı şekilde, katılımcıların neredeyse yakını, bu konuların öğrencilerde kendi değer yargıları konusunda kafa karışıklığı yaratabileceğini vurgulamaktadır.

Öğretmenlerin Genetik Okuryazarlık Öğretimine Yönelik Algı Ölçeği'nin bir diğer altboyutu olan "Öğretmenlerin genetik okuryazarlık öğretimine yönelik özyeterlik algıları" incelendiğinde, öğretmenlerin genetik okuryazarlık konusunu öğretmeye yönelik özyeterlilikleri konusunda kararsız kaldıkları görülmüştür (*M*=3.55, *SS*=0.62). Bu boyutta yer alan maddeler ayrıntılı olarak incelendiğinde ise katılımcıların büyük bir kısmının genetik okuryazarlık konusunu yeterince anladıklarına inandıkları (%73.4) bulgusuna ulaşılmıştır. Yine katılımcılardan yarısı genetik okuryazarlık konusunu etkili öğretebilecek kadar anladığını ifade ederken (%52.8), %33.3'ü ise bu konuda kararsız kalmışlardır. Katılımcıların %43.9'u genetik okuryazarlık konusuyla ilgili eğitim ve öğretim materyalleri geliştirme konusunda kendisine güvenirken, %42.4'ü ise bu konuda kararsız kalmıştır. Son olarak, öğretmenlerin önemli bir kısmı (%62.3) ne kadar çaba harcasalar da genetik okuryazarlık konularını diğer fen bilimleri konuları kadar iyi öğretemeyeceklerine inanırken, yaklaşık %20'si ise bu konuda kararsız olduklarını belirtmişlerdir.

5.5.Kanonik Korelasyon Sonuçları

Araştırmada kullanılan çeşitli değişkenlerin birbirleri ile olan ilişkileri Kanonik Korelasyon Analizi kullanılarak incelenmiştir. Araştırmaya katılan fen bilimleri öğretmenlerin demografik verileri (cinsiyet, mesleki deneyim, genetik okuryazarlık konularına ilgi ve genetik okuryazarlık konularındaki bilgi düzeyleri) araştırmanın bağımsız değişkenlerini oluşturmuştur (SET 1). Fen bilimleri öğretmenlerinin genetik okuryazarlık düzeyleri, çeşitli genetik okuryazarlık konularına tutumları (genel bilgi, genetik bilginin kullanımı, kürtaj, Pre-implementasyon Genetik Tanı, gen terapisi ve gen terapi uygulamaları) ile genetik okuryazarlık konularını öğretimine yönelik algıları (genetik okuryazarlık konularının öğretilmesinin önemi, genetik okuryazarlık konularının öğretilmesini engelleyen faktörler ve genetik okuryazarlık öğretimine yönelik özyeterlilik algıları) ise araştırmanın bağımlı değişkenlerini oluşturmaktadır (SET 2).

Kanonik korelasyon analizi yapılmadan önce, Kanonik Korelasyon analizi yapılabilmesi için gerekli olan varsayımlar (normal dağılıma uygunluk, doğrusallık, Çoklu ortak doğrusallık (multicollinearity) ve aykırı değerler (outliers) incelenmiştir (Tabachnick & Fidell, 2013). Araştırmanın değişkenlerinin normal dağılıma uygunluğu incelirken, değişkenlerin Basıklık (Kurtosis) ve Çarpıklık (Skewness) değerleri incelenmiştir ve bu değerlerin “+2” ile “–2” aralığında olduğu dolayısıyla normal dağılım gösterdiği görülmüştür. Araştırmadaki verilerin doğrusallığını incelemek amacıyla “scatter plot” çıktıları inceleniş ve verilerin doğrusal olduğu görülmüştür. Çoklu ortak doğrusallık (multicollinearity) varsayımının sağlanıp sağlanmadığını belirlemek amacıyla değişkenler arasındaki ilişkiler Pearson korelasyon analizi yöntemi ile incelenmiştir ve değişkenler arasındaki ilişkiler, sınır değer olan .8’den küçük olduğu dolayısıyla çoklu ortak doğrusallık varsayımının ihlal edilmediği görülmüştür. Son olarak aykırı değerlerin incelenmesi amacıyla Mahalanobis değerleri incelenmiş ve elde edilen değerler Tabachnik ve Fidel (2007)’nin belirttiği sınır değerlerle karşılaştırılmıştır. Mahalanobis sınır değerleri araştırmada kullanılan bağımlı değişken sayısına göre belirlenir. Araştırmada 10 adet bağımlı değişken bulunmaktadır. Tabachnik ve Fidel (2007)’e göre

10 bağımlı değişken için sınır χ^2 değeri 29.59'dur. Araştırmada elde edilen değerin bu değerden küçük olduğu dolayısıyla aykırı değerlerin olmadığı görülmüştür.

Önerilen modelin istatistiksel olarak anlamlı olduğu görülmektedir Wilk's Lambda (λ)= .62, F(40, 1590.65)= 5.43, $p < .001$. Wilk's λ değeri, modelin açıklamadığı varyansı ifade etmektedir. Dolayısıyla 1-λ değeri modelin etki derecesini (effect size) belirtmektedir (Sherry & Henson, 2005). Bu çalışmada önerilen modelin iki set arasındaki ilişkilerin %38'ini açıkladığı bulgusuna ulaşılmıştır.

Kanonik korelasyon katsayıları, varyansı açıklama oranları (kanonik korelasyonun karesi= özdeğer), Ki-kare (χ^2) ve Wilk's Lambda (λ) değerleri Tablo 8'de sunulmuştur:

Tablo 8:

Kanonik Korelasyon Anlamlılık (Ki-Kare Testi) Sonuçları

Kanonik Kök	Kanonik R	Kanonik R^2	Ki-kare (χ^2)	Serbestlik Derecesi (SD)	Wilk's Lambda (λ)
1	.50	.25	5.43	40	.67**
2	.32	.10	3.29	27	.86**
3	.25	.07	2.56	16	.91**
4	.17	.03	1.77	7	.97

$p < .001$

Tablo 8'e göre 4 farklı değişken çifti ve kanonik korelasyon katsayısı elde edilmiştir. Kanonik korelasyon katsayılarının anlamlılık testlerinden Wilk's Lambda değerlerini kullanarak Ki-kare (χ^2) değerlerine bakıldığında; her dört kanonik korelasyon katsayının da istatistiksel olarak anlamlı olduğu sonucuna ulaşılmıştır ($p < .001$). Ancak Kanonik R^2'ler incelendiğinde sadece 1. ve 2. Değişken çiftinin varyansın önemli bir kısmını açıkladığı (sırasıyla %25 ve %10), 3. ve 4. değişken çiftinin ise çok daha düşük yüzdelere sahip olduğu (sırasıyla %7 ve %3) görülmüştür. Dolayısıyla bu çalışmada, sadece ilk iki değişken çiftinin analiz sonuçları sunulmuştur.

Fen bilimleri öğretmenlerin demografik özellikleri olan cinsiyet, mesleki deneyim, genetik okuryazarlık konularına olan ilgileri ve konulardaki bilgilerini yönelik maddeler (SET 1) ve genetik okuryazarlık düzeyleri (GLAI), Genetik okuryazarlık konularına yönelik tutumları (genel tutum, genetik bilginin kullanılması, kürtaj, Pre-implementasyon Genetik Tanı, gen terapisi ve gene terapisi uygulamaları) ile genetik okuryazarlık öğretimine ilişkin algılarını (genetik okuryazarlık öğretiminin gerekliliği, genetik okuryazarlık öğretimini etkileyen faktörler ve genetik okuryazarlık öğretime yönelik özyeterlilik algıları) (SET 2) arasındaki ilişkileri gösteren Korelasyon, Korelasyon Katsayısı, Kanonik Korelasyon,Varyans ve Gereksizlik (redundancy) değerleri Tablo 13'te sunulmuştur. Tabachnik ve Fidell (2007)'nin belirlediği .3 olan korelasyon kritik değeri dikkate alınarak Tablo 13 incelendiğinde, Birinci Kanonik Korelasyon çiftinde cinsiyet (.30), ilgi (.63) ve bilgi (.83) değişkenlerinin öğretmenlerin genetik okuryazarlık düzeyleri, genetik okuryazarlık konularına yönelik genel tutumları ile genetik okuryazarlık öğretiminin önemine ilişkin algıları, genetik okuryazarlık öğretimine yönelik özyeterlilik algıları ve genetik okuryazarlığı etkileyen faktörlere yönelik algıları ile pozitif olarak ilişkili olduğu, buna karşın öğretmenlerin gen terapisi ve gen terapi uygulamalarına yönelik tutumları ile negatif olarak ilişkili içinde olduğu görülmüştür. Yani genetik okuryazarlık konularına daha ilgili ve bu konularda kendilerinin daha bilgili olduklarını düşünen bayan fen bilimleri öğretmenlerinin genetik okuryazarlık düzeylerinin daha yüksek olduğu, genetik okuryazarlık konularına yönelik genel tutumlarının daha olumlu olduğu görülmüştür. Yine bu kişilerin genetik okuryazarlık öğretiminin önemine ilişkin algıları ile genetik okuryazarlık öğretimine yönelik özyeterlilik algılarının daha olumlu olduğu ancak bu kişilerin genetik okuryazarlık öğretiminin önünde daha fazla engel bulunduğuna yönelik algıları olduğu görülmüştür. Buna karşın genetik okuryazarlık konularına daha ilgili ve bu konularda kendini daha bilgili olduklarını düşünen bayan fen bilimleri öğretmenlerinin gen terapisi ve gen terapisi uygulamalarına yönelik tutumlarının negatif olduğu yani gen terapisi ve gen terapisi uygulamalarına yönelik olumsuz bir tutum içinde oldukları sonucuna ulaşılmıştır.

İkinci kanonik korelasyon çifti incelendiğinde 1. Sette yer alan deneyim (-.93) ve bilgi

(-.38) değişkenlerinin, fen bilimleri öğretmenlerinin genetik okuryazarlık düzeyleri (.48), fen bilimleri öğretmenlerinin kürtaja yönelik tutumları (.64) ile gen terapisi (.50) ve gen terapisi uygulamalarına (.36) yönelik tutumları ile negatif olarak ilişkili oldukları görülmüştür. Yani genetik okuryazarlık konularında kendilerinin daha bilgili olduklarını düşünen deneyimli fen bilimleri öğretmenlerinin genetik okuryazarlık düzeyleri daha düşüktür. Aynı zamanda bu fen bilimleri öğretmenleri; kürtaj, gen terapisi ve gen terapisi uygulamalarına karşı olumsuz tutum içerisindedir (bk. Tablo 9).

Tablo 9:

Fen bilimleri öğretmenlerin demografik özellikleri (SET 1) ve genetik okuryazarlık düzeyleri, Genetik okuryazarlık konularına yönelik tutumları ve genetik okuryazarlık öğretimine ilişkin algılarını (SET 2) arasındaki ilişkileri gösteren Korelasyon, Korelasyon Katsayısı, Kanonik Korelasyon, Varyans ve Gereksizlik (redundancy) değerleri

	Birinci Kanonik değişken çifti		İkinci Kanonik değişken çifti	
	Korelasyon	Korelasyon Katsayısı	Korelasyon	Korelasyon Katsayısı
SET 1				
Cinsiyet	.30	.22	-.17	-.22
Deneyim	.19	.37	-.93	-.93
İlgi	.63	.42	-.07	.20
Bilgi	.83	.72	-.38	-.23
Varyans (%)	.30		.26	Toplam=.56
Gereksizlik (Redundancy)	.07		.02	Toplam=.09
SET 2				
GLAI	.47	.33	.48	.52
Genel tutum maddeleri	.33	-.01	-.25	.01
Genetik bilginin kullanımı	.24	.24	-.04	.11
Kürtaj	.15	-.01	.64	.62
Pre-implementasyon Genetik Tanı	.27	.05	.16	-.10
Gen terapisi	-.40	.18	.50	.38
Gen terapisi uygulamaları	-.33	-.09	.36	.14
Gereklilik	.58	.17	.07	.35
Engelleyici faktörler	.55	.19	-.28	-.35
Özyeterlilik	.82	.64	-.06	-.02
Varyans (%)	.21		.12	Toplam =.33
Gereksizlik (Redundancy)	.05		.01	Toplam =.06
Kanonik Korelasyon	.50		.32	

5.6.Fen Bilimleri Öğretmenleriyle Gerçekleştirilen Mülakatlardan elde edilen Bulgular

Araştırmada, fen bilimleri öğretmenlerinin genetik okuryazarlıkla ilgili çeşitli konularda karar verme süreçlerini ve bu süreçlere etki eden faktörleri belirlemek üzere 18 öğretmenle yarı-yapılandırılmış mülakatlar geçekleştirilmiştir. Gerçekleştirilen görüşmeler, öğretmenlerin izni doğrultusunda ses kaydına alınmıştır. Daha sonra elde edilen veriler, transkripte edilerek yazılı doküman haline dönüştürülmüştür. Elde edilen 200 sayfalık metin, nitel araştırma yöntemleri ile incelenmiştir. Bu metinde, verileri organize etmek amacıyla kodlamalar yapılmış ve metinden yola çıkarak kodlar, çeşitli temalar altında toplanmıştır (Miles & Huberman, 1994). Kodların ve temaların belirlenmesinde ilgili alan yazından yararlanılmıştır (Bell, 1999; Bell & Lederman, 2003; Sadler, 2004; Sadler& Zeidler, 2002; 2004; Topçu, 2008, Zohar& Nemet, 2002; van der Zande ve ark. 2009).

Elde edilen kodlar ve kodların tanımları Tablo 10'da sunulmuştur:

Tablo 10:

Araştırmada elde edilen tema ve kodların tanımları

Temalar	Kodlar	Kod Tanımları
Kişisel Deneyimler	Kendi aile bireyleri veya akrabaları	Katılımcılar verilen senaryoları yorumlarken önceki deneyimlerinden yararlanır.
Sosyo-kültürel faktörler	Türk kültür ve aile yapısı	Katılımcıların Türk sosyal ve kültürel aile yapısı ile ilgili kaygıları
Duygusal faktörler	Empati ve sempati duyma	Katılımcıların senaryolardan verilen karakterlere duydukları empati veya sempati gibi tepkileri
Dini faktörler	Din, dini inanç, Tanrı	Katılımcıların senaryoları yorumlarken kullandıkları dini kalıplar (kader, inanç vb).
Ekonomik faktörler	Finansal meseleler	Uygulamaların ulaşılabilirliğine yönelik algılar. Örneğin zengin insanların gen terapilerine daha kolay ulaşırken fakir insanların bu yönteme maddi güçlerinin yetmeyeceğine yönelik kaygılarına yönelik ifadeler
Teknolojik faktörler	Güvenilirlik (Credibility) Yan etkiler (side effects) Risk faktörleri (risk factors) Kötüye kullanım (malicious use)	Katılımcıların genetik teknolojilerin gelişmesinde ve kullanılmasında teknolojinin rolü hakkındaki kaygılarına yönelik ifadeler
Moral faktörler	İnsan hayatının sonlandırılması (taking human life)	Katılımcıların embriyoyu bir canlı olarak kabul etmelerinden dolayı embriyoların kullanılmasını bir canlının feda edilmesi olarak algılarını belirten ifadeler
	Embriyonun araç olarak kullanılması (means to an end)	Embriyoların bir araç/kaynak olarak görülmesini anlatan ifadeler
	Doğal dengenin bozulması (distrupting natural order)	Genetik uygulamalarının doğal dengeye bir müdahale olarak görülmesini anlatan ifadeler
	Hasta insanların iyileştirilmesi (health improvement)	Kullanılacak genetik teknolojilerinin bireylerin sağlıklı olması adına getireceği kolaylıkları anlatan ifadeler
	Sosyal tabakaların oluşması (social stratification)	Toplumda, “genetiği değiştirilenler” ve “genetiği değiştirilmeyenler” diye sınıfların oluşmasına yönelik ifadeler
	Kaygan zemin (slippery slope)	Genetik teknolojilerinin iyi bir amaca hizmet ederken bir yandan da

Tablo 10 (devam)

Moral faktörler (devam)	Toplumsal iyileşme (societal betterment)	Genetik teknolojilerinin toplumda genel anlamda yaratacağı iyileşmeleri anlatan ifadeler
	Çeşitlilik	Katılımcıların yapılacak genetik uygulamaların bireysel veya tüm insanlık için çeşitliliği azaltacağına dair inançlarını ifade eden cümleler
Değerler	Ailenin bilgilendirilmesi (informed consent of family)	Herhangi bir genetik uygulama öncesinde ailelerin uygulamanın olası sonuçları hakkında bilgilendirilmesine yönelik ifadeler
	Hasta/fetüs hakları ve fetüsün yaşam hakkı (patients'/fetus' rights/rights to live)	Embriyo/fetüsün yaşam hakkı olduğuna yönelik ifadeler veya hastaların kendi gelecekleri hakkında söz sahibi olduğunu açıklayan ifadeler
	Ailelerin hakları/sorumlulukları/ kararları (parents' rights/decisions/ respondibility)	Embriyonun yaşaması konusunda ailelerin söz sahibi olduğunu ifade eden veya bu duruma ailelerin karar vermesi gerektiğini açıklayan ifadeler
Sosyo-psikolojik faktörler	Çekilen acılar, çocuk bakımı	Ailelerin hasta olan çocuklarını yetiştirirken karşılaşacakları problemleri (ailenin/çocuğun acı çekmesi, çocuğun bakılması vb) anlatan ifadeler
Aileden gelen ön yargılar (Family bias)	Fikirlerin ailenin olduğu durumlarda değişmesi	Katılımcıların verdikleri kararların belirtilen durumun kendi başlarına veya aile üyelerinden birinin başına gelmesi durumunda verdikleri kararların değişebileceğine yönelik ifadeler
Politik faktörler	Hükümet politikaları	Genetik teknolojilerine kimlerin ulaşabileceği, bu teknolojileri kullanan kişilere kimlerin izin vereceği ve bu genetik teknolojilerinin geliştirilmesi ve kullanılmasında hükümetlerin/ülkelerin rollerini açıklayan ifadeler
Yasal faktörler	Yasalar ve yasal düzenlemeler	Genetik uygulamalarını düzenleyen yasal uygulamaları açıklayan ifadeler
Daha fazla bilgi	Ek bilgiye ihtiyaç duyulması	Katılımcıların karar verebilmek için daha fazla bilgiye ihtiyaçlarının olduğunu ifade etmeleri
Popüler kültür (Pop culture)	Medyadaki bilgiler	Katılımcıların kararlarını etkileyen faktörleri açıklarken film/belgesel gibi medya araçlarının kullanması
Bilimsel desteklemesi	Bilimsel gelişmeler	Katılımcıların bilimin ve bilimsel araştırmaların desteklenmese gerektiğini belirten ifadeleri

Tablo 10 (devam)

Diğer faktörler	Fikirlerin zaman içinde değişmesi	Katılımcıların verdikleri kararların kesin olmadığını zaman içerisinde bu kararların değişebileceği şeklindeki ifadeleri
	Doğum kontrolü	Katılımcıların riskli gebelikleri önlemek adına doğum kontrol yöntemleri kullanılması gerektiğine yönelik ifadeleri
	Alternatif tedavi seçenekleri	Katılımcıların senaryolarda verilen tedavi yöntemlerine alternatif tedavi seçenekleri (embriyoya zarar vermeyen) bulunabileceğine/geliştirilebileceğine ilişkin algıları
	İkilemler (2-edged sword)	Katılımcıların sunulan senaryoyla ilgili karma verme süreçlerinde karşılaştıkları ikilemler/güçlükler
	Belirsizlik	Katılımcıların genetik uygulamalarının veya yaşamın kendisinin belirsiz olduğuna yönelik ifadeleri
	Hastalık türü	Katılımcıların verdikleri kararların farklı hastalık türlerinde farklılık göstereceğine yönelik ifadeleri

Daha sonra bu kodların güvenilirlik analizi yapılmıştır. Bu amaçla, fen eğitiminde doktora yapan ikinci bir alan uzmanı gerçekleştirilen görüşmelerin %25'ini kodlamış daha sonra güvenilirlik analizi yapılmıştır. Bu amaçla, aşağıdaki formül kullanılmıştır:

Güvenilirlik= mütabakat sayısı / (toplam mükabakat sayısı + anlaşmazlık sayısı)

Bu analiz sonucunda, kodlamanın güvenilirliği .93 olarak bulunmuştur. Daha sonra katılımcıların karar verme süreçlerini etkileyen faktörlerin belirlenmesinde frekans analizi yapılmıştır. Her bir faktör ve frekans analizi Tablo 11'de sunulmuştur:

Tablo 11:

Fen bilimleri öğretmenlerinin karar vermelerini etkileyen faktörler ve sıklıkları

Temalar	Kodlar	Sıklık	Yüzde (%)
Kişisel Deneyimler	Kendi aile bireyleri veya akrabaları	15	1.78
Sosyo-kültürel faktörler	Türk kültür ve aile yapısı	14	1.66
Duygusal faktörler	Empati ve sempati duyma	44	5.22
Dini faktörler	Din, dini inanç, Tanrı	33	3.91
Ekonomik faktörler	Finansal meseleler	21	2.49
Teknolojik faktörler	Güvenilirlik	6	0.71
	Yan etkiler	44	5.22
	Risk faktörleri	9	1.07
	Kötüye kullanım	29	3.44
Moral/etik faktörler	İnsan hayatının sonlandırılması	39	4.63
	Embriyonun araç olarak kullanılması	17	2.02
	Doğal dengenin bozulması	30	3.56
	Hasta insanların iyileştirilmesi	123	14.59
	Sosyal tabakaların oluşması	18	2.13
	Kaygan zemin	40	4.74
	Toplumsal iyileşme	20	2.37
	Çeşitlilik	5	0.59
Değerler	Ailenin bilgilendirilmesi	14	1.66
	Hasta/fetüs hakları ve fetüsün yaşam hakkı	29	3.44
	Ailelerin hakları/sorumlulukları/ kararları)	19	2.25
Sosyo-psikolojik faktörler	Çekilen acılar, çocuk bakımı	70	8.30
Aileden gelen ön yargılar	Fikirlerin ailenin olduğu durumlarda değişmesi	15	1.78
Politik faktörler	Hükümet politikaları	4	0.47
Yasal faktörler	Yasalar ve yasal düzenlemeler	24	2.85
Daha fazla bilgi	Ek bilgiye ihtiyaç duyulması	7	0.83
Popüler kültür	Medyadaki bilgiler	12	1.42
Bilimin desteklenmesi	Bilimsel gelişmeler	50	5.93
Diğer faktörler	Fikirlerin zaman içinde değişmesi	4	0.47
	Doğum kontrolü	6	0.71
	Alternatif tedavi seçenekleri	30	3.56
	İkilemler	30	3.56
	Belirsizlik	10	1.19
	Hastalık türü	12	1.42

Tablo 11 incelendiğinde, fen bilimleri öğretmenlerinin en fazla kullandıkları faktörün “hasta insanların iyileştirilmesi” (%14.59) olduğu görülmektedir. Araştırmaya katılan fen bilimleri öğretmenlerinin tamamı, senaryolarda sunulan genetik uygulamalarının hasta insanların iyileştirilmesi amacıyla kullanılmasının öneminden bahsetti. Bundan dolayı, bu faktörün, öğretmenlerin kararlarını etkileyen önemli bir faktör olduğu sonucuna varılabilir. Katılımcıların bu faktörde yer alan cevaplarından örnekler aşağıda sunulmuştur:

> Bunun gerçek olduğunu varsayarsak bu yöntemi kabul edebilirim. Bu, sonuçta insanoğlunun keşfettiği bir tedavi yöntemi. Uygulamamak için bir neden yok. (GTHD; K2)

> Parkinson hastalığı ölümcül bir hastalık olduğu ve fetal doku transferi dışında başka bir yöntem de bulunmadığı için, deneysel de olsa bu uygulamaya izin verirdim. Burada bir hastalığın tedavisi söz konusu… (FT; K6)

Bu faktörün yanı sıra, katılımcıların kararlarını etkileyen diğer önemli bir faktör de “sosyo-psikolojik faktörler”dir (%8.30). Bir önceki boyutta olduğu gibi, öğretmenlerin tamamı, karar verirken hasta çocukların ve hasta çocukların ailelerin çekeceği acılardan, ailelerin bu çocuklara bakarken karşılaşacağı zorluklardan ve bakım problemlerinden bahsetmişlerdir. Katılımcıların bu faktörde yer alan cevaplarından örnekler aşağıda sunulmuştur:

> Çok hayati bir karar bu. Ama birde çocuğun geleceğini düşünmek lazım. Yani bu çocuk hastalık ölümcül ve 40 yaşından sonra hayatta kalma ihtimali ve o zamana kadar zaten yaşayamayabilir de… Ve ailenin direk özel ilgi ve alakasına muhtaç olacak. Sonuçta bu önceden belirlenebilen bir şeyse hamilelik sonlandırılmalı bence… (CF; K4)

> Yani şimdi burada ne kadar sağlıklı yaşadığı da önemli bence. Ne kadar yaşadığı değil bence. Bir de şöyle bir şey var. 50li yaşlarda öleceğini bilecek yani ölme tarihini bilerek yaşamak çok zor yani. Diyorsun ki ya sen şu hastasısın. Ya da sen saklasan bile ilerde bir yerden okuyacak. Yani sen 50 yaşına kadar yaşayacaksın. Bunun

> 35 senesi sağlıklı tamam ama bu aradaki yaşam da bence düzgün değil ki… Yani biliyorsun ki 50li yaşlarda öleceksin. Öleceğin zamanı bilerek yaşamak bence çok olumsuz bir şey. (HD; K7)

Yine fen bilimleri öğretmenleri karar verme süreçlerinde, bilimsel bilginin özellikleri, bilimin gelişmesinden deneysel çalışmaların rolü veya bilimsel çalışmaların insanlık adına önemi gibi konulardan bahsetmişlerdir ve bu ifadeler "bilimin desteklenmesi" kategorisine toplanmıştır. Bu boyutun öğretmenlerin karar verme süreçlerinde önemli olduğu görülmektedir (%5.93). Bu boyutta kodlanan bazı ifadeler, aşağıda sunulmuştur:

> Tabii ki her türlü bilimle ilgili her türlü çalışmaya kesinlikle izin verilmesi lazım diye düşünüyorum. Hani ayıptır günahtır dinimizde şöyledir böyledir bu tarz kelimelere yer olmaması lazım. Bilimde zaten böyle bir şey yok. Her türlü destek olunması taraftarıyım. (FTT; K1)

> Yani bununla ilgili çalışmaların başlanmış olması, bununla ilgili yöntemlerin deneniyor olması en azından hastalığın tedavisi boyutunda bir ışık uyandırdı bende… (HD; K2)

Bununla birlikte fen bilimleri öğretmenleri aynı zamanda sıklıkla genetik uygulamaların yan etkilerinden bahsetmiştir (%5.22). Bu ifadeler "yan etki" kodu altında toplanmıştır. Öğretmenler, genlere yapılan müdahalelerin çeşitli sorunlara yol açabileceğinden, bir geni değiştirmenin tüm gen yapısını bozabileceğinden ya da genlere müdahalenin "domino etkisi"ne sebep olarak insanın tüm genom yapısını değiştirebileceği şeklinde çeşitli endişelere sahiptir. Katılımcıların bu faktörde yer alan cevaplarından örnekler aşağıda sunulmuştur:

> Yani bir hastalığı tedavi ediyoruz derken bir yaratık da yaratabiliriz. Yani bir hastalığı tedavi ederken başka bir şeye de sebep olabiliriz. (GTHI; K6)

Öğretmenlerin önemli bir kısmı, karar verme süreçlerinde hasta ve hastaların ailelerine yönelik empati veya sempati gibi duygulardan yararlanmışlardır ve bu ifadeler "duygusal faktörler" kategorisinde toplanmıştır. Yine bu faktör, katılımcıların kararlarını etkileyen önemli bir faktör olarak ortaya çıkmaktadır (%5.22). Katılımcıların bu faktörde yer alan cevaplarından örnekler aşağıda sunulmuştur:

> Çok ilginç bir konu olmuş. Benim başıma gelse ne yapardım dedim de o yüzden. Ben kürtaj kesinlikle yaptırmayacağım için… Ne bileyim. Şuan bakınca böyle bir kötü oldum sonlandırmasından. Hemen de etkilenirim ben böyle olaylardan… (FT; K2)

> Evet… Burada çiftimiz kürtaja karar vermiş. Onun üzerine konuşacak olursak o zaman tamam. Duygusal açıdan yaklaşıyorum çünkü elimde olmadan. Bilimsel yaklaşamıyorum. (FT; K4)

Katılımcıların genetik uygulamalarının kabul edilebilir alanların dışında başka kabul edilmeyecek alanlarda kullanılabileceğine dair endişeleri ise "Kaygan Zemin (slippery slope)" kod altında ifade edilmiştir. Örneğin,

> Bence gen terapisi uygulamalarının zeka üzerinde uygulanmasına hiç izin verilmemeli. Zeki çocuk isteyen yarın kaşını gözünü de değiştirmek ister çocuğunun bundan dolayı ailelere böyle bir hak verilmemeli bence. (GTHI; K7)

> Siz izin verseniz de vermeseniz de eğer böyle bir şey ortaya çıkarsa insanlar bunu talep edecektir. Etik ya da değil bir şekilde yapılacaktır diye düşünüyorum… Ama işte durduramazsınız ki bu yöntem çıkarsa, insanlar yaptırmak isterler… Nereye kadar izin verilecek onlar belirlenmeli ama ne olursa olsun kaçak verecektir mutlaka. (GTHI; K4)

Fen bilimleri öğretmenlerinin karar vermesini etkileyen diğer önemli bir faktörün "İnsan hayatının sonlandırılması (taking human life)" olduğu görülmektedir (4.63%). Katılımcılar, özellikle 1.senaryoda sunulan doku transferi yönteminde insan embriyosu kullanılmasının embriyo bir canlı olduğundan, insan hayatını sonlandırmak olarak görmüştür ve bu yönteme karşı çıkmıştır. Katılımcıların bu faktörde yer alan cevaplarından örnekler aşağıda sunulmuştur:

> Fetüs sonuçta belli bir haftayı doldurdu. Sonuçta fetüs şimdi bir canlı. Baktığımızda fetüsün kullanılması çok etik gelmiyor açıkçası. (FT; K1)

> En son yöntem olarak bu tedavi seçeneği düşünülmeli. Bu yöntemde doktor, Allah tarafından verilen bir canlıyı yok etmiş oluyor. (FT; K3)

Katılımcıların karar verme süreçlerini etkileyen diğer bir önemli faktör "dini fakörler"dir (%3.91). Katılımcılar, karar verirken inançlarını ya da "Kader", "Takdir-i İlahi" gibi dini terimlerden yararlanmışlardır. Örneğin;

> Dini açıdan düşündüğümüzde bu yöntem, sakıncalı. Günah olmasa "tamam olsun" diyebiliriz. Günah olduğu için insanlar Down sendromlu olduğu bilinen çocuğu bile aldırmıyor insanlar. (FT; K3)

> Benim şahsi düşüncem bence hayır yani niye böyle bir şey düşünsün? Kendi babam olsaydı ne düşünürdüm ben biraz Takdir-i İlahi'ye inanan bir insanım. Hiçbirimizin sonu belli değil. Belki kadın babasının tedavisi için kürtaj yaptırıyor ama babasına belki doku nakli yapılacak ama babası belki yine iyileşmeyecek, ölecek. Belki vakti geldi, ameliyat anında ölecek. Asıl o amaç, olabilir mi bence olmamalı diye düşünüyorum (FT; K2)

Yine katılımcıların önemli bir kısmı karar verirken "alternatif tedavi seçenekleri"nin varlığından bahsetmiştir (%3.56). Bu faktör, özellikle embriyonun kullanılmasını gerektiği Doku Transferi senaryosunda görülmüştür. Öğretmenler, bu yöntem yerine embriyonun hayatının sonlanmayacağı, embriyoya zarar verilmeyecek yöntemler geliştirilebileceğini ifade etmişlerdir. Örneğin;

> Ben şunu düşünürdüm. Parkinson hatalığının tedavisi fetüs beyin doku transferi yerine, Parkinson sinirlerin arasındaki iletişimi sağlayan bir maddenin sanırım Seratonindi bilmiyorum işte bazı maddelerin eksik ya da fazla salgılanması ya da sıkıntılı olması ya da bir bölümün çalışmamasından kaynaklanıyor. Derdim ki ben sen madem böyle bir çalışma yapıyorsun ilk başta o maddeyi arttıracak bir yöntem bul onu araştır, ne bileyim doku kültürü yap, doku kültüründe hücreleri çoğalt, doku kültürü ile bu işi yapmaya çalış.

> Oradan maddeleri elde et, enjekte et, yani daha farklı bir bakış açısı olsun isterdim. Yan, illa fetüs dokusuyla mı çalışılmalı. (FT; K1)

Katılımcıların karar vermesini etkileyen diğer önemli bir faktör ise "doğal dengenin bozulması"dır. Katılımcıların önemli bir kısmının karar verirken, geliştirilen genetik uygulamalarının doğal dengeyi bozabileceğine yönelik endişeleri vardır. Katılımcıların bu faktörde yer alan cevaplarından örnekler aşağıda sunulmuştur:

> Gen terapisinin Huntington hastalığı üzerinde kullanılması normal bir durum. Olabilir niye olmasın. Mesela akıllı olmayan bir çocuğun genleri değiştirilseydi buna karşı çıkardım. Çünkü doğanın yapısına karşı çıkmış olurdum. Ama burada doğanın yapısına aykırı bir şey yapıyormuşum gibi gelmedi. (GTHD; K3)

> Ben gen terapisinde hastalık dışında başka durumlara uygulanmasına karşıyım. Çünkü dünyanın düzeni bozulur. Yani siz yılanları öldürünce farelerin sayısı artıyor değil mi? Ekolojik bir zincir var. Sen dünyadaki zinciri bozarsan, işte yok herkes kız isterse, herkes erkek olur, sen bu oranı bozarsın… (GTHD, K2)

Katılımcılar, bazı durumlarda karar vermede zorlanmışlardır ve kararsızlıklarını ifade eden cümleler "ikilemler" kategorisinde toplanmıştır. Katılımcılar, genetik uygulamaların yararlarından bahsederken aynı zamanda bu uygulamaların olası yan etkileri veya olumsuz sonuçları olduğundan da bahsederek kararsızlıklarını dile getirmişlerdir.

> K 18 (GTHI): teknolojinin bu kadar hızlı gelişmesi bir yandan beni endişelendiriyor bir yandan da ümitlendiriyor. Nasıl desem? Her gün yeni bir şeylerin çözümü bulunuyor ama aynı zamanda her gün de yeni bir hastalık ortaya çıkıyor. Ne biliyim genetiğiyle oynamış gıdalar mesela. Genetik teknolojisi ne güzel ama kanserojen yani…

6. Tartışma ve Sonuç

Bu araştırmanın ilk amacı, fen bilimleri öğretmenlerinin çeşitli demografik özellikleri ile genetik okuryazarlık düzeyleri, genetik okuryazarlık konularına yönelik tutumları ve genetik okuryazarlık konularının öğretimine yönelik algıları arasındaki ilişkileri incelemektir. Nicel verilerin analizinde betimsel istatistiklerden yararlanılarak, araştırmaya katılan fen bilimleri öğretmenlerinin cinsiyet, mesleki deneyim, mezun olunan bölüm, genetik okuryazarlık konularına yönelik ilgi ve bilgilerine yönelik çeşitli demografik verileri incelenmiştir. Daha sonra, bu demografik değişkenlerle araştırmada kullanılan Genetik Okuryazarlık Ölçme Envanteri, Genetik Okuryazarlık Konularına Yönelik Tutum Ölçeği ve Genetik Okuryazarlık Konularının Öğretimine Yönelik Algı Ölçeği kullanılarak elde edilen toplam puanlar kullanılarak Kanonik Korelasyon analizi yapılmıştır. Yapılan Kanonik Korelasyon analizi sonucunda iki Kanonik Korelasyon çiftinin değişkenler arasındaki ilişkileri açıkladığı görülmüştür. 1. Kanonik Korelasyon çifti incelendiğinde, genetik okuryazarlık konularına daha ilgili ve bu konularda kendilerinin daha bilgili olduklarını düşünen bayan fen bilimleri öğretmenlerinin genetik okuryazarlık düzeylerinin daha yüksek olduğu, genetik okuryazarlık konularına yönelik genel tutumlarının daha olumlu olduğu görülmüştür. Yine bu kişilerin genetik okuryazarlık öğretiminin önemine ilişkin algıları ile genetik okuryazarlık öğretimine yönelik özyeterlilik algılarının daha olumlu olduğu ancak bu kişilerin genetik okuryazarlık öğretiminin önünde daha fazla engel bulunduğuna yönelik algıları olduğu görülmüştür. Buna karşın, bu kişilerin gen terapisi ve gen terapisi uygulamalarına yönelik tutumlarının negatif olduğu yani gen terapisi ve gen terapisi uygulamalarına yönelik olumsuz bir tutum içinde oldukları sonucuna ulaşılmıştır. İkinci Kanonik korelasyon çifti incelendiğinde, genetik okuryazarlık konularında kendilerinin daha bilgili olduklarını düşünen deneyimli fen bilimleri öğretmenlerinin genetik okuryazarlık düzeyleri daha düşük olduğu, aynı zamanda bu fen bilimleri öğretmenlerinin; kürtaj, gen terapisi ve gen terapisi uygulamalarına karşı olumsuz tutum içerisinde oldukları bulgularına ulaşılmıştır.

Bu araştırmanın diğer bir amacı ise, fen bilimleri öğretmenlerinin çeşitli genetik okuryazarlık konularındaki karar verme süreçlerini etkileyen faktörleri belirlemektir.

Temmuz-Aralık 2013 döneminde, nitel verilerin analizi için ilgili alan yazın incelenmiş; kod ve temaların belirlenmesine süreci tamamlanmıştır. Nitel verilerin analizi sonucunda öğretmenlerin karar verme süreçlerinde çeşitli faktörlerin etkili olduğu görülmüştür. Bu faktörler çok geniş bir yelpazede yer almaktadır. Örneğin, öğretmenlerin karar verme süreçlerini etkileyen en önemli faktörlerin ise, hasta insanların iyileştirilmesi, sosyo-psikolojik faktörler, duygusal faktörler, dini faktörler, yan etkiler, doğaya müdahale, kaygan zemin ve bilimin desteklenmesi olduğu görülmüştür. Öğretmenlerin tümü, genetik uygulamaları ile ilgili karar verirken hasta bireylerin iyileştirilmesini ön planda tutmuşlardır. Yine katılımcıların tamamı karar verme süreçlerin hasta ve hasta ailelerin çekebileceği acı ve sıkıntılardan bahsetmişlerdir. Ayrıca katılımcıların önemli bir kısmı, bilimsel çalışmaların doğasından ve bilimsel çalışmaların desteklenmesinin gerektiğine değinmişlerdir. Beklenildiği üzere, dini faktörler, katılımcıların kararlarını etkileyen diğer bir önemli faktör olarak görülmüştür. Aynı zamanda insan hayatının sonlandırılması da katılımcıların kararını ve genetik uygulamalara bakış açısını önemli ölçüde etkilemiştir. Fetüs dokularının kullanıldığı 1.senaryoda bu genetik uygulamaya karşı çıkan fen bilimleri öğretmenleri fetüsün bir canlı olduğuna ve bu çalışmada fetüs kullanılmasının ise insan hayatının sonlandırılması olduğunu ifade etmişlerdir. Burada, öğretmenler "alternatif tedavi yöntemleri"ne yönelinmesi gerektiğini vurgulamışlardır. Örneğin fetüsün yaşamına zarar vermeyecek çeşitli çalışmaların yapılabileceği, çalışmalarda farklı memeli embriyolarının kullanılabileceği ya da plasenta sıvısı, göbek bağı gibi çeşitli alternatif tedavi önerileri ileri sürmüşlerdir. Katılımcıların kararlarını belirleyen çeşitli endişeleri de mevcuttur. Bu araştırmada öne çıkan en temel endişe yan etkilerin olmasıdır. Öğretmenler, genetik çalışmaların veya genlere yapılan müdahalelerin insan genomunun tüm yapısını bozabileceği, ya da istenmeyen diğer etkiler doğurabileceğine yönelik çeşitli endişeler belirtmişlerdir. Aynı zamanda, öğretmenler, yapılan genetik uygulamaların geliştirildiği alan dışında da kullanılabileceği endişesi taşımaktadırlar ve bu belirgin bir faktör olarak frekans analizinde ortaya çıkmıştır. Örneğin öğretmenler, gen terapisi ve gen terapi uygulamalarının hastalıkların tedavisinde kullanılmasının önemine değinirken bu uygulamaların insanların zeka, saç rengi veya cinsiyet gibi çeşitli başka özelliklerinin de değiştirilmesinde kullanılabileceği gibi çeşitli endişeler taşımaktadırlar. Ayrıca öğretmenler, yapılan bu çalışmaların doğal yapıya bir müdahale olduğuna yönelik endişeye sahiptir ve bu faktör de belirgin bir faktör olarak frekans analizinde ortaya çıkmıştır. Frekans analizinde ortaya çıkan diğer faktörler, fen bilimleri öğretmenlerinin karar vermelerini etkileyen unsurlar arasında yer almaktadırlar.

Bu araştırmadan elde edilen sonuçlar, öncelikle fen bilimleri öğretmenlerinin çeşitli karakteristik özelliklerinin onların genetik okuryazarlık düzeyleri, çeşitli genetik okuryazarlık konularına yönelik tutumları ve genetik okuryazarlık öğretimine yönelik algılarını etkileyebileceğini göstermektedir. Dolayısıyla geliştirilecek olan hizmet içi eğitim programlarında bu özelliklerin göz önünde bulundurulması, bu programların etkililiği açısından önemlidir. Ayrıca, bu çalışmada elde edilen nitel veriler, fen bilimleri öğretmenlerinin genetik okuryazarlık konularına etkileyen pek çok faktör olduğu sonucunu ortaya koymaktadır. Fen bilimleri öğretmenlerinin genetik okuryazarlık konuları yönelik bilgilerini ve tutumlarını dolayısıyla bu konuların öğretimine yönelik algılarının geliştirilmesine yönelik hizmet içi eğitim programları geliştirilmesi gerekmektedir. Bu programlar geliştirilirken gerek fen bilimleri öğretmenlerinin cinsiyet, öğretmenlik deneyimi gibi çeşitli karakteristik özellikleri gerekse onların bu konularda karar vermelerini etkileyen çeşitli faktörler göz önünde bulundurulmalıdır. Genetik okuryazarlık kavramının tek bir boyutunun olmadığı, çoklu bir çerçevede değerlendirilmesi ve geliştirilmesi gerektiği unutulmamalıdır.

APPENDIX M

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü	[ ]
Sosyal Bilimler Enstitüsü	[X]
Uygulamalı Matematik Enstitüsü	[ ]
Enformatik Enstitüsü	[ ]
Deniz Bilimleri Enstitüsü	[ ]

YAZARIN

Soyadı : CEBESOY
Adı : Ümran Betül
Bölümü : İlköğretim

TEZİN ADI (İngilizce) : An Analysis of Science Teachers' Genetics Literacy and Related Decısıon Making Process

TEZİN TÜRÜ : Yüksek Lisans [ ] Doktora [X]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]
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