INVESTIGATING PRE-SERVICE SCIENCE TEACHERS' PERCEIVED TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE REGARDING GENETICS

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ABSTRACT

INVESTIGATING PRE-SERVICE SCIENCE TEACHERS' PERCEIVED TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE REGARDING GENETICS

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The purpose of this study was to investigate the preservice science teachers' perceived technological pedagogical content knowledge (TPACK) on genetics. More specifically, the purpose was to examine the relationships among the components of TPACK and genetics knowledge of the preservice science teachers. Moreover, findings the effect of the demographic information on perceived TPACK was also aimed.

This study was conducted with preservice science teachers who were enrolled in elementary science education department of Education Faculties of eight public universities located in Central Anatolia. 1530 preservice science teachers participated to the study. There were two instruments used in this research which were perceived TPACK questionnaire, which was later adopted by the researcher as perceived TPACK on genetics, and genetic concepts test.

Data were analyzed by using descriptive and inferential statistics. In order to answer the first research question, descriptive information about the components of TPACK was given. Correlational analyses were used to identify the relationship between each component of the perceived TPACK on genetics and their genetic knowledge. Another correlational analysis was conducted for the third research question which seeks the relationships among the components of the TPACK. Moreover, MANOVA was conducted to investigate the impact of gender and year of enrollment on perceived TPACK on genetics of preservice science teachers.

The results revealed that genetic knowledge was correlated with each component except the perceived project specific technology knowledge. Moreover, there were positive significant correlations among the components of the TPACK. According to the MANOVA results, the mean scores of male and female preservice science teachers differ in five components of TPACK, namely project specific technology knowledge, pedagogical knowledge, pedagogical content knowledge, technological content knowledge and technological pedagogical content knowledge. The results of MANOVA for year of enrollment revealed that the mean ETK, GTK, PSTK, and CK scores of participants with different year of enrollment differ significantly.

Keywords: Technological Pedagogical Content Knowledge, Genetics, Pre-service Science Teachers, Year of Enrollment, Gender

ÖZ

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ GENETİK KONUSU İLE İLGİLİ TEKNOLOJİK PEDAGOJİK ALAN BİLGİLERİ ALGILARININ ARAŞTIRILMASI

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Bu çalışmanın amacı fen bilgisi öğretmen adaylarının genetik konusuyla ilgili teknolojik pedagojik alan bilgilerinin (TPAB) algılarını araştırmaktır. Daha özel olarak, fenbilgisi öğretmen adaylarının sahip olduğu TPAB leriyle genetik bilgileri arasındaki ilişkiyi araştırmaktır. Ayrıca bu çalışmada öğretmen adaylarının demografik bilgilerinin algılanan TPAB lerine olan etkisini ortaya çıkarmak amaçlanmıştır.

Bu çalışma İç Anadolu'da yer alan sekiz tane devlet üniversitesinin ilköğretim fen bilgisi bölümünde eğitim gören fenbilgisi öğretmen adaylarıyla yapılmıştır. Çalışmada 1530 fenbilgisi öğretmen adayı yer almıştır. Çalışmada iki adet ölçek kullanılmıştır. Bunlar; araştırmacı tarafından adapte edilmiş genetik ile ilgili algılanan TPAB lerini ölçen anket ve genetik bilgilerini ölçen başarı testi.

Verilerin analizinde betimleyici ve çıkarımsal istatistik kullanılmıştır. İlk araştırma sorusunu cevaplamak için TPAB ile ilgili bazı betimleyici bilgiler verilmiştir. Öğretmen adaylarının genetik ile ilgili algılanan TPAB leri ile genetik bilgileri arasındaki ilişkiyi tanımlamak için korelasyonal analiz kullanılmıştır. Diğer bir korelasyonel analiz ise üçüncü araştırma sorusu olan TPAB lerin bileşenleri arasındaki ilişkiyi ortaya çıkarmak için kullanılmıştır. Ayrıca fenbilgisi öğretmen adaylarının cinsiyet ve sınıf bilgilerinin genetik ile ilgili algılanan TPAB leri üzerindeki etkisini araştırmak için MANOVA kullanılmıştır.

Araştırma sonuçlarına göre fen bilgisi öğretmen adaylarının genetik bilgileri, algılanan proje bazlı teknoloji bilgileri dışındaki diğer bileşenlerle ilişkilidir. Ayrıca, bileşenler arasında da pozitif anlamlı bir ilişki bulunmaktadır. MANOVA sonuçlarına göre, erkek ve bayan öğretmen adaylarının proje bazlı teknoloji bilgisi, pedagoji bilgisi, pedagogik alan bilgisi, teknolojik alan bilgisi, ve teknolojik pedagojik alan bilgisi ortalamaları anlamlı farklılık göstermektedir. Sınıf seviyesi için elde edilen MANOVA sonuçlarına göre, katılımcıların eğitim teknolojileri bilgileri, genetik teknolojileri bilgileri, proje bazlı teknoloji bilgileri ve alan bilgileri farklı sınıf düzeylerinde anlamlı farklılık göstermektedir.

Anahtar Kelimeler: Teknolojik Pedagogik Alan Bilgisi, Genetik, Fenbilgisi Öğretmen Adayları, Sınıf düzeyi, Cinsiyet

To My Parents

Safiye and Yaşar Savaş

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CK: Content Knowledge

EFA: Exploratory Factor Analysis

ETK: Educational Technology Knowledge

GTK: Genetic Technologies Knowledge

df: Degrees of Freedom

DVs: Dependent Variables

MANOVA: Multivariate Analysis of Variances

PK: Pedagogical Knowledge

PCK: Pedagogical Content Knowledge

PSTK: Project Specific Technology Knowledge

SD: Standard Deviation

TCK: Technological Content Knowledge

TK: Technology Knowledge

TPACK: Technological Pedagogical Content Knowledge

TPK: Technological Pedagogical Knowledge

1. INTRODUCTION

History of technology is as old as history of mankind. Technology accompany with religion, art, literature and norms in a country. It affects economy, culture and sociology (Aksoy, 2003).

In the early days it was thought as “applied science” which shows a unidirectional relationship between science and technology. However, with the emergence of the domain of philosophy of technology, this paradigm has been challenged (de Vries, 1996). Although it was thought that technology is the end product of the science, there is a bi-directional relationship in which both are affected by and affects each other (Constantinou et al., 2010).

Although technology has relationship with many domains, it has prominent place in science education due to many reasons. Firstly, it is considered as an important aspect of the nature of science. Then, technological products are the bridges between science lessons and daily life (de Vries, 1996). Moreover, realizing the potentials and constraints of both technology and science is required to be engaged in socio-scientific issues (Sadler, 2004). Therefore, both technology education and technology integration are required in science education.

One of the aims of the technology education is developing a technology concept in students’ minds. In technology education, technological knowledge should be taught with the normative components of that knowledge, including the ethical norms, in order to make students justice the nature of technological knowledge. To do this, students should learn both the functioning of the technological artifacts and norms, standards, and rules of thumbs of technological knowledge (de Vries, 2005).

Technology integration is something different from technology education. Technology integration means to use technology in an educational context to enhance student learning. The main benefit of technology in education is that it makes students independent learners who adjust their pace of learning according to their own rate (Al-Alwani, 2005). Students can determine the pace of the learning process according to their own pace by using information and communication technologies. Moreover, technology makes students more active and engaged in lessons and stimulates teamwork (Matray & Proulx, 1995). Information technologies laboratories provide chance to make teamwork and by this way every student have chance to participate actively in learning process. Becta (2002) report the advantages of using technology in education as greater motivation, increased self-esteem and confidence, enhanced questioning skills, promoting initiative and independent learning, improving presentation, developing problem solving capabilities, promoting better information handling skills, increasing ‘time on task’, improving social and communication skills.

Technology has also benefits on teacher. Teachers profit especially from information and communication technologies to keep record and organize students’ information and by this way they get more time for instructional activities. Moreover, teachers can communicate with their students in anytime from anywhere. It also helps teachers to be more creative and to present materials more interesting (Matray & Proulx, 1995) by the use of the properties of information communication technologies.

1.1. Science Education and Technology

Science teachers are early-adaptors of technology with the use of hand-held graphic calculators. They started to use technology in science lessons because it makes possible the lab activities, which cannot be held due to lack of time or equipment (Matray & Proulx, 1995). One of the first examples of uses of technology in lab is virtual frog-dissecting software program. With the heşp of this software, students can observe each organ of the frog in detail from different angles. Moreover, it helps science teachers in terms of solving the environmental regulations, safety and cleaning up problems. Technology also makes easier the data collection, experimentation and communication processes with appropriate software programs that yield immediate graphics or animations. Moreover, it can be more concentrated on process of science rather than scientific facts with these programs.

Due to the ongoing emergent technologies and knowledge, the need for new skills and qualities for citizens increased. Therefore, in order to ensure the inclusion of these skills, the curriculum has been changed in Turkey in early 2005. The name of the science lessons were changed to science and technology lessons with the curriculum reform in elementary schools. With this curriculum reform, science lessons were redesigned by integrating science technology society approach. The study of Tala (2008) reveals the needs for unification of science and technology education, although they are considered as separated domains traditionally. Therefore, the author suggests a new unifying view, *technoscience* in education to increase the coherence of learning processes of the two elements. Moreover, with the inclusion of the ICTs in schools, learning mediums are being changed. However, the technoscience teaching or effective ICT integration can be possible if pedagogical processes are managed successfully (Brooks, 2010). Therefore, the pedagogical practices of teachers gain importance. The next section focuses on pedagogical content knowledge and the integration of technology to it.

1.2. Pedagogical Content Knowledge

There is an emphasis on development of teacher knowledge for decades through research. By the late 1970s, it was thought that subject matter knowledge is the main focus for teaching. If a teacher knows about a subject more than all of his or her students, it would be sufficient for being an effective teacher. Shulman (1986) state the importance of content knowledge of teachers. The author demonstrated that the content knowledge is the core of the teaching. Then, again Shulman (1986) first introduced the notion of pedagogical content knowledge (PCK). Until when the first proposition of PCK notion, content and pedagogy have been considered separately. It has always been asserted that if one knows content, pedagogy is secondary and unimportant or if one knows pedagogy, content is not in his responsibility (p.6). Shulman defines the pedagogical content knowledge as knowing the reasons of difficulty or easiness of a specific subject matter by knowing different-aged students' cognitive levels and backgrounds. The researcher categorized content knowledge into three. The first category of content knowledge is subject matter content knowledge which is previously elaborated in Bloom's cognitive taxonomy, Gagne's varieties of learning, Schwab's distinction between substantive and syntactic structures of knowledge, and Peter's notions that parallel Schwab's (Shulman, 1986). The second category is pedagogical content knowledge which goes beyond knowledge of subject matter *per se* to subject matter *for teaching*. Shulman's (1987) PCK includes,

> for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations- in a word, the ways of representing and formulating the subject that make it comprehensible to others. (p. 9)

The last category of content knowledge is curricular knowledge which is the knowledge on programmes prepared to teach a particular topic to a particular grade level, the materials needed in the programme, and the indications and contraindications of the use of the programme or materials in particular situations.

In 1987, Shulman explained the knowledge bases of teachers broadly in seven categories which are content knowledge, general pedagogical knowledge, curriculum knowledge, and pedagogical content knowledge, knowledge of learners, knowledge of educational contexts and knowledge of educational ends, purposes, and values. (p. 8)

Since 1980s, when Shulman proposed PCK notion, the model has been revised many times by numerous science educators (Gess-Newsome & Lederman, 2002; Grossman, 1990; Magnusson, Krajcik, & Borko, 1999; Tamir, 1988). Grossman (1990) elaborated Shulman's framework in four general areas which are: (a) subject matter knowledge, (b) general pedagogical knowledge, (c) knowledge of context, and (d) pedagogical content knowledge.

After Grossman's (1990) elaboration, Magnusson, Krajicik, and Borko (1999) described the PCK as the *transformation* of several types of knowledge for teaching and conceptualized it similarly by adding one component. They include the "orientation toward science teaching and learning" component instead of the "overarching conceptions" term of Grossman. After little modifications Magnusson et al. (1999) defined the PCK for science teaching with five components which are (a) orientation toward science teaching, (b) knowledge of science curriculum, (c) knowledge of assessment for science, (d) knowledge of science instructional strategies, and (e) knowledge of student science understanding which is illustrated in Figure 1.1. They also differentiated between subject-specific and topic- specific instructional strategies in their model.

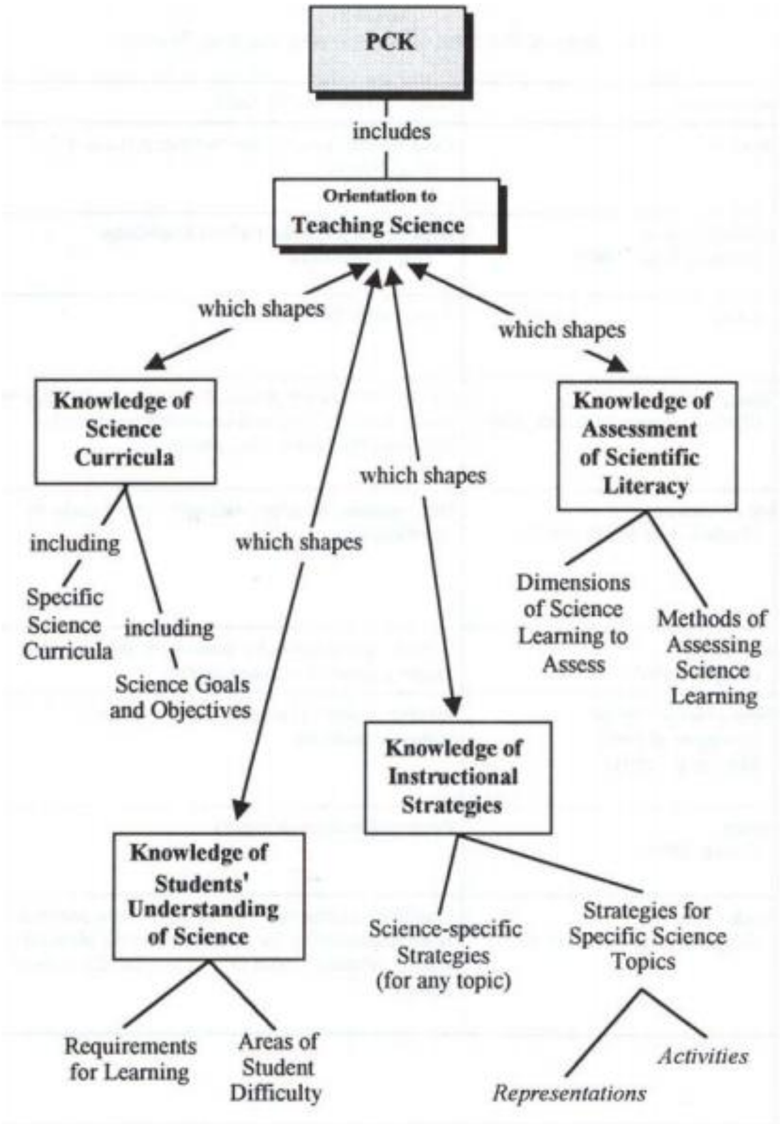

Figure 1.1 Components of pedagogical content knowledge framework

Source: Magnusson, Krajirik & Borko, 1999

Above discussion outlines the general views of researchers hold on PCK. From a general overall examination of PCK, researches on PCK have shifted to a more focused subject matter specific research studies. According to van Driel, Verloop and Vos (1998) a thorough and coherent understanding of subject matter acts as a prerequisite, preceding the development of PCK. For this reason, many researchers tried to explain the PCK development of science teachers by investigating their specific subject matter knowledge (Dawkins, Dickerson, McKinney, & Butler, 2008; Kaya, 2009; Uşak, 2005).

The content knowledge to be taught is genetic knowledge in this study. Therefore, in order to identify preservice science teachers perceptions of their competency of pedagogical content knowledge on genetics they were asked six point Likert-type questions including their competency on selecting teaching strategies, identifying common student misconceptions in genetics, selecting proper assessment strategies and using assessment outcomes when teaching genetics, and creating and managing science investigations related to genetics.

1.3. Technological Pedagogical Content Knowledge

Beside the above mentioned knowledge bases of teachers, technology knowledge has become an important category of knowledge base with the increase in presence of technology resources in schools and the changes in the curriculums. The need for elaborating PCK has emerged to make teachers learn how to teach with technology. Angeli and Valanides (2005) proposed ICT-related PCK to meet this need. Their ICT-related PCK notion includes pedagogical knowledge, subject area knowledge, knowledge of students, knowledge of environmental context, and ICT knowledge. Mishra and Koehler (2006) one of the proponents of Angeli and Valanides (2005) also think that teacher may use these communication and information technology in their daily life or they may know the working principles of them. However, it is not adequate for effective technology integration. In order to use those technological tools in an educational context, teachers should be able to blend their knowledge about the technology itself, and knowledge about how to use it in specific educational situations or contexts. Therefore, technology knowledge, which is the knowledge about technological devices and how to use them, is not by itself adequate not does it guarantee the effective technology integration. Thus, teacher should have other types of knowledge besides technology knowledge including content knowledge and pedagogical knowledge. Combination of these three important types of teacher knowledge - pedagogical knowledge, content knowledge, and technology knowledge - constitutes a new framework of Technological Pedagogical Content Knowledge (TPCK or TPACK) (Koehler & Mishra, 2008; Mishra & Koehler, 2006; Thompson & Mishra, 2007).

More recently researchers have started to conduct studies in order to better understand better the relationships between technological understanding and integration of them into courses. For this purpose, some of the researchers developed instruments to measure teachers' perceptions about technology and PCK (Koehler & Mishra, 2009), others interested in understanding this issue by collecting more detailed information about participants' practices with technology in natural setting through qualitative research (Epp, Green, Rahman, & Weaver, 2009; Ertmer, 1999).

In order to find the appropriate way to implement technology in science lessons teachers should have deep content knowledge, and technology knowledge, as well as pedagogical knowledge. Technological pedagogical content knowledge framework is a helpful framework in solving this complex problem of technology integration. Chalmers (1976) states that "precise, clearly formulated theories are a prerequisite for precise observation statements" (p.27). TPACK framework will also guide us for predicting preservice science teachers' future performances in technology integration. This study will contribute the literature with the development of an instrument which measure preservice science teachers' perceptions of their technological pedagogical content knowledge on a specific subject matter. In this study the preservice science teachers' perceptions of TPACK on genetics is investigated.

1.4. Genetics and TPACK

From first arguments until now, many knowledge categories and frameworks are generated to define and determine teacher knowledge (e.g., Borko & Putnam, 1996; Grossman, 1990; Guerrero, 2005; Koehler & Mishra, 2005; Shulman, 1986). The third component of pedagogical technology knowledge proposed by Guerrero (2005) is the depth and breadth of content. In the author's study the key role of the content knowledge is emphasized. Teachers should have extremely strong knowledge base in the subject matter in order to be confident in their ability to handle students' investigations and inquiries (Guerrero, 2005, p.263). When students are allowed to learn with technology, they will encounter a wide range of knowledge sources and in order to superintend their investigations teacher should have deeper content knowledge than the students. As a result, content knowledge is important in developing technology integration skills. Therefore, in this study a specific content knowledge which is genetics is emphasized in the investigation of the preservice science teachers' level of technological pedagogical content knowledge.

In this study genetics is decided for the subject matter. Genetics has close relationships with our daily life experiences. It is closely related with medicine, agriculture, industry, ethics as well as technology (Starbek, Starčič Erjavec, & Peklaj, 2010) which are the disciplines from daily life. Although they are from daily life, genetics concepts are abstract and not easy to teach and learn. Researches show that teaching these concepts with the aid of technological tools results better acquisition of knowledge (Kokol, Kokol, & Dinevski, 2005; Starbek et. al, 2010; Stewart, Hafner, Johnson, & Finkel, 1992) by ensuring visualization of abstract concepts and making students engaged in all activities and by yielding opportunity to manipulate organisms in virtual software programs that is hard to do with real organisms. Therefore, technological pedagogical content knowledge has important role in teaching genetics.

1.5. Significance of the Study

The importance of educational technology and integration of technology has increased over the years. Moreover, the ongoing increase in the new and innovative educational technologies changes the educational environment. Since teachers are responsible for adjusting the learning environment, new skills have aroused which a teacher should have for better technology integration have aroused (Cox, 2008).

In last few decades the technology opportunities of schools has increased in Turkey. SETI (Search for Extraterrestrial Intelligence at University of California, Berkeley) group's statistics reveal that Turkey is in 42nd order out of 102 country regarding computerization. Ministry of National Education has some attempts to integrate technology in schools. There are projects held by MoNE to improve the schools technologically. For example, with FATİH (Movement of Enhancing Opportunities and Improving Technology) project schools around the Turkey aimed to be equipped with information and communication technologies. With this project, 40 thousand schools and nearly 600 thousand classes will be equipped with the latest information technologies. With ICT-enhanced classrooms, it is aimed to increase quality in education and training and to ensure equality of opportunities. More recent projects about technology use in education are electronic exams, telecast, e-twinning, EĞİTEK call center, satellite and ADSL internet, INTEL teacher, and INTEL students (EĞİTEK, 2011).

Above mentioned information indicates that schools in Turkey have been equipped with technological products over time. However, the efficiency of technology integration is beyond counting. The ratios of students to computers or the number of hours they get used are not a measure of effective technology integration (U.S. Department of Education, National Center for Education Statistics, 2002; Ertmer, 1999). Putting computers into the classrooms without well trained teachers is not technology integration (Dockstader, 1999). Technology integration means to use technology in an educational context in a manner that enhance student learning. Technology integration can be achieved when technology is used effectively and efficiently in the general content areas to allow students to learn how to apply technology skills in meaningful ways. Effective technology integration can be ensured if discrete technology skills are integrated within the curriculum; technology is incorporated into education in a manner that enhances student learning; software supported for business applications are used so students learn to use computers flexibly, purposefully and creatively; have the curriculum drive the technology not the reverse; and the goals of curriculum and technology are organized into a coordinated, harmonious whole (Dockstader, 1999).

Therefore, integrating technology require not just the technology knowledge but a complex mixture of technology, pedagogy and content knowledge. There is not much study concerning the technology, pedagogy, and content knowledge of teachers in Turkey. Teachers' competencies in technology integration should be determined before putting the latest technologies into the classrooms. Otherwise, they remain just as waste of energy, time and money.

Since todays' preservice teachers will use those technologies in their future classrooms, their perceptions of TPACK are also important. Therefore, this study aimed to investigate preservice teachers' perceived TPACK which is the indicator of effective technology integration.

The developments related with environmental and health problems like transplantation, gene therapy, human genome project, microorganism genetics, and cancer make genetics education more important. In order to understand the developments in these areas, individuals should know basic genetic concepts, understand the relationships between them and make interpretations about them.

However, despite the increase in the importance of the genetics education, researches show that genetics is the most difficult topic to teach and learn. The reasons of the difficulty in understanding these concepts are lack of motivation, visual materials, experiementation, interest, and the nature of the topic which is based on memorization (Güneş & Güneş, 2005). Moreover, genetics topic includes invisible biological processes and abstract concept and the pronounciations of the concepts in the topic are so similar. Learning the genetics topic requires higher cognitive levels. Furthermore, the genetics topic is not suitable for experimentation. All of these make the teaching and learning genetics difficult (Sezen, Bahçekapılı, Özsevgeç & Ayaş, 2008). These difficulties in teaching and learning genetics make resarchers to seek for teaching methods that ensure meaningful learning in these difficult concepts. Because the methods that do not make the abstract concepts concrete on students mind cannot be sufficient to teach those concepts and the relationships between those concepts (Saka et. al, 2006). In order to teach genetic concepts in a way that make students active, ensure meaningful learning, and prevent misconceptions, teachers should be able to select proper instructional materials. Using technology is one of the most popular ways to make abstract concepts be more meaningful to the students. Therefore, teachers should have adequate knowledge to integrate technology into teaching effectively.

1.6. Research Questions

It is aimed in this study to answer the following questions:

1. What is the preservice science teachers' perceived technological pedagogical content knowledge on genetics?
2. Is there any relationship between the preservice science teachers' content knowledge and their perceived technological pedagogical content knowledge?
3. What are the relationships among the components of TPACK framework?
4. Is there a significant mean difference in perceived technological pedagogical content knowledge of male and female preservice science teachers?

5. What is the impact of year of enrollment on preservice science teachers' perceived technological pedagogical content knowledge?

1.7. Definition of Terms

Pre-service teachers: Teacher candidates who are enrolled in a teacher education undergraduate program in the universities in Central Anatolia in Turkey.

Technology: Technology is anything, process or product, by which humans modify nature to meet their needs and wants.

Educational technology: Tools, techniques and collective knowledge applicable to education including analog technologies (e.g., blackboard, pen, microscope) and digital technologies (e.g., computer) (ATE, 2003).

Technology integration: Using technology when appropriate times in appropriate topics and ways while following the curriculum. That is, organizing the goals of curriculum and technology into a coordinated, harmonious whole (Dockstader, 1999).

Technological Pedagogical Content Knowledge (TPACK): refers to the knowledge of teaching any content area with good pedagogy by using appropriate technology.

2. LITERATURE REVIEW

There is a huge body of research on teacher knowledge since 1980s when Shulman (1986, 1987) first introduced the notion of PCK. Although Shulman did not mention technology as an important knowledge base that teachers should have and its relations to pedagogy and content, there were technologies in the educational context at those times also. What preclude Shulman to consider technology is that the technological issues were not envisioned to the extent that they are today (Mishra & Koehler, 2006). Traditional classroom had also a variety of technologies from textbooks to overhead projectors at those times. However, most technologies were commonplace and were not considered even as technology. Today, in contrast, the term technology commonly refers to the digital computer technologies, artifacts, and mechanisms. The emergence of these digital technologies in education changed the learning environment or at least it has potential to do so. Therefore, what has changed from the Shulman's approach is that technologies have gained importance in educational context because of the availability of the new, digital technologies. Therefore, requirements for learning how to apply them into teaching has also appeared. In order to meet this requirement, Shulman's notion of PCK has been elaborated by many researchers in last decade.

In the next section, evolution of TPACK through a body of research in this field was mentioned. It has started from the elaboration of Shulman's PCK to integrate technology. Then some alternative terms to identify the knowledge required for effective technology integration was given from the literature. Then in the next section the current framework of TPACK was mentioned in detail. This chapter continued with the detailed explanation of the framework and subject-specific TPACK followed. After that, TPACK development and assessment of TPACK was examined in the light of the literature. Lastly, the gender issues in TPACK were mentioned and the chapter was closed with some information about genetics and genetics educational technologies knowledge.

2.1. From PCK to TPACK

Before the term was first stated, the idea of TPACK has been mentioned in many studies. Mishra (1998) was the first who mention the idea of TPACK in the context of educational software design. The researcher brought together different issues, which are studied generally in isolation. The issues which are brought into the same package were the nature of the domain and its relation to educational theory and the process of design and evaluation of computer programs. In short, Mishra (1998) laid the foundations of the idea of TPACK by mentioning the triad of content, theory and technology.

Pierson's (1999, 2001) works reveal the closest diagrammatic conceptualization of TPACK to the current diagram of TPACK. The findings of those studies suggest another component, which is *technology knowledge*, to the PCK model of Shulman (1986). Pierson (2001) defined technology knowledge as "not only basic technology competency but also an understanding of the unique characteristics of particular types of technologies that would lend themselves to particular aspects of the teaching and learning process" (p. 427). Pierson (2001) also stated the need for teachers to have an extensive content knowledge and pedagogical knowledge in combination with technology knowledge in order to integrate technology effectively and defined the intersection of the three knowledge areas as "true technology integration". Keating and Evans (2001) also mentioned the lack of TPACK of preservice teachers as the source of disconnect between feelings about using in their daily life and in their future classrooms.

Other researchers also mention the idea of TPACK under different labeling. For example, Gunter and Baumbach (2004) mentioned "curriculum integration" which is the effective integration of technology into the curriculum to meet the goals of the curriculum units and contains computer literacy, information literacy, and integration literacy. Since today's educators need to integrate technology into teaching to facilitate learning, they all should have *integration literacy* which is the ability to use technologies in combination with multiple teaching and learning strategies to enhance student learning. Likewise, Hughes (2004) use the term "technology integrationists" to define the teacher who have the ability to understand, consider, and choose to use technologies only when they uniquely enhance the curriculum, instruction and student understanding. In order to raise technology integrationists the researcher proposed four principles from the literature for in-service and preservice education which are (a) connecting technology learning to professional knowledge; (b) privilege subject matter and pedagogical content connections; (c) using technology learning to challenge current professional knowledge; and (d) teaching many technologies.

Angeli and Valanides (2005) defined the same idea with another label which was *the information and communication technology (ICT)-related PCK*. The researchers expanded the construct of PCK to explain the teacher knowledge which is necessary to teach with technology. Their ICT-related PCK notion consists pedagogical knowledge, subject area knowledge, knowledge of students, knowledge of environmental context and ICT knowledge. They also defined five principles as a guiding procedure to design ICT-enhanced learning which should be considered as inseparable dimensions. The dimensions of ICT-related PCK are (a) identify topics to be taught with ICT; (b) identify representations to transform the content; (c) identify teaching strategies; (d) select ICT tools to afford content transformations and support teaching strategies; and (e) infuse ICT activities in classroom instruction (Angeli & Valanides, 2005).

Another idea proposed by Guerrero (2005) to envision the teacher knowledge necessary for technology integration emphasize a new domain of expertise which is pedagogical technology knowledge. The researcher summarized many knowledge domains from the literature on teacher knowledge which are general pedagogical knowledge, subject matter knowledge, pedagogical content knowledge, knowledge of learners, theoretical knowledge, classroom knowledge, knowledge of context, craft knowledge, case knowledge, personal-practical knowledge and curricular knowledge and called the missing domain as pedagogical technology knowledge (PTK). Similar to other researchers, Guerrero (2005) mentioned the inadequacy of knowing some operational skills about technology to reach successful technology integration in teaching and learning. In this regard, the researcher viewed PTK beyond just knowing technology and characterized it by five central components. These components include ‘the general principles of instruction’, ‘organization and classroom management specific to the application of technology in the classrooms’, ‘teachers’ subject matter knowledge’, ‘understanding of how technology can make the subject matter more comprehensible for students’, and ‘content-specific nature of pedagogical technology knowledge’.

Similarly, Niess (2005) mentioned the idea in the label of ‘technology pedagogical content knowledge’. The researcher emphasized the difference between learning subject matter with technology and learning to teach that subject matter with technology. The technology PCK (TPCK) includes the overarching conception of what it means to teach with technology and requires multiple dimensions of knowledge. Niess (2005) defined the outcomes of TPCK development in a teacher preparation program by improving the four principal components of PCK defined by Grossman (1990). These components are (1) an overarching conception of what it means to teach a particular subject integrating technology in the learning; (2) knowledge of instructional strategies and representations for teaching particular topics with technology; (3) knowledge of students' understandings, thinking, and learning with technology in a particular subject; and (4) knowledge of curriculum and curriculum materials that integrate technology with learning in the subject area (Niess, 2005).

The current conceptualization of TPACK has been emerged with a series of publication in the field (Koehler, Mishra, Hershey, & Peruski, 2004; Koehler & Mishra, 2005a; 2005b; Koehler & Mishra, & Yahya, 2007; Mishra & Koehler, 2003, 2006). In their study, Mishra and Koehler (2003) investigated three learning by design courses for TPACK development of teachers, teacher candidates and instructors. They mainly focused on *how* to learn the technology rather than *what* technologies to learn and criticize the teacher education programs for other approaches. In their study, they generated an environment for technology integration learners to become *producer* of the technology instead of *consumer* of the technology. By comparing with another example in which the instructor was just the content developer and a technology expert was the technology developer, they mentioned the superiority of the learning by design approach in understanding of how content, pedagogy, and technology come together to give the course coherence. In these studies the researchers proposed the transactional model of effective technology integration with three components -content, technology and pedagogy- to integrate (Koehler, Mishra, Hershey, & Peruski, 2004; Koehler & Mishra, 2005; Mishra & Koehler, 2003). After a huge body of research studies which is based on five years of work focused on teacher professional development and faculty development in higher education, the TPACK framework has been emerged. The most comprehensive knowledge about TPACK can be found in Mishra and Koehler's (2006) study with a detailed description of the technology, pedagogy, and content knowledge as well as the knowledges emerging at the intersections of these knowledge domains. In the next section the framework and the knowledge domains in this framework were explained in detail with the examples from the literature.

2.2. TPACK Framework

The advancement in technology has changed the teaching and learning mediums, and practices. Teachers in 21^{st} century have become subject to many new, digital technologies that are not familiar to them. Therefore, teachers are obliged to gain new skills to compensate these learning environments. The competencies of teachers to become skillful in technology integrated classrooms in this information age forms a big list including concrete skills, software application, key technology concepts, and transformative uses of technology in the classroom (Mishra & Koehler, 2003). However, although teachers started to be educated about what technology to use, they are not well trained about how and where to use technology. This lack of comprehensive understanding on teacher knowledge can be due to the deficiency of theoretical grounding for technology integration (Mishra & Koehler, 2006). From an atheoretical perspective, it is difficult for a researcher to understand the complex relationship between the knowledge domains that teachers should gained. In order to fill this gap, TPACK framework was generated. It is aimed to give guidance to technology integration studies with a theory. In this regard, Mishra and Koehler (2006) constructed the Technological Pedagogical Content Knowledge (TPACK) framework to explain each aspect which is technology knowledge, content knowledge and pedagogical knowledge, and the relationships between and among them.

There are seven components in the framework arising from the intersections of the three main parts: Technology Knowledge (TK or T), Pedagogical Knowledge (PK or P) and Content Knowledge (CK or C). Technological Content Knowledge (TCK) arises from the intersection of TK and CK, while Technological Pedagogical Knowledge (TPK) takes place at the intersection of TK and PK, and Pedagogical Content Knowledge (PCK) at the intersection of PK and CK as indicated in the Figure 2.1. In this framework the interaction between teachers' understanding of educational technology and PCK is described by building upon the Shulman's (1987, 1986) description of PCK. Mishra and Koehler's (2008) definition of TPACK includes knowledge of how to make concepts understandable by using technology, knowledge of how to use technology with pedagogical knowledge in order to meet students' needs, knowledge of the difficulties in learning concepts and how to eliminate these difficulties by using technology, knowledge of students' epistemological beliefs and background knowledge and how to increase their epistemological beliefs level by using technology.

Each main knowledge domains and the component of the TPACK framework arising from the intersection of these knowledge domains were explained in detail in the following sections.

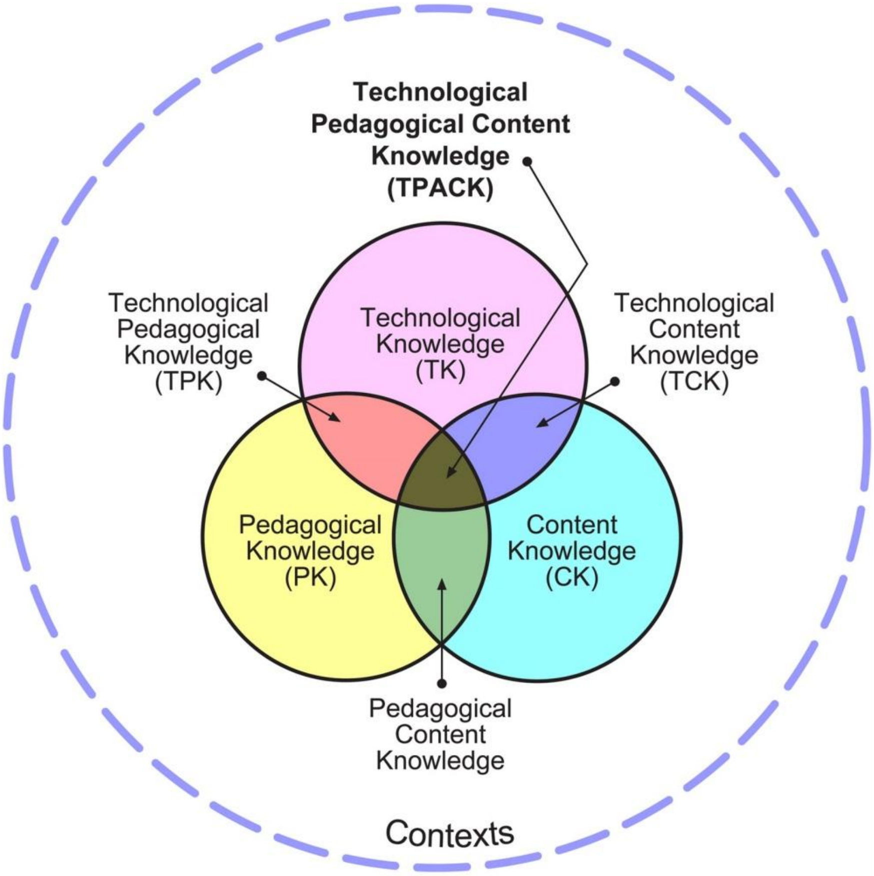

Figure 2.1 Technological Pedagogical Content Knowledge Framework

Source: Koehler & Mishra, 2009

2.2.1. Content Knowledge

Researchers define content knowledge as actual subject matter to be taught and learned (Koehler et al., 2004; Koehler & Mishra, 2005; Koehler et al., 2007; Koehler & Mishra, 2009; Mishra & Koehler, 2006; Mishra & Koehler, 2008). Shulman's (1987) definition of content knowledge is the knowledge, understanding, skill, and disposition that are to be learned by school children. While shaping the view of subject matter knowledge (SMK), Shulman (1986, 1987) defined the SMK as more than knowing the facts in a domain by using parallel characterization of knowledge as substantive and syntactic structures. SMK include not only the key facts, theories, and principles (substantive structure) but also the rules of evidence, proofs to generate justification and the nature of the inquiry in the field (syntactic structure). Briefly, a teacher needs to know *that* something is so as well as to understand *why* something is so (Shulman, 1986).

There are different studies in science education research to identify science teachers' subject matter knowledge. While some studies take the criteria of the number of science courses taken to define teachers' SMK, others use their conceptions and misconceptions in science. In order to determine conceptions and misconceptions of in-service and pre-service science teachers many forms of assessment were used like true/false questions, multiple choice questions, interview questions. Some studies tried to figure out syntactic SMK in science while others sought correlations between general science substantive

SMK and other teacher characteristics (Abell, 2007). There are discipline-specific studies on teacher SMK in biology, chemistry, earth and space science, and physics and their mixture. In this study preservice science teachers' SMK in biology, specifically in genetics concepts, was studied with a multiple choice test. Moreover, their perceived competency in genetic concepts was asked them with likert type questions.

2.2.2. Pedagogy Knowledge

Pedagogical Knowledge (PK) generally refers to knowledge about the processes and practices of teaching and learning, as well as the goals and values of education, teaching, student learning and assessment (Koehler et al., 2004; Koehler & Mishra, 2005, 2009; Koehler, Mishra & Yahya, 2007; Mishra & Koehler, 2006, 2008). Therefore, this knowledge covers knowledge about techniques or methods used to teach, educational purposes, characteristics of the learners, classroom management, lesson plan development and implementation, and methods to evaluate the understandings of the learners. In order to have a deep pedagogical knowledge a teacher should know about cognitive, social and developmental learning theories to understand how learners construct knowledge in mind or acquire skills (Mishra & Koehler, 2006).

Morine-Dershimer and Kent (1999) stated the distinction between general pedagogical knowledge and personal pedagogical knowledge in their model. According to their model classroom management and organization, instructional models and strategies, and classroom communication and discourse shape the general pedagogical knowledge while personal practical experience and personal beliefs affects the personal pedagogical knowledge. In their chapter the importance of classroom management and organization was stressed due to the fact that students learn more when teachers assign academic tasks appropriate to students' level, use time efficiently, implement instructional strategies with high involvement, communicate rules and expectations. Teachers use this knowledge depending on degree of their awareness of student cognition, the complexity of their knowledge structures and the extent of their practical experience. Instructional models and strategies is also crucial aspect of general pedagogical knowledge (Morine-Dershimer & Kent, 1999) which require the consideration of principles of learning like metacognition, individual differences, zone of proximal development, internalized dialogue and higher level thinking, process of group inquiry, students' developmental level and assessment procedures (Brown, 1997). The other aspect that feed general pedagogical knowledge is classroom communication and discourse which is the linguistic characteristics of teaching-learning process. Understanding communication patterns, the levels and qualities of questions used in the classroom, cultural differences in communication patterns leads to creation of more effective learning environments (Morine-Dershimer & Kent, 1999).

With the effect of teachers' prior beliefs and conceptions, and personal practical experience, personal pedagogical knowledge is formed. It is the context-specific knowledge which contributes to the pedagogical content knowledge. According to Morine-Dershimer and Kent (1999) prospective teachers' prior beliefs and images of learning and teaching affect what they learn in their professional development. Moreover, novice teachers' knowledge and perceptions change during student teaching and the first year of profession when they encounter cases which provide realistic, authentic examples to practice problem solving skills.

It is impossible to teach content without this pedagogical knowledge or to implement this pedagogical knowledge without content. Unification of these two elements of teacher knowledge constitutes the Shulman's concept of pedagogical content knowledge. Therefore, the knowledge presented in this section is pertinent to general pedagogical knowledge. In this study the questions asked under the pedagogical knowledge section in the instrument to figure out the perceptions of preservice science teachers' pedagogical knowledge are also related with the general pedagogical knowledge.

2.2.3. Technology Knowledge

Technology knowledge (TK) was defined by Cox & Graham (2009) as knowing how to use emerging technologies. Technology knowledge was defined by researchers as the knowledge about standard technologies like books, chalk, as well as more advanced ones like digital technologies or the Internet (Koehler et al., 2004; Koehler & Mishra, 2005; Koehler et al., 2007; Mishra & Koehler, 2006, 2008). Guerrero (2005) defined technology operationally as contemporary instructional and learning technologies that engage teacher and students in teaching and learning processes. However, Koehler and Mishra (2009) emphasized the difficulty of making definition of this term due to its being always in state of flux. The difficulty causes from the danger of the definitions' becoming outdated. In this study mostly advanced technologies were referred like Internet and digital technologies with the term technology. Preservice teachers' perceptions of their competency in educational knowledge, genetic technologies and project-specific technologies like Wikis, blogs or podcasts were aimed to be assessed with the instruments used in the study.

Technology knowledge includes the skills required to operate particular technologies. However, it is beyond to know how to use a specific technology. Since technology is in state of flux, the nature of technology knowledge should also change in time as well. Due to its changing nature many technologies used by teachers may change or even disappear in time. Therefore, instead of learning the technology itself, teacher would be better to gain the ability to learn and adapt to new technologies. To summarize, teachers with technological knowledge can operate a technological device, troubleshoot the problems they encounter when using technology, notice the affordances and constrains of technology, and adopt themselves with the changes in technology.

2.2.4. Pedagogical Content Knowledge

Shulman (1986) was the first scholar who unified the content and pedagogy into the notion of pedagogical content knowledge. The researcher analyzed the studies about teacher knowledge held until that time for their focus which was either of knowledge of content or knowledge of how teachers manage the classroom, organize activities, allocate time and turns and other pedagogical issues. What was missed in those studies was the content of the lessons taught, the questions asked and the explanations offered. Sole content knowledge is as useless as content-free skills (Shulman, 1986, p.8). Therefore, the missing paradigm was the blending of these two. Shulman defined this intersection as pedagogical content knowledge which is the subject matter for teaching. However, some researchers continued to use separate knowledge domains in their researches. There are two types of models for pedagogical content knowledge that researchers accept; namely, integrative and transformative model (Gess-Newsome, 1999).

In the integrative model, PCK resembles a mixture in which the teacher selects the knowledge of content, pedagogy and context and integrates them when needed. Therefore, the teacher with PCK can be defined as who has well-organized individual knowledge base that are easily accessed and flexibly used during teaching (Gess-Newsome, 1999, p.11). The transformative model on the other hand emphasizes the importance of synthesized knowledge base for teaching which resembles a compound. While there are different knowledge bases including subject matter, pedagogy, and context, they are useful only when they are transformed into PCK. In this case the transformed PCK is easily accessible to the teacher in teaching. In Figure 2.2 these two models are illustrated.

Both models have implications for teacher education programs and have advantages and disadvantages. In integrative model, in which subject matter, pedagogy and context are separated, there is danger that teachers emphasize the importance of content over pedagogy. On the other hand, in the transformative model which recognize the value of synthesized knowledge base the danger is that teachers may ignore the development of decision making skills and mimic the cases (Gess-Newsome, 1999).

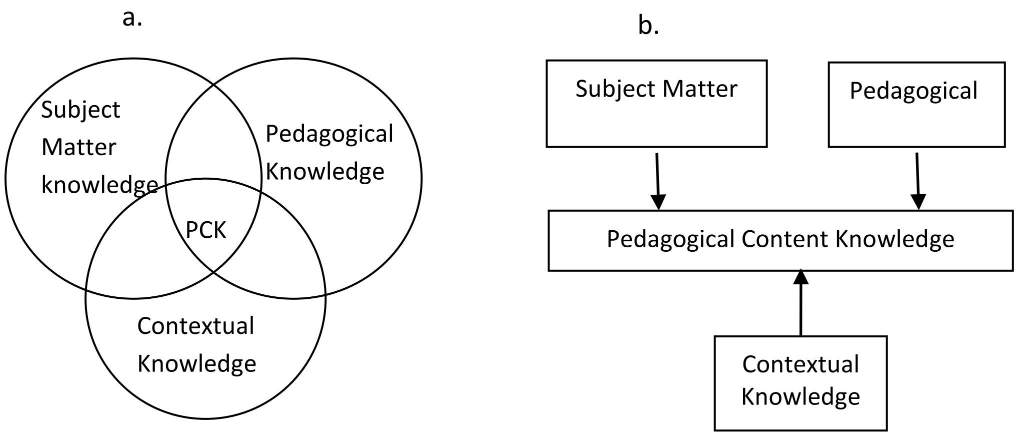

Figure 2.2 Models of teacher knowledge (a)Transformative model (b) Integrative model Source: Gess-Newsome, 1999

In this study, pedagogical content knowledge (PCK) refers to ability to blender the teaching method with the content knowledge to be taught by using the knowledge of learning and learners and knowledge about educational goals in order to meet students' needs effectively (Schmidt, Baran, Thompson, Mishra, Koehler and Shin, 2009).

2.2.5. Technological Content Knowledge

Technological content knowledge (TCK) is an understanding that technology and content influence and constrains one another (Mishra & Koehler, 2009). This definition states a bidirectional relationship between technology and content. At one hand content constrains the representations given with technology and on the other hand technology can constrains the kinds of representations possible.

Technology constrains the representation of the subject matter taught. On the other hand technology affords the types of content to be taught. For example, by the help of technology, physics can be learned without calculus (McCrory, 2008). Increasing the types of representation is another affordance of technology. Using the analogy of pump when teaching the hearth can be given as an example to this situation.

In some situations in which technology is integral to science, teaching the technology is teaching the content itself. In these cases teacher's TCK gains a prominent role. For example, using a microscope can be an example. It is meaningless to teach about a microscope or to teach about what can be seen with a microscope. The best way is to have students to use microscope

(McCrory, 2008). Therefore, teacher should know what technologies to use in which situation that requires TCK.

In the elaborated model of TPACK that Cox and Graham (2009) proposed, TCK refers to “knowledge of the topic-specific representations in a given content domain that utilize emerging technologies” (p.64). Although their definition does not state a bidirectional relationship as in the definition of Mishra and Koehler’s (2009) one, they define TCK practically as knowledge of how to represent concepts with technology. In this study, TCK in the elaborated model of TPACK was preferred in the simple form. Therefore, preservice teachers are asked about their perceptions of competency on choosing proper technologies that enhance student learning in genetics.

2.2.6. Technological Pedagogical Knowledge

Technological pedagogical knowledge (TPK) is knowledge of how to use specific technology in specific ways to change learning and teaching (Mishra & Koehler, 2009). It is the knowledge of general pedagogical activities that a teacher can engage in using emerging technologies (Cox & Graham, 2009). Therefore, it is independent from the content and can be applicable to any content. The relationship between technology and pedagogy is also bidirectional as in the relationship between technology and content. Therefore, TPK is the knowledge about the potential of technology to change and enhance teaching and learning environments. TPK means also knowing how teaching can be changed by using particular technologies. Therefore, teachers with TPK know the pedagogical uses of any technology. Conversely, teachers with TPK know how to enhance their teaching and solve the pedagogical problems by using technology.

To illustrate, a teacher can use the forums to create an online discourse environment. This can help teachers in the way that teacher can encourage all the students to participate since students who hesitate to participate in oral discourse can easily participate in online discourse. Moreover, the wait time can be increased to encourage student participation. These help teachers to make all the students active in learning process. In this case technology affords the pedagogy. However, in order to be effective, teacher should know the structure of online discourse environment. For example, online discourse may not give chance to give instant feedback. Moreover, both teachers and students should know the rules of using written discourse since it hides the gestures or mimics used for appreciation, approval or disapproval. In this case pedagogy restricts the use of technology.

Teacher should be able to identify the pedagogical issues that are difficult to solve in the absence of technology. Some of the situations that technology use is useful in science are speeding up time via simulations of natural events, seeing things that could not otherwise be seen, recording and organizing data that would otherwise be hard to do, sharing information and communicating with others, etc. (McCrory, 2008). Other pedagogical uses of technology are increasing student motivation and creating cooperative learning environment as mentioned in the elaborated model of Cox and Graham (2009).

TPK is particularly important for teachers, because most of the software programs or technological devices that teachers use are not designed for educational purposes (Koehler & Mishra, 2009). Therefore deciding the pedagogical uses of the technologies which are originally used for the purpose of business, entertainment, communication or social networking requires TPK.

In this study preservice science teachers were asked for perceptions of their competency on identifying technologies that work effectively with specific teaching approaches, choosing technologies to enhance teaching and learning, adopting technology used based upon the student needs, managing the classroom while using technology etc. with likert type questions.

2.2.7. Technological Pedagogical Content Knowledge

Technological Pedagogical Content Knowledge (TPACK) refers to the complex interrelationship between technology knowledge, pedagogical knowledge and subject matter knowledge of teachers (Mishra & Kohler, 2006). It means more than technology knowledge, pedagogy knowledge or content knowledge per se. According to the definition of the researchers (Mishra & Koehler, 2006, 2008; Koehler & Mishra, 2009) TPACK is

> the basis of good teaching with technology and requires and understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to

> teach content; knowledge of what makes concept difficult or easy to learn and how technology can help redress some of the problems that student face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones.

TPACK is the knowledge required for effective technology integration. Teaching with technology entails interweaving of the three sources of knowledge which are technology, pedagogy and content. There is no one way for every teacher, every course or every context to integrate technology. Therefore, there is a complex, dynamic relationship between these three sources of knowledge. Introduction of an emergent technology into teaching practices cause imbalance in this dynamic and teacher need to consider pedagogical issues as well as content to be taught when teaching with that technology.

TPACK is a knowledge domain that teachers use in any teaching although they are not aware; because, teachers use many technologies form chalkboards to smart boards in teaching. As Cox and Graham (2009) mentioned in their elaborated model, TPACK transforms into PCK when the technologies used in the activities become commonplace. For example, a teacher may know how to use laboratory environments to make experiments in teaching and alternatively she may know how to use virtual laboratory environments. While knowledge of how to use virtual laboratory activities represent TPACK of the teacher, knowledge of how to use laboratory environments represent PCK and when virtual laboratory environments become transparent to the teacher, TPACK transforms into PCK. However, the need for TPACK never ends; because, there will always be new emerging technologies that have not yet become transparent part of teaching tools (Cox & Graham, 2009).

2.3. Subject - Specific TPACK

There is extensive study on pedagogical content knowledge in science (Gess-Newsome & Lederman, 2002; Magnussan, Krajcik & Borko, 2002). Since TPACK is the extension of PCK, the similar studies with PCK were done for TPACK. Many science education researchers conducted research with technology itself and science teaching. There is not so much study that uses TPACK as a framework in science education research. The studies that recommend the development of subject-specific TPACK and that use TPACK as a framework in science teaching and learning were mentioned in this section.

Niess's (2005) study is one of the proposers of the need for developing subject-specific TPACK. According to the researcher the main challenge in teacher education programs is to prepare teacher candidates to teach their specific subject matter in an integrated manner. This integrated knowledge structure includes the intersection of knowledge of subject matter and knowledge of teaching and learning which constitute pedagogical content knowledge. In the case of the integration of technology in teaching and learning, science teachers should also develop an integrated knowledge structure of teaching their specific subject matter with technology. However, pre-service teachers are taught about teaching and learning with technology in a more generic manner that is unconnected with the development of their knowledge of subject matter. This contradicts with the meaning of TPACK that is the integration of the development of knowledge of subject matter with the development of technology and of knowledge of teaching and learning (Niess, 2005, p.510).

In the study of Doering and Veletsianos (2007) it was mentioned about the lack of the integration of geospatial technology into geography lessons. However, this problem is not related with the access to such technologies. They claimed that although the geospatial technologies and data are available, the integration of them cannot be successful even if the design and development of preservice and inservice teacher education programs include geographical technological pedagogical knowledge (G-TPCK).

According to the approach that is based on empirical assumption proposed by Harris, Mishra and Koehler (2009), the best technology integration can be accomplished by considering students' content-related learning needs. The main focus in this approach to planning construction was on content-based (content specific) pedagogy that is enhanced with selected and implemented technologies. Therefore, the development of teachers'

TPACK-in-action require the understanding the differences among learning activities in different content areas.

Graham et. al's (2009) experimental study used TPACK as a framework in a professional development program to measure the increase in inservice science teachers' TPACK confidence. According to their results there were significant improvements in all TPACK constructs while the TCK scores were so much lower than TPACK scores. They also found that the science teachers generally used technology with general pedagogical strategies than with content-specific pedagogical strategies. This may be due to the fact that science teachers were not even aware of technologies related with their subject matter at the beginning of the study but they were given general pedagogical uses of technologies in their teacher education programs. The researchers recommended to help teachers develop TCK confidence by helping them learn more about content-specific technologies that are used in doing science.

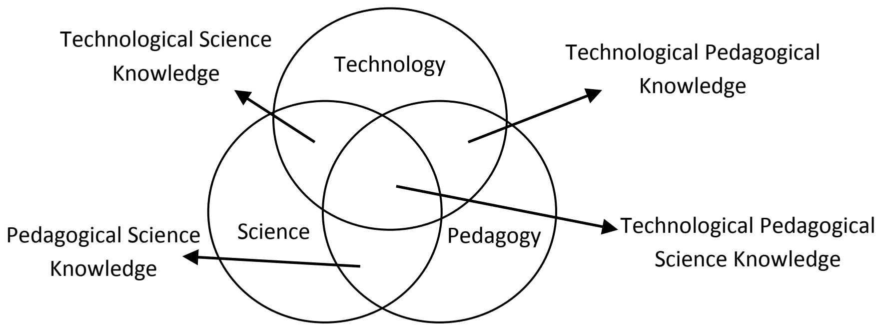

Figure 2.3. The framework for technological pedagogical science knowledge (TPASK) Source: Jimoyiannis, 2010

Jimoyiannis (2010) designed and implemented a new model of Technological Pedagogical Science Knowledge (TPASK) for science teachers' professional development which was built upon the integrated TPACK model (Figure 2.3). The researcher described all of the elements of TPASK and evaluated the model with a phenomenological case study conducted with four participants.

The researcher's model makes contribution to the educational research in implementing TPACK model with detailed description of the elements of it. With this descriptions researcher aimed to overcome the theoretical restriction in the applications of TPACK and to clarify the boundaries and interrelations between technology, pedagogy, and content (science) (Jimoyiannis, 2010). The detailed descriptions regarding the elements of TPASK proposed by the researcher are given in Table 2.1.

Table 2.1 Knowledge Components of TPASK

Elements of TPASK	Knowledge Components
Pedagogical Science Knowledge (PSK)	• Scientific Knowledge • Science curriculum • Transformation of scientific knowledge • Students' learning difficulties about specific scientific fields • Learning strategies • General pedagogy • Educational context
Technological Science Knowledge (TSK)	• Resources and tools available for science subjects • Operational and technical skills related to specific Scientific knowledge • Transformation of Scientific Knowledge • Transformation in scientific processes
Technological Pedagogical Knowledge (TPK)	• Affordances of ICT tools • Learning strategies supported by ICT • Fostering scientific inquiry with ICT • Information skills • Student scaffolding • Students' technical difficulties

There are also studies about subject-specific TPACK in Turkey (Kaya, Kaya, Yilayaz, Aydemir, & Karakaya, 2011; Timur & Tasar, 2011). Timur and Tasar (2011) aimed to examine the development of pre-service teachers' technological pedagogical content knowledge components when using micro teaching in force and movement subjects in their study. The researchers found that micro teachings were effective for developing the two components of TPACK which are instructional strategies and representations for teaching force and movement subjects with technology (ISTE) and curricula and curriculum materials that integrate technology with learning in this subject area (CUTE).

The other study related to the subject-specific TPACK was conducted by Kaya et al. (2011). The researchers explored preservice science teachers' TPACK and their real classroom teaching practices about photosynthesis and cellular respiration. The researchers found that preservice science teachers have insufficient conceptual knowledge and views on nature of science. Moreover, the participants' understandings of students' learning difficulties and topic-specific technological knowledge were very low.

2.4. Development of TPACK

Many researchers stated lack of confidence as one of the problems in effective technology integration (Becta, 2002; Bingimlas, 2009; Brickner, 1995; Hendren, 1995). According to Becta's survey (2004) lack of confidence is the mostly responded alternative among the barriers (21% of the total responses). Teachers feel themselves anxious when using technology in front of the students even they feel themselves confident in using technology in their daily life. Lack of confidence of teachers for using technology can be attributed to students' being more experienced with these technologies. In Becta's survey (2004) teachers were stated their hesitation for entering classrooms which are full of students who are well equipped with technological knowledge and they fear to fail and to be humiliated. This shows that lack of teacher knowledge cause teachers to feel not confident with using technology.

The main problem which directly affects the level of teacher confidence is teachers' competence in using technology in educational context (Bingimlas, 2009). As it can be predicted, competence can be achieved with adequate and appropriate trainings. Therefore, teacher training become the determinant of teacher competence. Teachers can achieve effective technology integration with the development of TPACK in teacher education programs.

There are different approaches for the development of TPACK. However, the approaches that teach technology skills per se do not go far enough (Koehler & Mishra, 2008). Since the TPACK is intertwined teacher knowledge, teaching technology, pedagogy, and content in isolation will not help teachers to develop an understanding to put this knowledge to good use (Koehler & Mishra, 2008). The researchers recommend spiral-like development of TPACK in that it is started with simple and more familiar technologies and moving through more advance unfamiliar technologies because the understanding of constraints and affordances of technology can be applied to any kind of technology. Besides spiral-like development they also suggest the need for the emphasis on subject matter instead of applying technological knowledge in every subject matter. While developing TPACK as mentioned, giving chance to practice and considering the context are crucial.

2.4.1. TPACK in Pre-service Education

Integrating TPACK into the preservice teacher education programs is a wicked problem because preservice teachers do not have experience in learning their subject matter with these new and emerging technologies. Since teachers teach in the way they were taught (Smith and Kubasko, 2006; Kengwe, Onchwari & Wachira, 2008), teacher educators' or mentees who are taken as model by pre-service teachers are important in learning how to use technology in educational contexts. However, preservice teachers lack role models to guide them through the necessary changes they will need to make to be successful in integrating new technology into their classroom (Johnson & Lui, 2000). In order to reach successful technology integration, education leaders should provide model for teachers (Keengwe et al., 2008).

In order to solve this wicked problem, teacher educators should teach the preservice teachers to rethink, unlearn, and relearn, change, revise and adapt (Niess, 2008). The teacher preparation programs must challenge the preservice teachers with the issues in teaching with technology. For example, science preservice teachers must be faced with the difference in student learning with direct experience and with technological tool or simulations. The preservice teachers should evaluate both to decide which one of them provides the best classroom experience (Niess, 2008).

In order to make preservice teachers to rethink, unlearn, and relearn, change, revise and adapt their TPACK knowledge, Jang and Chen (2010) proposed a transformative model for preservice science teachers' TPACK development which is TPACK-COPR. According to their model preservice science teachers realized that it was difficult to implement traditional instructional strategy on some abstract units; thus, they would tend to incorporate powerful pedagogy in the Comprehension phase of the model. In the Observation phase, observing experienced science teachers helped them imitate and apply instructional strategies. In the Practice of teaching, they were offered practical opportunities to select and transform technology tools with science pedagogy in lesson design. In the last phase which is the Reflection phase, they reflected that they had learned TPACK.

This model can be applied in method courses to provide an environment for preservice teachers to discuss TPACK, gain experience with teaching TPACK via microteachings and instructional planning, and give feedback about their development of TPACK. There are some studies using method courses, where the curriculum and technology meet, to develop TPACK of preservice teachers (Keeler, 2008; Ozgun-Koca, Meagher & Edwards, 2010; Timur & Tasar, 2011).

In their study, Ozgun-Koca, Meagher and Edwards (2010) investigated how preservice teachers develop TPACK during their method classes and field experiences. The researcher analyzed the activities and field experience reports, and mathematics technology attitudes survey (MTAS) results of 20 preservice teachers. The researchers claimed a shift in thinking of technology as a reinforcement tool to thinking of technology as tool for developing understanding. The participants realized the affordances and constraints of the technology to engage students in inquiry based tasks when they were mixing technology, content and pedagogy. The researchers also claimed the change in participants' own identity from learner of mathematics to teacher of mathematics with technology use. Their desire to do mathematics has increased with technology. At the end of the study researchers found that the participants realized most of the relationships among technology, pedagogy and content. Several preservice teachers mentioned the appropriate uses of technology which shows their TCK and at the end of the study participants stated that they feel themselves prepared to use technology in their teaching.

It can be concluded from the studies that in teacher preparation programs, changing the design of method courses by considering developing TPACK's way of thinking can meet students' needs to learn to integrate technology and develop TPACK.

2.4.2. TPACK in In-service Education

Experienced teachers' knowledge is situated, event-structured, and episodic; therefore, any attempt to develop experienced teachers' TPACK should consider these characteristics (Harris, 2008). The researcher claimed that well-developed TPCK may be positively correlated with general teaching expertise. Teachers have rich event-structured, socially situated and episodic experience, although they have less technology expertise. This gives advantage to the experienced teachers in development of TPCK. In the definition of TPCK, Mishra and Koehler stated that "quality teaching requires developing a nuanced understanding of the complex relationships among technology, content, and pedagogy, and using this understanding to develop appropriate, context-specific strategies and representation (2006, p.1029)". If teachers have rich array of strategies and representations the development of TPCK take place more quickly in experienced teachers than the novice teachers.

In order to develop TPACK of in-service teachers, the researchers used professional development programs like field experiences (Cantrell & Knudson, 2006), online learning environments (Doering, Veletsianos, Scharber & Miller 2009) or projects. These studies aimed to increase the teachers' specific experiences related to the integration of technology in their field and to develop their TPACK.

In order to assist development of TPCK, Harris (2008) suggested "activity structures" in which activity refers to specific phenomena taking place in the classroom and the structures are more general and applicable across multiple contexts. This approach in teacher professional development about technology integration help teachers to recognize, differentiate, discuss, select among, combine, and apply TPCK-oriented activity types in curriculum standard-based instructional design (Harris, 2008).

A more specific professional development opportunity for social studies teachers and the impact of it on TPCK was examined in the study of Doering et al. (2009). They assisted geography teachers' TPACK development with GeoThentic Professional Development. In their study, researchers proposed a new model for TPACK in which there exist context around the circles and the size of the circles concerning technology, pedagogy and content can varies. The reasons for this change were that teachers may not practice what they know. Because context influences teachers' practice and in turn their knowledge. Moreover, teachers may not use all of the knowledge equally. Therefore, the model should not be thought static. The representation of it should be dynamic with one knowledge domain dominated over the others (Doering et al., 2009).

As it can be concluded from the studies, in-service teachers have already representations and strategies in teaching and learning. In order to develop their TPACK, they should be provided technology enhanced teaching and learning experiences via professional development programs.

2.5. Assessment of TPACK

Assessing the effectiveness of teacher education programs or professional development programs should be more than getting feedback from the participants about their satisfaction (Pierson & Borthwick, 2010). There should be a framework to evaluate the effectiveness of the program which aims the development of TPACK of preservice or inservice teachers. There are many studies aim to develop TPACK and they used qualitative and quantitative methods to evaluate the effectiveness of the study and the increase in TPACK.

In order to better understand how TPACK can be developed an instrument is needed to measure it. There are some studies in the literature that aim to develop a valid and reliable instrument to measure TPACK (Angeli & Valanides, 2009; Archambault & Crippen, 2009; Chai, Koh & Tsai, 2010; Koh, Chai & Tsai, 2010; Lee & Tsai, 2010; Lux, 2010; MaKinster, Boone& Trautman, 2010; McCrory, 2010; Sahin, 2011; Schmidth et al., 2009; Timur & Tasar, 2011) in different contents.

Schmidt et al. (2009) first attempted to measure preservice teachers' TPACK for content areas of mathematics, social studies, science and literacy. They validated the items with expert reviews and piloted it with 124 preservice teachers. The Cronbach's alpha value of at least 0.80 for each construct indicated the reliability of the instrument. The dissertation of Lux (2010) also aimed to assess the preservice teachers' TPACK with PT-TPACK Survey. The instrument validated with exploratory and confirmatory factor analysis. It was found that TCK dimension did not emerge as opposed to the model of Koehler and Mishra (2006). Moreover, the study conducted by Koh, Chai and Tsai (2010) also aimed to examine the profile of Singaporean preservice teachers in terms of TPACK with a TPACK survey. They studied with 1185 preservice teachers and found five constructs in their survey with exploratory factor analysis. They also examined the difference in TPACK perception by gender.

There are also studies on the development of TPACK surveys for specific areas. Graham et al. (2009) developed an instrument for inservice teachers to measure their TPACK in science teaching. Archambault and Crippen (2009) developed a 24 items instrument that measures the online teachers' knowledge. The instrument designed in 5-point Likert-type scale and includes at least 3 items in all domains of TPACK. The Cronbach's alpha found in their study ranged form 0.70 to 0.93 for the seven TPACK constructs. Another study conducted by Chai et al. (2010) aimed to develop an instrument to assess the preservice teachers' development of TPACK in TPACK-driven ICT course design. The purpose of the Lee and Tsai's (2010) study was to fill the gaps in development of TPACK surveys for Singapore teachers. Their survey aimed to measure teachers' perceived self-efficacy in terms of TPACK-W. This survey was developed to measure Taiwanese teachers' TPACK with respect to educational use of web. High internal consistency was found while the exploratory factor analysis showed the unification of pedagogical knowledge and pedagogical content knowledge in the validation process. McCrory (2010) also developed an instrument which is Technology Integration in Mathematics for Prospective Elementary Teachers Survey (TIMPETS) to measure preservice mathematics teachers' TPACK.

There are also instrument development studies in Turkey. Sahin (2011) developed a survey of TPACK which contains items in seven subscales of TPACK. The validity and reliability analyses were performed by conduction exploratory factor analysis and by calculating item correlations and Cronbach's alpha internal consistency coefficients. The Cronbach's alpha coefficients were ranged form 0.86 to 0.93. Moreover, an instrument adaptation study was conducted in Turkey by Timur and Tasar (2011) to measure the teachers' TPACK confidence. The study was conducted with 393 science and technology teachers and the validity of the instrument was examined with confirmatory factor analysis. The instrument includes 31 items in four dimensions and their reliabilities ranged from 0.86 to 0.92.

There are many instruments to measure the preservice and inservice teachers' TPACK. However, these studies only aimed to develop and validate the instruments. The effect of the demographic variables to the TPACK scores did not examined in these studies except the ones conducted by Lee and Tsai (2010) and Koh, Chai and Tsai (2010).

In this study the instrument which was developed by Makinster, Boone and Trautman (2010) to measure the perceived TPACK of preservice science teachers was adopted to the Perceived TPACK on Genetics version and translated into Turkish.

2.6. Gender Issues in TPACK

Technology is considered masculine in nature because of its privileged definition which derivate from ‘tekne’ Greek word which means ‘woodmaker’ (Daker, Dow & McNamee, 2009). Technology education also holds the same nature. However, this does not mean women or girls lack the technical skills or knowledge. The reason for girls in choosing technology interest is the perception of technology as masculine. According to the results of the study of Daker, Dow and McNamee (2009) when technological knowledge is taught based on knowing how and knowing that, girls are less interested in these technologies. On the other hand if they taught the understanding between technology and ethics and sustainability and debating the impact of technology on their lives, both girls and boys develop more interest in the subject matter. Therefore, the masculinity of the technology knowledge is based on the technology education style.

There are some studies interested in the gender differences in TPACK. In the study conducted by Kaya, Ozdemir, Emre and Kaya (2011), the gender difference in perception of self-efficacy in Web-TPACK was examined. 177 preservice teachers from the departments of Computer Education and Instructional Technology in Faculty of Education, and Electronics and Computer Education in Faculty of Technical Education were selected for the study. Their study revealed that self-efficacy in Web-TPACK differed only in Web communication sub dimension in favor of males. However, this study was conducted with low number of females who have already been following technologically oriented career paths.

Koh, Chai and Tsai (2010) conducted another study with 1185 preservice teachers who just began the first semester of their teacher education training program and they did not take any form of ICT instruction yet. Their study revealed that male participants rated themselves higher in the perception of technological knowledge, content knowledge and knowledge of teaching with technology.

2.7. Genetics and Genetics Educational Technologies Knowledge

Many researchers indicated the relationship between subject matter knowledge and teaching. Because the researches showed that the teachers' alternative conceptions are the same with their students' alternative conceptions (Wandersee et al., 1994). Therefore, the knowledge of teachers in a subject matter determines the effectiveness of their teaching in that subject matter. In the case of genetics, teacher knowledge gains more importance. Teachers need to keep up to date their knowledge continually, because the genetics and genetic technologies evolve rapidly. Teaching and learning genetics is more difficult that the other discipline areas because of the abstract nature of the genetic concepts.

Saka, Cerrah, Akdeniz & Ayas (2006) studied the knowledge and images of different aged students about gene, DNA and chromosome. The researchers analyzed their drawings and the explanations of the concepts. All of the participants made the functional explanation of the gene while none of them made the structural explanation. Their drawings and explanations showed that students have alternative conception about the concepts of DNA, gene and chromosome in terms of their place in the cell and in the hierarchy among them.

Since the genetic concepts are abstract and teaching genetics with multimedia results better acquisition of knowledge and improvement in comprehension (Kokol, Kokol, & Dinevski, 2005; Starbek et. al, 2010; Stewart, Hafner, Johnson, & Finkel, 1992), the use of genetics educational technologies is important. The study of Nisselle, Aitken, Kennedy, Metcalfe (2007) investigated the most popularly used genetic educational technologies by the Australian secondary school science teachers. The researchers found that Australian secondary science teachers use genetics educational technologies in computer laboratories rather than science laboratories indicating that it was the students themselves using the technology. Moreover, 200 participants reported use of 140 different genetics educational technology, although the participants may not be representative.

3. METHOD

3.1. Research Design and Variables

This study aimed to investigate the preservice science teachers' perceived technological pedagogical content knowledge on genetics. In this regard, the following research questions were answered:

1. What is the preservice science teachers' perceived technological pedagogical content knowledge on genetics?
2. Is there any relationship between the preservice science teachers' content knowledge and their perceived technological pedagogical content knowledge?
3. What are the relationships among the components of TPACK framework?
4. Is there a significant mean difference in perceived technological pedagogical content knowledge of male and female preservice science teachers?
5. What is the impact of year of enrollment on preservice science teachers' perceived technological pedagogical content knowledge?

In this study, survey research methodology was used. Survey research is the most appropriate research design to obtain the information about the participants' perceived technological pedagogical content knowledge on genetics.

3.2. Participants and Sampling Procedure

This study was conducted with preservice science teachers who are enrolled in elementary science education departments of Education Faculties of eight public universities located in Central Anatolia. All of the 11 public universities in Central Anatolia constituted the target population of this study. The accessible population constitutes the preservice science teachers enrolled in eight public universities. At her convenience the researcher was able to collect data from eight public universities which were Gazi University, Hacettepe University, Middle East Technical University, Osmangazi University, Erciyes University, Selcuk University and Ahi Evran University. There are about 3800 preservice science teachers continuing their education in these universities. Of these 3800 preservice teachers, 1530 preservice science teachers participated to the study. The 40 % response rate was achieved and this response rate can be accepted as high enough to represent accessible population.

3.2.1. Descriptive Analyses

The descriptive statistics were performed with PASW 18. General characteristics of the participants were provided in Table 3.1. According to Table 3.1 most of the participants were female (72,8 %). About 65% of the participants have gained neither formal nor informal teaching experience during their undergraduate education. Only 3.2% of the participants have more than 200 hours formal experience, which involve participants' school or dershane experiences as teachers or interns, and 2.2% of the participants have informal experience.

Table 3.1 Demographic Characteristics of the Sample

	n	**Percent**
Gender		
Male	415	27,1
Female	1114	72,8
Grade Level		
Freshmen	429	28,0
Sophomore	384	25,1
Junior	456	29,8
Senior	258	16,9
Formal experience		
None	1021	66,7
0-50 hours	282	18,4
50-100 hours	89	5,8
100-200 hours	55	3,6
200+ hours	49	3,2
Informal experience		
None	895	62,2
0-50 hours	417	29,0
50-100 hours	63	4,4
100-200 hours	33	2,3
200+ hours	31	2,2
Planned technology use frequency		
Never	7	0,5
Sometimes	33	2,2
Frequently	242	15,8
Usually	1032	68,1
Always	198	13,7
Interest areas in technology		
Energy Technologies	326	21,3
Transportation	348	22,7
Biotechnology, Bioinformatics	628	41,0
Robotics and Applied Mechanics	217	14,2
Information Technology	805	52,6
Communication Technology	909	59,4
Others	28	1,8

When the participants were asked how frequent they plan to use technology in science teaching, most of them (68%, n=1032) stated that they will usually use technology in their science teaching. Seven of them said they will never use technology and about 14% of them said they will always use technology in teaching.

Participants were also asked about the courses they took in their universities about teaching methods, field experience and technology. They took about two teaching method courses (M=1.69), less than one field experience course (M=0.33) and more than one technology course (M=1.19).

The last demographic information about the participants was related to their field of interest in technology. More than half of the participants were interested in information technology (52.6%) and communication technology (59.4%). The other popular technology field was biotechnology/bioinformatics. Over 40% of the participants were interested in this field. Moreover, 22.7% of them were interested in transportation technology and 14.2% of them were interested in robotics.

3.3. Survey Instruments

The survey instruments used in this study which are perceived TPACK on Genetics Questionnaire and Genetic Concepts Test were mentioned in this section.

3.3.1. Perceived TPACK on Genetics Questionnaire

There were two instruments used in this research which were perceived TPACK questionnaire, which was later adopted by the researcher to perceived TPACK on genetics (see Appendix A), and genetic concepts test (see Appendix B). The perceived TPACK questionnaire was developed by MaKinster, Boone, and Trautmann, (2010). It was originally developed to assess preservice science teachers' perceived TPACK on science. The items related to science knowledge were changed to specific genetic concepts. One of the subdimensions, which was related with geospatial technologies, was removed and the genetic technologies subdimension was added. By this way, the questionnaire was adapted to genetic concepts and translated into Turkish by the researcher of this study. Before translation of the scale into Turkish, adaptation of the scale to the genetics concepts was done in English. The researcher Boone, who is one of the developers of the instrument and a professor in science education, provided his comments on the adapted scale. According to his suggestion the necessary revisions were made for the items. After finishing the adaptation on genetic concepts in English, the Turkish translation was done. An expert committee worked for the translation of the instrument. First, the researcher translated the instrument into Turkish and feedbacks on this version are obtained from the academic writing center of the university. Necessary changes were made by considering the suggestions of the language expert. Then, to maintain the consistency of the terms with their original uses of the scale a specialist in the research on pedagogical content knowledge, an expert from biology education, and an expert from science education reviewed the instrument. By considering all of the suggestions, the final revision was formatted with the help of English language expert in the academic writing center.

Table 3.2 Components of Technological Pedagogical Content Knowledge Instrument

Components	**Description**	**Number of Items**
Technology Knowledge (TK)	Items related to the measurement of preservice science teachers' technology knowledge	
Educational Technology (ET)	Items related to the measurement of preservice science teachers' educational technology knowledge	8
Genetic Technology (GT)	Items related to the measurement of preservice science teachers' genetic technology knowledge	9
Project Specific Technology (PST)	Items related to the measurement of preservice science teachers' project specific technology knowledge	8
Content Knowledge (CK)	Items related to the measurement of preservice science teachers' content knowledge	9
Pedagogical Knowledge (PK)	Items related to the measurement of preservice science teachers' pedagogical knowledge	9
Pedagogical Content Knowledge (PCK)	Items related to the measurement of preservice science teachers' pedagogical content knowledge	9
Technological Content Knowledge (TCK)	Items related to the measurement of preservice science teachers' technological content knowledge	9
Technological Pedagogical Knowledge (TPK)	Items related to the measurement of preservice science teachers' technological pedagogical knowledge	9
Technological Pedagogical Content Knowledge (TPACK)	Items related to the measurement of preservice science teachers' technological pedagogical content knowledge	9

Note. This table contains the variable names and number of items for 7 components on the TPACK scale.

There are seven main components in the instrument which are technology knowledge (educational technologies, genetic technologies, and project-specific technologies), content knowledge, pedagogical knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge. Numbers of items for each component are given in the Table 3.2. There are totally 79 items in the instrument. The answers of the participants were collected by using the 6-point Likert scale format ranging from strongly disagree to strongly agree. Table 3.2 presents the components of the instrument.

3.3.2. Genetic Concept Test

The other scale used in this study was the genetic concept test which utilized to measure the preservice science teachers' content knowledge on genetics. There are 20 multiple choice items in this test. This instrument was adapted from the genetic concepts test of Sadler and Zeidler (2005). Sadler and Zeidler (2005) found the internal consistency of the instrument which is calculated by Kuder-Richardson estimate (KR_{20}) as 0.79. For this study the test was translated from English to Turkish with an expert committee. Two specialists from science education and one expert from academic writing center reviewed the translated test. The Turkish version was finalized after making the necessary changes in light of the suggestions of the experts.

3.4. Piloting the Instruments

The instrument was piloted with 131 preservice science teachers. Johanson and Brooks (2009) suggested 30 representative participants as the minimum number in a pilot study of preliminary survey and scale development although the sample size depends on the purpose of the study in pilot studies. The researchers also stress the need for selecting samples which are representative of the population in interest. Therefore, characteristics of the sample which are used in piloting are also crucial.

The reliability statistics were calculated for each knowledge domain. The reliabilities, as represented by coefficient alpha values, were .859 for TK, .902 for CK, .954 for PK, .888 for TCK, .943 for TPK, .940 for PCK, and .959 for TPACK. These values represent high reliability.

The other test developed by Sadler and Zeidler (2005), and adopted by the researchers, was also piloted with 131 preservice science teachers. ITEMAN analysis was run to analyze each content question. According to the results of the ITEMAN analysis, two of the twenty items were decided to be removed.

3.5. Preliminary Instrument Analysis

3.5.1. Validity and Reliability of the Genetics Concept Test

For the current study validity and reliability analysis of the instruments were conducted. Therefore item analysis was run to examine the validity and reliability of the instrument. Moreover, Cronbach's coefficient alpha and KR20 values were calculated to examine the reliability.

3.5.2. ITEMAN Analysis

For item analysis as a rule-of-thumb proposed by Nunnaly (1967, as cited in Crocker & Algina, 1986) it is necessary to have 5 to 10 times as many subjects as items. Moreover, Crocker and Algina (1986) recommend minimum number of 200. Therefore, there should be at least 200 samples, since we have 20 items. The sample is 1530 in this study; therefore there were enough participants to do item analysis.

Raw scores ranged from 0 (0.3%) to 19 (0.1%) items answered correctly out of 20 items. The distribution of scores approximated a normal distribution (skewness = -0.296; kurtosis = -0.151) with a mean of 10.929 and standard deviation of 3.136. The proportion of individuals who answered a particular question correctly (p value) which shows the difficulty of the item, ranged from 0.888 indicating a very easy question to 0.108 indicating a very difficult question. The alpha value is 0.650 which suggested that the test was moderately reliable. It gave the same alpha value with PASW 18.

Since the test was dichotomously coded, the index of discrimination was found by looking to the biserial and point biserial values. Biserial correlation coefficients ranged from 0.205 to 0.732. Point-biserial correlation coefficients varied from 0.146 to 0.576. There were 6 questions that have point biserial value less than .30. Ebel (1965) recommends revising the items with discrimination values between .20 and .30. There were two items which have point biserial values less than .20. These items were 3th, and 14th items.

Therefore, these items were removed from the instrument in the main study. Table 3.3 gives the item statistics for each 20 item in the Genetics Concept Test.

Table 3.3 Item Statistics of the Genetics Concept Test

Item No	Prop Correct	Biserial	Point Biserial
1	0.878	0.353	0.218
2	0.798	0.537	0.377
3	0.165	0.260	0.174
4	0.284	0.264	0.199
5	0.888	0.532	0.322
6	0.701	0.338	0.256
7	0.529	0.717	0.572
8	0.609	0.732	0.576
9	0.817	0.669	0.459
10	0.688	0.684	0.522
11	0.216	0.205	0.146
12	0.724	0.555	0.415
13	0.415	0.419	0.331
14	0.108	0.272	0.162
15	0.760	0.665	0.484
16	0.625	0.622	0.487
17	0.408	0.417	0.329
18	0.710	0.536	0.405
19	0.348	0.478	0.371
20	0.256	0.409	0.301

When we examine the items in terms of the proportion of correct answers, it can be realized that item 14 is the most difficult item. Only 11% of the participants answered this item correctly. This item was related to ranking of the genetic structures. Most of the participants chose the wrong alternatives. This indicates that participants have difficulty in genetic structures. This can also be realized by the third item which was the next difficult one with 17%

correct answers. In this item one of the confounding alternatives was chosen more than the correct alternative. The reason of this distraction can be the misconceptions of the participants in the concepts of allele and gene. Moreover, in item 11 participants were confused about the allele, gene, DNA, chromosome, and genome concepts. The participants had also difficulty in understanding the function of the genes as it can be understood from the fourth item.

The easiest item is the 5th item as it can be seen from the Table 3.3. It was answered correctly by 89% of the participants. The items numbered 7, 13 and 17 had the ideal difficulty level which was between .40 and .60 (Crocker & Algina, 1986).

The results were consistent with the literature because one of the most widely-recognized misconceptions in genetics is the 'hierarchy' of genetic organizations (Nisselle; Aitken, Kennedy, Metcalfe, 2007). Moreover, students can understand the patterns of inheritance because of the chance of observation; however, they have difficulty with the alternative forms of genes (alleles) and dominance (Nisselle et al., 2007).

3.5.3. Reliability Analysis for Genetic Concept Test

Cronbach's coefficient alpha value was calculated with reliability analysis in PASW 18 in order to check internal consistency of the test. This analysis yield alpha value of .659 which can be considered acceptable (Cronbach, 1951). Moreover, ITEMAN analysis gave the same results.

This test is composed of dichotomously scored items; therefore, it would be better to calculate the Kuder Richardson 20 value. The item difficulties vary as it is seen in the results of ITEMAN analysis. Therefore, KR 20 can be preferred to KR 21 because when item difficulties vary, the reliability estimate from the KR 21 is systematically lower than the KR 20 (Crocker & Algine, 1986). The KR 20 formula is

$$KR_{20} = \frac{k}{k-1}\left(1 - \frac{\sum pq}{\hat{\sigma}_x^2}\right)$$

where k is the number of items $\hat{\sigma}_x^2$ is the total test variance, and pq is the variance of item *i*. The computations according to this formula also yield .659 which is consistent with the alpha value obtained from PASW 18 and ITEMAN analysis.

3.5.4. Validity and Reliability Analysis of Perceived TPACK on Genetics Questionnaire

Exploratory factory analysis (EFA) was conducted to examine the dimensionality of the 79 items on the TPACK questionnaire. There are 79 items in the scale. In this study exploratory factor analysis was conducted to determine how many factors are present and whether the factors are correlated. The cross-loaded items were removed from the scale and seventy six items were decided to be included in the scale. With these items principal component analysis was conducted. The use of principal component analysis (PCA) helped us transforming a set of correlated variables into a set of uncorrelated variables (the components) since PCA ensure the researcher who is interested in reducing a large number of variables down to a smaller number of variables (Tabachnick & Fidell, 1996). These components are interpreted by using the component-variable correlation (factor loadings) (Stevens, 2009). In order to interpret the extracted factors varimax rotation was used. The goal of varimax rotation is to simplify factors by maximizing the variance of the loadings within factors (Tabachnick & Fidell, 1996). The resulted model yielded 8 factors: educational technology knowledge (ETK), genetic technologies knowledge (GTK), project specific technology knowledge (PSTK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK).

3.5.4.1. Assumptions of Factor Analysis

Pallant (2007) stated size and the strength of the relationship among variables as the main two issues to be considered in order to check the suitability of the data for factor analysis.

Regarding sample size, Tabachnick and Fidell (1996) stated that "it is comforting to have at least 300 cases for factor analysis" (p. 640). Nunally (1978, as cited in Pallant, 2007) recommends 10 cases for each item to be factor analyzed. In this study, there were 79 items and 1530 participants. According to the Nunally's recommendation of the ratio of factor to independent variable, there should be at least 79*10= 790 participants. We have 1530; therefore, the sample size assumption was assured.

Regarding the strength of the correlations among the items, Tabachnick and Fidell (1996) recommended to check correlation matrix to seek an evidence of coefficient greater than .3. It was seen from the correlation matrix that coefficients .3 and above present. Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) values also gave information about the factorability of the data. The Bartlett's test of sphericity should be significant ($p<.05$) for the factor analysis to be considered appropriate. The KMO value should be greater than .6 for a good factor analysis (Tabachnick & Fidell, 1996). For this study, Kaiser-Meyer-Olkin (KMO) was .965, exceeding the recommended value of .6 (Kaiser, 1970, 1974) and Bartlett's test of sphericity (1954) reached statistical significance ($p=.000<.05$), supporting the factorability of the correlation matrix.

3.5.4.2. Communalities

Communality values are multiple R^2 values for regression models predicting the variables of interest from the 8 factors. The communality for a given variable can be interpreted as the proportion of variation in that variable explained by the three factors. In other words, if we perform multiple regression of item1 against the two common factors, we obtain an $R^2 = 0.559$, indicating that about 55.9% of the variation in item1 is explained by the factor model. The results suggest that the factor analysis explain variation in item1 well. According to Pallant (2007) low communality values (e.g. less than .3) indicate that the item does not fit well with the other items in its component (p.196).

One assessment of how well this model is doing can be obtained from the communalities. What one wants to see is the values that are close to one. This would indicate that the model explains most of the variation for those variables. In this case, the model explains the variance in items generally, and it does better for some variables than it does for others. The model explains item 20 the best with the communality value of 0.804. Communalities for the items of TPACK questionnaire were consistently high with communality values greater than 0.3. The least communality value, 0.414, was obtained for item 10.

3.5.4.3. Factor Extraction

According to the most widely used criteria of Kaiser (1960), if the number of factors ranged from 10 to 40, components having an eigenvalue of 1 or more were interested in. Although this rule makes us retain only the most important factors and increase the practical significance, it causes too much factor extraction. Therefore, it should be better to look also the scree plot which is illustrated in Figure 3.1. A change (or elbow) should be looked at in the shape of the plot.

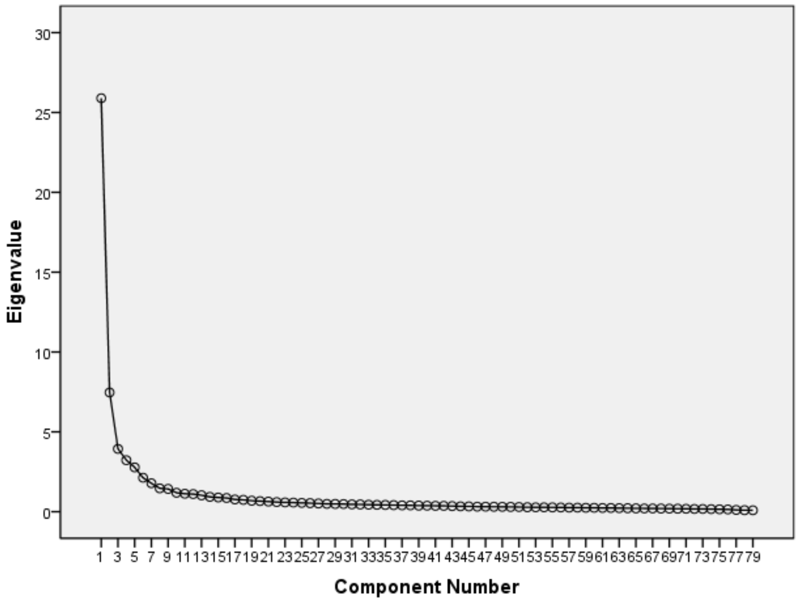

Figure 3.1 Scree Plot

In our study there are 13 components that have eigenvalue higher than 1 and these explains 69% of the variance. However, it is seen more proper to extract 8 components by looking at the scree plot. The first 8 component explains 63.4% of the variance. Therefore, it was decided to extract 8 components.

3.5.4.4. Factor Rotation

In order to interpret eight components, Varimax with Kaiser Normalization rotation method was performed. These eight factors explained a total of 63.4 per cent of the variance. The first component contributed over 33% of the total variance, while the second one approximately 10 %. The third and fourth components contributed about 4% and the fifth one 3.6%, the sixth and seventh components contributed approximately 2.5%. The last components contributed 1.9% of the total variance.

There are many rules in interpreting the significance of factor loadings. Stevens (2009) suggests considering sample size in determining the critical value for a correlation coefficient and recommends a table for it based on the sample size. In this table doubling value of .081 is recommended for sample size larger than 1000. According to this table, only loadings > 2(.081) = .162 in absolute value would be declared statistically significant (p.332). Although this loading is statistically significant, the practical significance is in doubt; because, this loading value indicates only 4% shared variance between the variable and the factor. To increase this percent to 15, .40 or greater loading value will be used to interpret the results. In Table 3.4 factor loadings and communality values of each 76 item were given.

Table 3.4 Factor Loadings and Communalities (h^2)

Item	F_1^a	F_2	F_3	F_4	F_5	F_6	F_7	F_8	h^2
TPACK_73	,752		,226						,692
TPK_66	,739	,284							,673
TPK_70	,725	,243							,644
TPK_64	,721	,344							,710
TPK_65	,712	,290							,651
TPK_69	,709	,286							,636
TPACK_76	,705		,264						,661
TPACK_74	,703		,269						,659
TPK_68	,695	,302							,621
TPACK_75	,690		,300						,676

Table 3.4 Continued / 1

TPK_63	,676	,338							,643
TPACK_79	,657		,256						,584
TPACK_78	,654		,337						,641
TPACK_77	,654		,328						,602
TPK_67	,651	,352							,588
TPACK_71	,648		,334						,603
TPACK_72	,640		,389						,665
TPK_62	,602	,287							,545
PK_37	,236	,757							,691
PK_40	,280	,756							,724
PK_36	,253	,736							,688
PK_39	,272	,730							,682
PK_35	,248	,718							,676
PK_43	,297	,712							,662
PK_38	,251	,701							,620
PK_42	,279	,697	,219						,634
PK_41	,252	,695	,204						,621
PCK_45	,230	,260	,707	,221					,699
PCK_47	,298	,234	,692	,225					,695
PCK_46	,287	,293	,691	,257					,744
PCK_48	,312	,239	,678	,228					,694
PCK_49	,306	,255	,657					,200	,684
PCK_50	,313	,274	,641					,235	,689
PCK_44	,280	,338	,630	,251					,698
PCK_51	,285	,302	,613					,286	,686
PCK_52	,309	,302	,606					,235	,656
CK_32	,200			,758					,696
CK_31	,204			,725					,681
CK_33	,221			,694	,219				,626
CK_30				,676		,320			,630
CK_27				,668		,272			,628
CK_34	,240		,200	,655					,594
CK_29				,626		,276			,528
CK_26				,621		,283			,581
CK_28				,596		,217			,486
PSTK_20					,865				,804
PSTK_19					,849				,778
PSTK_21					,840				,761
PSTK_22					,831				,733
PSTK_18					,803				,703
PSTK_23					,720				,724
PSTK_25					,666				,732
PSTK_24					,556				,670
GTK_15						,809			,712
GTK_14						,790			,671
GTK_13					,266	,684			,585
GTK_16				,310		,667			,589
GTK_12				,229		,587			,488

Table 3.4 Continued / 2

GTK_17				,407		,583			,542
GTK_11				,238		,558			,471
GTK_9				,252		,472			,479
GTK_10				,262		,464			,414
ETK_5	,213						,712		,644
ETK_3	,205						,674		,629
ETK_6	,206						,674		,607
ETK_4							,672		,529
ETK_2							,649	,217	,673
ETK_1							,606		,577
ETK_7	,222						,599		,516
ETK_8	,256						,552		,470
TCK_54		,203	,252					,622	,728
TCK_57			,284					,608	,728
TCK_56			,305					,608	,736
TCK_58			,294					,591	,702
TCK_55			,285	,222				,569	,693
TCK_53								,566	,384

[a] Factor labels:

F_1 Tehnological Pedagogical Content Knowlegde (TPACK)

F_2 Pedagogical Knowledge (PK)

F_3 Pedagogical Content Knowledge (PCK)

F_4 Content Knowledge (CK)

F_5 Project Specific Technology Knowledge (PSTK)

F_6 Genetic Technology Knowledge (GTK)

F_7 Educational Technology Knowledge (ETK)

F_8 Technological Content Knowledge (TCK)

The first component included the items associated with the overall understanding of the interactions between pedagogy, content and technology which was called TPACK. This component also included the items related to Technological Pedagogical Knowledge (TPK). The two components of the original scale, which are TPACK and TPK, loaded in the same component and they were called as TPACK. Component 2 was composed of the items related to general pedagogical knowledge including teaching methods, classroom management, assessment and the knowledge of the students. This component was called as PK”. Component 3 contained items related to the interaction between content knowledge and pedagogical knowledge and it was called as PCK”. The fourth component was comprised of the items related to the genetic knowledge and it was called as CK. Component 5 included the items related to the knowledge of project specific technologies like Wikis, blogs or podcasts. This component was called as PSTK. The next component was composed of items that are related to genetic technologies including gene therapy, recombinant DNA etc. and this component was called GTK. Component 7 included items about educational technology knowledge and this component was called as ETK. The last component was comprised of the items related to the knowledge of technology to teach the genetics topic. This component was labeled as TCK. Although the priory hypothesis proposed by Koehler and Mishra (2005) purports that TPK is a component of the TPACK construct, this idea did not hold true for this study.

3.5.5. Reliability Analysis for Perceived TPACK on Genetic Questionnaire

After administration of the instruments to the sample, reliability values were examined for Perceived TPACK on Genetic Questionnaire with proper methods. The reliability of each factor and of the entire scale was examined. In order to estimate the internal consistency of the scale, Cronbach's coefficient alpha was calculated with the aid of PASW 18. Alpha value for the whole scale suggested strong internal consistency (α=.967). A commonly-accepted rule of thumb is that an α of 0.6-0.7 indicates acceptable reliability, and 0.8 or higher indicates good reliability (Cronbach, 1951).

The corrected item-total correlation values were also interpreted to examine the degree to which each item correlates with the total score. These values are the Pearson product-moment correlation between responses to the item and average scores for examinees. According to Crocker and Algina (1986, p. 315), if item-scale correlation ≥ .40, it means the item is functioning quite satisfactorily. If .30 ≤ item-scale correlation ≤ .39, little or no revision is required. If .20 ≤ item-scale correlation ≤ .29, the item is marginal and needs revision. If item-scale correlation ≤ .19, the item should be eliminated or completely revised. Our reliability values revealed that most of the items had item-scale correlation value higher than .40 and these items are functioning quite well (see Appendix D). Only ten items have internal-consistency value between .30 and .39 and these are also acceptable values. The impact of removing each item from the scale was also examined. If any of the Cronbach alpha value when item deleted is higher than the final alpha value, we may consider removing this item from the scale. There was no such item to remove for this questionnaire.

After examining the reliability values of the whole questionnaire each adapted factor's Cronbach's coefficient alphas were also calculated. All the results from the adapted stepwise reliability analysis were given in Table 3.5.

Table 3.5 Results of reliability analysis for adapted TPACK scale

Latent Variable	Adapted Instrument Items	α
Technological Pedagogical Content Knowledge (TPACK)	62-79	.960
Pedagogical Knowledge (PK)	35-43	.939
Pedagogical Content Knowledge (PCK)	44-52	.946
Content Knowledge (CK)	26-34	.910
Project Specific Technology Knowledge (PSTK)	18-25	.921
Genetic Technology Knowledge (GTK)	9-17	.874
Educational Technology Knowledge (ETK)	1-8	.866
Technological Content Knowledge (TCK)	53-58	.866

3.6. Data Collection Procedures

The survey instruments were administered to the preservice science teachers in their classrooms. The approximate time of filling the scale was 20 - 30 minutes. The researcher administered the questionnaire to the participants. Before administration, the researcher informed the participants about how to fill the questionnaire. Moreover, the researcher stayed in the class to answer the further questions coming from the participants. Throughout this procedure the researcher tried to ensure the consistency in data collection procedure.

The data collection period was started at November, 2010 and lasted until May, 2011. All the students who enrolled in teacher training program in the selected universities were expected to fill the TPACK instrument. An Informed

Consent form (see Appendix C) was distributed to each participant before the administration of the instruments. The participants were allowed to participate to the study voluntarily. After they signed the Informed Consent form, the survey instrument was given to the voluntary ones.

3.7. Data Analysis Procedures

Data which were gathered from the preservice teachers were imported to the PASW18, Predictive Analytics SoftWare. The imported data were analyzed by using descriptive and inferential statistics. Descriptive statistics was used to summarize, organize and simplify data while inferential statistics was used to make conclusions from them.

In the Perceived TPACK on Genetics Questionnaire the statement Strongly Disagree was coded with 1 while the statement of Strongly Agree with 6. By this way the data was treated as interval data. The mean of each of the component of TPACK was able to be calculated. Like statements participant was also given number, but not to treat as interval data, just to give identity to each. The two items related to teaching experience in demographics part was coded from 0 to 4. The answers to the frequency question were numbered from 1 to 5 corresponding from never to always, respectively.

The missing data was changed with the mean of the item. Moreover, the pairwise case was used in analysis in order not to lose all data of an individual when there is a non-response item.

In order to answer the first research question descriptive information about the components of TPACK was given. Correlational analyses were used to identify the relationship between each component of the perceived TPACK on genetics and their genetic knowledge. A Pearson Correlation assisted in determining whether there was a relationship or not between them. Effect size, the strength and the direction of the relationship were also found from this statistical analysis. The results were used to answer the second research question. Another correlational analysis was conducted for the third research question. By calculating Pearson correlation coefficients the relationship among the components of the TPACK were investigated.

MANOVA was conducted to investigate the impact of gender on perceived TPACK on genetics of preservice science teachers. Whether there were mean differences among the TPACK components in terms of gender and where these differences lie were investigated by this analysis. The results of the analysis were used to answer the fourth research question. Lastly, another MANOVA was conducted to answer the last research question and to find a statistically significant mean difference among the year of enrollment for each component of TPACK. Then follow-up ANOVA analyses were conducted to find out where the mean differences exist.

3.8. Internal Validity Threat

In order to handle the mortality threat, more samples was selected than it is needed. Although 1090 sample was necessary to conduct this survey, 1400 participants were selected in case of lack of participants. At the end of the study 1530 participants were reached. Therefore, mortality threat was handled in this study.

Moreover, instrumentation threat was handled by an appropriate research design. Administration procedure was made consistent. For example, the questionnaires to all of the participants were administered by the researcher.

Furthermore, the location threat was handled by trying to keep the data collection places similar. Although data was collected from different universities in different cities, they were all collected in the classrooms of the participants which were similar to each other.

The selection of participants may result in the individuals or groups differing from one another in unintended ways which are related to the variables to be studied. This is defined as subject characteristics threat (Fraenkel and Wallen, 2006). In this study in order to minimize this threat, characteristics of the participants are tried to be controlled. Moreover, their demographic information was requested in the data collection with the questions about their gender, age etc.

History threat takes place if unexpected event affects results of the study (Fraenkel and Wallen, 2006). Although there seems to be no unexpected events during data collection, this threat may not be handled, since the researcher cannot know what happens in the life of the participants before the administration of the instruments.

There was not testing threat because the instruments were administered to the participants once. Therefore, there is no risk of becoming used to questions being asked.

Maturation was not a threat for this study. This is not a longitudinal study that the participants become mature during the data collection procedure. There was one administration in time. Moreover, the participants were in similar age. Therefore, maturation was not a threat.

3.9. Limitation of the Study

This study uses self-reported survey instrument to measure the preservice teachers' perception of their TPACK although there is the risk that some respondents may "overestimate or underestimate their competency" (Perkmen, 2008, p.20). In the survey, participants were asked how much they agree with the items which include the statements about the ability to use technology in teaching, ability to teach genetics concepts etc. The possible disadvantage of these items is that participants may be prone to give answers in the way that they think the data collector or teacher education program expect them to respond. This situation cause systematic bias in the data collection and can influence the validity and reliability of the instrument.

Another limitation in the study is again related with the instruments used in the study. The genetic concept test was used to measure participants' genetic knowledge. This test was in the multiple choice format. However, in multiple choice questions there is always chance factor. Participants may select one alternative by guessing. Although the answer was right this does not show that the participant knows the answer of the question. Moreover, this test was applied to the participants together with perceived TPACK on genetic questionnaire and there are 119 items in total to be answered by participants. They can be tired and select the alternatives by guessing. This also causes bias in the study and affects the reliability of the instrument.

The third limitation of this study is about the understandability of the instrument. This study was conducted with preservice science teachers from all grades. They were asked about their content, technology and pedagogy knowledge. However, in teacher education programs the pedagogy lessons are given intensely starting from the second year. Therefore, the freshmen may not know the terms related with the pedagogical knowledge. Similarly, they take the genetics and biotechnology courses in third and fourth years. Thus, the items may seem them meaningless and their answers may be affected from this.

4. RESULTS

This chapter represents the results of the study. The results were presented pertaining to each research question.

4.1. Research Question One

What is the pre-service science teachers' perceived technological pedagogical content knowledge on genetics?

The aim of the research question 1 was to explore the pre-service science teachers' perceived technological pedagogical content knowledge according to their answers to the questions in the TPACK on genetic scale. Descriptive analysis was used to answer this research question. Table 4.1 gives the descriptive information about the participants' perceived TPACK on genetics for each component.

Table 4.1 Descriptive Analysis for perceived TPACK on Genetic Scale

	Mean	SD	Skewness	Kurtosis
ETK	4,3791	,73232	-,972	1,590
GTK	3,3536	,89186	-,025	-,360
PSTK	2,8704	1,12037	,311	-,440
CK	3,7459	,90926	-,264	-,347
PK	4,9239	,75744	-1,214	3,155
PCK	4,4955	,84642	-,933	1,478
TCK	4,4936	,89399	-,808	,977
TPACK	4,5300	,76136	-,737	1,190
TPACK_Total	4,1464	,60128	-,409	,537

According to Table 4.1, the participants' highest mean value of perceived knowledge belonged to pedagogical knowledge (PK). The participants felt less competent in project specific technology knowledge (PSTK) than the other components of the TPACK. The participants' mean value of the total TPACK scale is 4.15 out of six.

4.2. Research Question Two

Is there any relationship among the preservice science teachers' content knowledge and their perceived technological pedagogical content knowledge?

In order to address the second research question Pearson product-moment correlation coefficients were computed among pre-service science teachers' content knowledge and each components of TPACK. Content knowledge was computed by the total score of the 20 items in the Genetic concept test. For analysis of TPACK the mean scores for each component were computed. Before conducting correlational analysis, preliminary analyses were performed to ensure no violation of the normality, linearity, and homoscedasticity assumptions of correlational analysis.

1. Normality. Visual examination of the histograms, distribution curves and normal Q-Q plots in PASW indicated no apparent violations of normality assumption. Skewness and kurtosis statistics indicated an acceptable range of departure from a normally distributed population for all measures, except for

the PK (see Table 4.1). All of the skewness and kurtosis values were between the range of -2 and +2 except PK (Kurtosis = 3.155). This showed normal distribution. Most of the skewness values were negative indicating negatively skewed distribution.

2. Linearity. Visual examination of the scatterplot revealed that there was no violation of this assumption since the distribution was not in curve shape but in linear shape.

3. Homoscedasticity. The assumption of homoscedasticity, which is the variance of errors, was the same for all variables. The visual examination of standardized scatter plots (P-P plots), histogram, bell-curve distribution and normal plots showed that there was no violation of the assumption.

Table 4.2 Correlations between Content Knowledge and perceived TPACK Components

	Pearson Correlation (r)	N	Coefficient of Determination (r^2)	p values
ETK	.099**	1528	.010	.000
GTK	.164**	1527	.026	.000
PSTK	.037	1519	.001	.151
CK	.165**	1529	.029	.000
PK	.098**	1527	.011	.000
PCK	.150**	1526	.023	.000
TCK	.141**	1525	.022	.000
TPACK	.089**	1521	.008	.001

**Correlation is significant at the 0.01 level (2-tailed) – Perceived TPACK components (ETK: Educational Technology Knowledge. GTK: Genetik Technologies Knowledge. PSTK: Project Specific Technology Knowledge. CK: Content Knowledge. PK: Pedagogical Knowledge. PCK: Pedagogical Content Knowledge. TCK: Technological Content Knowledge. TPACK: Technological Pedagogical Content Knowledge)

When it was decided that there was no violation of the assumptions, Pearson product moment correlations were calculated. Alpha level was determined at .01 significance level of analysis. Listwise deletion was performed with 1505 subject. Results of the bivariate correlation revealed that there were statistically significant correlations between content knowledge and the components of TPACK except PSTK. The correlation analysis results were given in the Table 4.2.

As it is seen from the Table 4.2, participants' genetic knowledge was positively correlated with ETK at $\alpha = .01$ with $r = .099$, $p = .000$ values; with GTK at $\alpha = .01$ with $r = .164$, $p = .000$ values; with CK at $\alpha = .01$ with $r = .165$, $p = .000$ values; with PK at $\alpha = .01$ with $r = .098$, $p = .000$ values; with PCK at $\alpha = .01$ with $r = .150$, $p = .000$ values; with TCK at $\alpha = .01$ with $r = .141$, $p = .000$ values and with TPACK at $\alpha = .01$ with $r = .089$, $p = .000$ values. There was no correlation between content knowledge and PSTK with $r = .037$, $p = .151$ values.

4.3. Research Question Three

What are the relationships among the components of TPACK framework?

This research question sought the relationships among the components of TPACK. Pearson product moment correlation analysis was decided to be conducted to answer the question.

Before starting the analysis, assumptions were checked. The normality, linearity and homoscedasticity assumptions were checked via the scatterplot that were requested as part of the analysis. This plot showed that the distribution was normal and linear. The cigar shape of the scatterplot showed that the standard deviations of errors of prediction were approximately equal for all predicted DV scores. This showed homoscedasticity of the DVs. The detailed description about these assumptions was given in previous section.

After the preliminary analysis to check the assumptions Pearson product moment correlations were calculated. Alpha level was determined at .05 significance level of analysis. Listwise deletion was performed with 1505 subject. The examination of Pearson correlation values indicated that there was statistically significant positive correlation among all of the components of perceived TPACK.

Table 4.3 Correlation Among the Components of Perceived TPACK

	ETK	GTK	PSTK	CK	PK	PCK	TCK	TPACK
ETK	1,000	---						
GTK	,353**	1,000	---					
PSTK	,251**	,394**	1,000	---				
CK	,385**	,624**	,370**	1,000	---			
PK	,464**	,194**	,058*	,351**	1,000	---		
PCK	,415**	,377**	,173**	,565**	,631**	1,000	---	
TCK	,435**	,347**	,208**	,488**	,527**	,692**	1,000	---
TPACK	,514**	,320**	,191**	,475**	,628**	,686**	,734**	1,000

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

* Correlation is significant at the 0.05 level (2-tailed) – Content Knowledge. Perceived TPACK Components (ETK: Educational Technology Knowledge. GTK: Genetik Technologies Knowledge. PSTK: Project Specific Technology Knowledge. CK: Content Knowledge. PK: Pedagogical Knowledge. PCK: Pedagogical Content Knowledge. TCK: Technological Content Knowledge. TPACK: Technological Pedagogical Content Knowledge.)

The results of the correlational analysis were presented in Table 4.3. All of the correlations among the components of perceived TPACK were significant and had the same direction. There were positive correlations among the components of perceived TPACK. TPACK component was correlated with TCK at $\alpha = .01$ with $r = .734$, $p = .000$; with PCK at $\alpha = .01$ with $r = .686$, $p = .000$; with PK at $\alpha = .01$ with $r = .628$, $p = .000$; with ETK at $\alpha = .01$ with $r = .514$, $p = .000$; with CK at $\alpha = .01$ with $r = .475$, $p = .000$; with GTK at $\alpha = .01$ with $r = .320$, $p = .000$; and with PSTK at $\alpha = .01$ with $r = .191$, $p = .000$. The highest correlations were the ones with TPACK components.

The highest correlation was between technological content knowledge and technological pedagogical content knowledge at $\alpha = .001$ with $r = .734$, $p = .000$. The second highest correlation was between technological content knowledge and pedagogical content knowledge at $\alpha = .001$ with $r = .692$, $p = .000$. On the other hand, the smallest correlation was between project specific technology knowledge and pedagogical knowledge at $\alpha = .01$ with $r = .058$, $p = .000$. The r values corresponding to the remaining correlations ranged from $r = .173$ to $r = 686$.

4.4. Research Question Four

Is there a significant mean difference in perceived technological pedagogical content knowledge of male and female preservice science teachers?

There were 8 dependent variables (ETK, GTK, PSTK, CK, PK, PCK, TCK, and TPACK) of interest and one independent variable (gender) with two levels (female, male); therefore, multivariate analysis of variance (MANOVA) was conducted to investigate mean differences among them. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity.

1. Sample size. There were more cases in each cell than the number of dependent variable. There were 8 dependent variables and the sample was 1530. Therefore, this assumption was not violated.

2. Normality. Univariate and multivariate normalities were checked. Univariate normality was checked by examining skewness, kurtosis values and by visual examination of histograms. As presented in Table 4.1 the skewness and kurtosis values were in acceptable range which is between -2 and +2 for all dependent variables. In order to check multivariate normality, Mahalanobis distances were calculated to compare the critical value given in the Chi-square table (Pallant, 2007). For 8 variables critical value is indicated as 26.13 and the maximum Mahalanobis distance in our study was 98.371 indicating the existence of outliers in the data.

3. Outliers. In order to determine outliers Mahalanobis distances were examined. These distances for the first 15 cases were higher than the critical value; however, the Cook’s distances of these cases were lower than 1.

Therefore, these cases can be remained in the analysis. Moreover, the outliers can be accepted since there was a reasonable size data file (Pallant, 2007).

4. Linearity. In order to check linearity scatterplots were generated for each dependent variable pairs. The scatterplots revealed that there was no apparent violation of linearity assumption.

5. Multicollinearity and singularity. These assumptions were checked by calculating the correlation coefficients between dependent variables. The correlation coefficients between the dependent variables ranged from .173 to .734, smaller than .8 as it was presented at Table 4.3. This showed that dependent variables were moderately correlated. Therefore, there was no violation of this assumption.

6. Homogeneity of variances. In order to check this assumption, Levene's Test of Equality of Error Variances was checked. According to the results, the error variance of the dependent variable was not equal across groups for all DVs. This assumption was not assured for PSTK ($p = .011$), PK ($p = .007$), PCK ($p = .004$), and TCK ($p = .000$) while it was assured for ETK ($p = .065$), GTK ($p = .288$), CK ($p = .571$), and TPACK ($p = .376$).

After checking the assumptions of MANOVA, analysis was conducted. The results revealed that there was a statistically significant mean difference for male and female participants on the combined dependent variables, F (1, 1504) = 14.32, $p = .000$; Wilks' Lambda = .93; partial eta squared = .071 indicating small effect size.

In order to investigate whether male and female participants differed in all dependent variables or not, between- subjects effects were examined. When the results for the dependent variables were considered separately, the differences to reach statistical significance, using a Bonferonni adjusted alpha level of .006, were PSTK, F (1, 1504) = 32.721, p = .000, partial eta squared = .02; PK, F (1,1504) = 36.188, p = .000, partial eta squared = .02; PCK, F (1,1504) = 47.228, p = .000, partial eta squared = .03; TCK, F (1, 1504) = 22.683, p = .000, partial eta squared = .02; and TPACK, F (1,1504) = 18.871, p = .000, partial eta squared = .01. The results of the follow- up pairwise comparisons were illustrated in Table 4.4.

Table 4.4 Follow-up Pairwise Comparions

Source	DVs	df	F	Sig (p)	Partial Eta Squared
Gender	ETK	1	.141	.707	.000
	GTK	1	.030	.862	.000
	PSTK	1	32.721	.000*	.021
	CK	1	5.839	.016	.004
	PK	1	36.188	.000*	.024
	PCK	1	47.228	.000*	.030
	TCK	1	22.683	.000*	.015
	TPACK	1	18.871	.000*	.012

* Significant at Bonferonni adjusted alpha level of .006

According to the statistics obtained from the analysis, there was a statistically significant mean difference in project specific technology knowledge scores for males (M = 3.14, SD = 1.18) and females M = 2.77, SD = 1.08; F = 32.721, p < .006 (two-tailed) in favor of males. However, the magnitude of the differences in the means was small (eta squared = .020).

The follow-up analyses for pair wise comparisons showed that the mean scores on perceived pedagogical knowledge were significanlty different with respect to gender (F = 36.188, $p < 0.006$) in favor of females (M = 4.99, SD = .02 for females; M = 4.74, SD = .04 for males). However, the magnitude of the differences in the means was small (eta squared = .020).

The results of follow-up analysis showed that there is a statistically significant mean difference in perceived pedagogical content knowledge score of males (M = 4.26, SD = .89) and females M = 4.58, SD = .81, F = 47.228, $p <$ .006 (two-tailed). However, the magnitude of the differences in the means was slightly small (eta squared = .030).

The results of the analysis revealed that there is a statistically significant mean difference in perceived technological content knowledge of male (M = 4.32, SD = .98) and female M = 4.56, SD = .85; F = 22.683, $p <$ .006 (two-tailed). However, the magnitude of the differences in the means was small (eta squared = .01).

According to the results of the analysis, the mean scores on perceived technological pedagogical content knowledge were significanlty different with respect to gender (F = 18.871, $p < 0.006$) in favor of females (M = 4.59, SD = .76 for females; M = 4.39, SD = .75 for males). However, the magnitude of the differences in the means was small (eta squared = .01). Table 4.5 represented the group statistics regarding each dependent variable.

Table 4.5 Group Statistics

	Gender					
	Male			Female		
	Mean	SD	N	Mean	SD	N
ETK	4.39	.77	415	4.37	.71	1112
GTK	3.35	.92	415	3.36	.88	1111
PSTK	3,14	1,18	414	2.77	1,08	1104
CK	3.65	.93	414	3.78	.89	1114
PK	4.73	.04	413	4.99	.02	1113
PCK	4.26	.89	413	4.58	.81	1112
TCK	4.32	.98	413	4.56	.85	1111
TPACK	4.39	.75	410	4.58	.76	1110

4.5. Research Question Five

What is the impact of year of enrollment on preservice science teachers' perceived technological pedagogical content knowledge?

There were 8 dependent variables (ETK, GTK, PSTK, CK, PK, PCK, TCK, and TPACK) in interest and one independent variable (year of enrollment) with four levels (freshmen, sophomore, junior, and senior); therefore, multivariate analysis of variance (MANOVA) was conducted to answer this question. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity.

1. Sample size. There were more cases in each cell than the number of dependent variable. There were 8 dependent variables and the sample was 1530. Therefore, this assumption was not violated.

2. Normality. Univariate and multivariate normalities were checked. Univariate normality was checked by examining skewness, kurtosis values and

by visual examination of histograms. As presented in Table 4.1 the skewness and kurtosis values were in acceptable range which is between -2 and +2 for all dependent variables. In order to check multivariate normality, Mahalanobis distances were calculated to compare the critical value given in the Chi-square table (Pallant, 2007). For 8 variables critical value is indicated as 26.13 and the maximum Mahalanobis distance in our study was 98.76 indicating the existence of outliers in the data.

3. Outliers. In order to determine outliers Mahalanobis distances were examined. These distances for first 15 cases were higher than the critical value; however, the Cook's distances of these cases were lower than 1. Therefore, these cases can be remained in the analysis. Moreover, the outliers can be accepted since there was a reasonable size data file (Pallant, 2007).

4. Linearity. In order to check linearity scatterplots were generated for each dependent variable pairs. The scatterplots revealed that there was no apparent violation of linearity assumption.

5. Multicollinearity and singularity. These assumptions were checked by calculating the correlation coefficients between dependent variables. The correlation coefficients between the dependent variables ranged from .173 to .734, smaller than .8 as it was presented at Table 4.3. This showed that dependent variables were moderately correlated. Therefore, there was no violation of this assumption.

6. Homogeneity of variances. In order to check this assumption, Levene's Test of Equality of Error Variances was checked. According to the

results, the error variance of the dependent variable was not equal across groups for all DVs. This assumption was not assured for ETK (p = .000), CK (p = .018), and TPACK (p = .001) while it was assured for GTK (p = .228), PSTK (p = .659), PK (p = .102), PCK (p = .203), and TCK (p = .097). Therefore, Tukey HSD test was used in Post Hoc analysis for the DVs that assure the assumption while Dunnett C's test was used for the DVs that was not assumed homogeneity of variances across groups.

After checking the assumptions of MANOVA, analysis was conducted. The results revealed that there was a statistically significant mean difference among the participants which have different year of enrollment on the combined dependent variables, F (7, 1502) = 6.03, p = .000; Wilks' Lambda = .91; partial eta squared = .03 indicating small effect size.

Between- subjects effects were examined to better understand the difference in relation to each of dependent variables. When the results for the dependent variables were considered separately, the only differences to reach statistical significance, using a Bonferonni adjusted alpha level of .006, were ETK, F (3, 1502) = 6.41, p = .000, partial eta squared = .01; GTK, F (3, 1502) = 30.42, p = .000, partial eta squared = .06; PSTK, F (3, 1502) = 10.59, p = .000, partial eta squared = .02; CK, F (3, 1502) = 15.23, p = .000, partial eta squared = .03. The results of the follow- up pairwise comparisons were illustrated in Table 4.6.

Table 4.6 Follow-up Pairwise Comparions

Source	DVs	df	F	Sig (p)	Partial Eta Squared
Year of enrollment	ETK	3	6.414	.000*	.013
	GTK	3	30.417	.000*	.057
	PSTK	3	10.587	.000*	.021
	CK	3	15.226	.000*	.030
	PK	3	1.091	.352	.002
	PCK	3	3.092	.026	.006
	TCK	3	3.144	.024	.006
	TPACK	3	1.843	.137	.004

* Significant at Bonferonni adjusted alpha level of .006

In order to identify where the significant differences lie, post-hoc analyses were conducted for ETK, GTK, PSTK, and CK. Each comparison was tested with Bonferonni adjusted alpha level of .006. The results of the analysis revealed that there was a statistically significant difference in ETK score at the $p < .05$ level for four groups: F (3, 1521) = 6.74, $p = .000$. Although there is statistically significant difference, the actual difference in mean scores between the groups was very small with the effect size of .02, calculated using eta squarred. Post-hoc comparisons using the Dunnett C test showed that the mean scores of freshmen ($M = 4.26$, $SD = .79$) was significantly different from sophomore ($M = 4.41$, $SD = .68$) and junior ($M = 4.47$, $SD = .68$). The other groups did not differ significantly from each other.

The one-way between-groups analysis of variance results revealed that there was a statistically significant difference at the $p < .05$ level in genetic technology knowledge for the four groups: $F(3,1520) = 30.42$, $p = .000$. The actual difference in mean scores between groups was moderate. The effect size, which was calculated using eta squared, was .06. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for freshmen (*M* = 3.07, *SD* =.84) was significantly different from sophomore (*M* = 3.29, *SD* = .92), junior (*M* = 3.53, *SD* =.85), and senior (*M* =3.61, *SD* =.87); mean score for sophomore was significantly different from junior and senior. Junior did not differ significantly from senior.

A one-way between-groups analysis of variance results revealed that there was a statistically significant difference at the $p < .05$ level in project specific technology knowledge for the four groups: $F(3,1515) = 10.62$, $p < .05$. The actual difference in mean scores between groups was small although the difference was statistically significant. The effect size, which was calculated using eta squared, was .02. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for junior (*M* = 3.09, *SD* =1.11) was significantly different from freshmen (*M* = 2.67, *SD* = 1.10) and sophomore (*M* = 2.84, *SD* =.1.10). Other groups did not differ from each other.

A one-way between-group analysis of variance was conducted also for the last dependent variable which reached statistical significance in MANOVA. The results revealed that there was a statistically significant difference at the p < .05 level in the content knowledge for the four groups: F (3, 1515) = 10.62, $p < .05$. Despite reaching statistical significance, the actual difference in mean scores between the groups was small with eta squared value of .03. Post-hoc comparison using the Dunnett C test indicated that the mean score for freshmen (*M* = 3.53, *SD* = .95) was significantly different from sophomore (*M* = 3.70, *SD* = .91), junior (*M* = 3.91, *SD* = .86), and senior (*M* = 3.88, *SD* = .86).

Moreover, the difference in mean scores of senior and junior were statistically significant. The results concerning each pair wise analysis were presented at Table 4.7.

Table 4.7 The Bonferonni Test Results at Different Year of Enrollment

	Mean Scores			
	ETK	GTK	PSTK	CK
Year of Enrollment				
Freshmen	4.26^{a*}	3.07^{a*}	2.67^{a*}	3.54^{a*}
Sophomore	4.40^{b*}	3.29^{b*}	2.84^{a*}	3.70^{b*}
Junior	4.48^{b*}	3.53^{c*}	3.09^{b*}	3.91^{b*}
Senior	4.37^{ab*}	3.63^{c*}	2.89^{ab*}	3.89^{c*}

Means with different letters (a, b, c) are significantly different from each other

ab means that the mean is both similar with means named a and b.

5. DISCUSSION, CONCLUSION and IMPLICATIONS

This chapter includes the discussions, conclusions drawn from the results of the study and implications and recommendations for future study related to TPACK.

5.1. Discussion

The purpose of this study was to investigate the preservice science teachers' perceived technological pedagogical content knowledge (TPACK) on genetics. More specifically, the purpose was to examine the relationships among the components of the TPACK and genetics knowledge of the preservice science teachers who are enrolled in teacher education faculties in the Central Anatolia in Turkey. Moreover, the effect of the demographic information on perceived TPACK was also aimed to be figured out. In the light of these purposes this research study attempted to answer the following research questions:

It is aimed in this study to answer the following questions:

1. What is the preservice science teachers' perceived technological pedagogical content knowledge on genetics?
2. Is there any relationship among the preservice science teachers' content knowledge and their perceived technological pedagogical content knowledge?

3. What are the relationships among the components of TPACK framework?
4. Is there a significant mean difference in perceived technological pedagogical content knowledge of male and female preservice science teachers?
5. What is the impact of year of enrollment on preservice science teachers' perceived technological pedagogical content knowledge?

TPACK is the most prevalent framework that is used commonly in the technology-related studies in education. As it can be seen from the TPACK Newsletters it is commonly used in research in the field of technology in education. It was reported in the last edition of TPACK Newsletter that there are sixteen articles, two chapters, six dissertations, thirteen presentations published related to TPACK (Mishra, 2011). This shows that TPACK provides a good framework to technology integrated education studies.

However, the problem with the TPACK related studies is that they are usually case based and require enrollment in a course or professional development program. Those studies are related with the development of technology integration skills in the light of TPACK. However, Harris, Mishra and Koehler (2009) criticize this approach as that TPACK is not a professional development model that aims to teach only the skills. TPACK is more than gaining skills; it is an understanding for effective technology integration. Therefore, there is a need for the examination of theoretical basis of technological pedagogical content knowledge. In order to fill this gap an instrument was adopted in this study to examine the preservice science teachers' understanding of their own TPACK on genetics.

In the adaptation of the test, exploratory factor analysis was used to determine how many factors exist. It was hypothesized before data collection that there were nine dimensions in the participants' understanding of TPACK. Exploratory factor analysis results showed in this study that the items related to technological pedagogical knowledge were loaded on the factor related to technological pedagogical content knowledge. The factor loading values of the items related to technological content knowledge were also high in the factor of TPACK. This situation makes contribution to the debate of the pathways to TPACK development. While some researchers believe that teachers develop TCK first and translate it into TPACK, others believe that teachers develop TPK first, still others believe that teachers develop TPACK directly (Cox, 2008). Moreover, Cox (2008) hypothesized that a person with TPACK may also have TPK and TCK; but the reverse is not possible. When this hypothesis considered true, the unification of TCK and TPK items under the TPACK construct can be explained.

There are some studies that cannot find all hypothesized TPACK dimensions after the study. For example, Lux (2010) found that the items related to TCK either cross loaded or loaded less than .50 and diminished. This study also shows that TPK, TCK and TPACK may not be independent constructs. Further studies that examine the fuzzy boundaries between the constructs in depth are needed for validation of the independence of these construct.

In the rest of the section discussion of the findings will be given in the order that the results were given.

Research Question 1: *What is the preservice science teachers' perceived technological pedagogical content knowledge on genetics?*

In answering this research question, obtaining descriptive information about the preservice science teachers' TPACK on genetics was aimed. The results revealed that preservice science teachers generally partially agree (M = 4.15) that they have TPACK on genetics. However, the results can be either overestimated or underestimated, because results are only based on the self evaluation of the participants. With this in mind, one can say that the participants' perceived TPACK on genetics was not so low or so high. This result can be used in the further attempts to develop preservice science teachers' TPACK on genetics.

The least mean values correspond to perceived technology knowledge and perceived content knowledge. Especially, the perceived project specific technology knowledge has very low mean value. This shows that participants do not feel themselves competent in preparing blogs, using wikis, or using podcasts. Although these technologies can be used easily in educational context, participants even do not competent in using these in their daily life.

When we asked the participants about their interest on technology, we also found that most of the participants are not interested in technology. They are mostly interested in communication technology and information technology. However, even those technologies were not selected much. The percentage of the participants who are interested in communication technologies is 59.4, while the percentage of participants who are interested in information technologies is 52.6. While few participants (1.2%) are interested all of the technology areas that is asked in the instrument, 25.9% of them stated that they are not interested in any technology areas. These findings show that the participants are not interested much in technology. Their perception of their technology knowledge seems quite low correspondingly.

Moreover, the participants do not feel themselves competent in genetic knowledge and genetic technologies knowledge. This may be due to the abstract nature of the genetics. In literature, it was also found that the students from different age level, including college students, have difficulty in understanding genetic concepts (Saka et al., 2006). The competence in genetic technology knowledge become less correspondingly, because understanding genetic technologies requires understanding the genetics concepts.

Research Question 2: *Is there any relationship among the preservice science teachers' content knowledge and their perceived technological pedagogical content knowledge?*

In this research question, the relationships of content knowledge with perceived TPACK components were investigated. The results revealed that genetic knowledge was correlated with each component except the perceived project specific technology knowledge. This finding matches up with the studies in the literature that indicates the relationship between subject matter knowledge and teaching. As Harris, Mishra and Koehler (2009) stated, the best technology integration can be accomplished by considering students' content-related learning needs. Therefore, having content knowledge affects the knowledge in other components of TPACK.

The reason that content knowledge is not correlated with PSTK may be that participants are not familiar with these technologies. The results of the descriptive analysis mentioned above also confirm this situation. The participants feel themselves least competent in project specific technology knowledge. Therefore, there is no relationship between PSTK and content knowledge.

The correlations were quite low, although there were significant relationships between content knowledge and the components of perceived TPACK. The relationship between content knowledge and perceived content knowledge was also low. Although that correlarion was the highest one among the other correlations, the result was not high. This means, participants' content knowledge and perceived content knowledge do not correlate much. This may be due to the limitation of the instrument. In the self-reported instruments there is a risk to get insincere answers. The participants may answer the questions biased in order to be seemed to the data collector or their professors more successful. In this study also their content knowledge and perceived content knowledge do not have high correlation. They might have given answers to the self-reported test lower or higher than their real competencies.

Research Question 3: *What are the relationships among the components of TPACK framework?*

The relationships among the components of the TPACK were examined in this part of the study. The results revealed that all of the relationships among the components were significant. There were positive correlations among the components of the TPACK. Timur and Tasar (2011) also found high relationship between the general TPACK and TPACK, TPK, TCK, and TK components. The similar result was found also in the study of Sahin (2011). The researcher also found that the knowledge in technology, pedagogy, content, and their intersections are related. These results show the complex relationships among technology, content and pedagogy as stated in the definition of Mishra and Koehler (2006) which is "quality teaching requires developing a nuanced understanding of the complex relationships among technology, content, and pedagogy, and using this understanding to develop appropriate, context-specific strategies and representation (p.1029)". The researchers stated the need for considering technology pedagogy and technology knowledge in correlation with each other. Their model also shows these complex relationships (see Figure 2.1).

Moreover, according to the results of the Pearson product moment correlation analysis, the highest relationship exists between TCK and TPACK. This is consistent with the factor analysis results which were used to validate the instrument. In the results of the factor analysis, loading of the TCK under TPACK component was also high.

When all these findings are considered together, the need for considering interdependency of the technology, pedagogy and content in teacher education and teaching become clear. Therefore, TPACK should be considered as Total PACKage of the intersection of these three knowledge domains as Thompson and Mishra (2008) stated. This is the reason for calling the technological pedagogical content knowledge as TPACK instead of TPCK. The complex and multidirectional relationships among these knowledge domains should always be kept in mind when studying TPACK.

Research Question 4: *Is there a significant mean difference in perceived technological pedagogical content knowledge of male and female preservice science teachers?*

The effect of gender on perceived TPACK on genetics was also investigated in this study. According to the MANOVA results, the mean scores of male and female preservice science teachers differ in five component of TPACK, namely project specific technology knowledge, pedagogical knowledge, pedagogical content knowledge, technological content knowledge and technological pedagogical content knowledge. On the other hand there were not statistically significant differences in the mean scores of the male and female participants in terms of ETK, GTK, and CK.

Female participants outcompeted in four components. The only TPACK component that male participants outcompeted was PSTK. This component aimed to assess the participants' competence in only technological knowledge. The reason for outcompetence of the males in this component may be the conception of technology as masculine in nature. This finding is consistent with the findings of the Koh, Chai and Tsai's (2010) study which is similar with this study in terms of the characteristics of the sample. They also studied with a large sample and their sample was not enrolled in a technology related program which may have effect on the technology perception of the participants. In both this study and their study male participants rated themselves higher in technology knowledge.

On the other hand, female participants outcompete the male participants in the PK, PCK, TCK, and TPACK subdimensions. These findings are different from the literature because the researchers found that male preservice teachers generally rate themselves higher in technology related knowledge domains (Koh et al., 2010). Although TCK and TPACK are technology related knowledge domains female participants rated themselves higher in their perceived TCK and TPACK. This may be due to the topic selected for this study. Since we examined their perceived TPACK on genetics, participants' attitudes toward genetics are impartant. Although we did not found any difference in participants' perceived content knowledge according to their gender, some studies show that there are gendered preferences about scientific domains and girls have tendency toward biology (Farenga & Joyce, 1997; Stark & Gray, 1999).

There was no difference in perceived content knowledge of male and female participants in this study although female participants were expected to have higher perceptions in content knowledge, specifically in genetics knowledge. There are some studies that found a difference in content knowledge (Koh et al., 2010) while there are also some studies that found little or no difference in science knowledge of male and female (Nowell, Hedges, 1998).

Research Question 5: *What is the impact of year of enrollment on preservice science teachers' perceived technological pedagogical content knowledge?*

In this research question the effect of year of enrollment on the components of TPACK was investigated. According to the MANOVA results the mean ETK, GTK, PSTK, and CK values of participants with different year of enrollment differ significantly. In each of these components freshmen students have the least mean value. For example the mean GTK and CK scores of freshmen significantly lower than the rest of the participants. In the case of ETK freshmen have significantly lower mean scores than the others except seniors. Lastly, in PSTK scores, the mean scores of freshmen significantly different from only juniors. These results can be due to the courses taken until those grade levels. In Sahin's study (2011) significant relationships were found between measured TPACK components and the average grades of related classes. This implies for example that when preservice teachers take technology related courses and get high grade from these courses, their technology knowledge get higher. As it was figured out in this study freshman students have least mean scores in ETK, GTK, PSTK, and CK components. This may be due to the fact that freshmen students did not take enough courses related with educational technology, genetic technology, project specific technology and genetics. These results can be validated by looking at the centralized course schedules of the universities. Genetic technology is taught in Turkey in the third year of teacher education programs while educational technology related courses start in second year. However, the skills related to the using of blogs, wikis or podcasts are not taught in technology courses. Therefore, the same reason cannot be implied for the case of PSTK. The technology courses given in universities generally aim to make preservice teachers gain the skills to operate basic software programs like Microsoft Office tools. The preservice teachers generally taught to prepare a courseware with PowerPoint or to prepare posters.

5.2. Conclusions

This study aimed to gather descriptive information about the perceived TPACK on genetics of preservice science teachers in Turkey. The findings of descriptive analysis can be used as foreknowledge in further research.

Moreover, the relationships between the content knowledge and the components of the TPACK and among the components of the TPACK were investigated to understand the complex structure of the framework and to make clear the interdependence of the knowledge domains in the framework. It was aimed to make contribution to the understanding of fuzzy boundaries in the framework by examining the validity of the constructs in the framework. Since the boundaries are not so clear-cut between the knowledge domains, some knowledge domains intertwined in the study. In this study TPACK component covered the priorly hypothesized TPK component.

Furthermore, it was aimed to fill the gap in literature related to effect of the demographic variables on TPACK. For this reason, the effect of gender and year of enrollment on perceived TPACK on genetics were investigated. It was seen that there were differences in the components of perceived TPACK according to the gender and the year of enrollment. However, some of the components of perceived TPACK were not affected from these variables.

5.3. Implications

This study just aimed to serve as a descriptive research on perceived TPACK of preservice science teachers on genetics in Central part of Turkey. The development of TPACK was not investigated as a part of the study. With the light of the information that this study yielded, further research can be done to analyze the pathways of TPACK development. This study just gives an overview about the relationships between and among the components. However, there is a need to further investigate the affect of having one type of knowledge domain on having other types. Whether one with high TPK gain TPACK easier or not can be elucidated. Similarly, the effect of having TCK on gaining TPACK can also be studied in detail. The results of those studies can be helpful in making reforms in teacher education programs to raise science teachers with enough TPACK and effective technology integration skills.

Moreover, this study was limited to the preservice science teachers' perceived TPACK on genetics. More studies can be done about other subject matters. Since developing TPACK is not subject independent, the effect of the subject matter from different domains can be compared to understand the effect of content knowledge on TPACK. The perception or development of TPACK may be effected from the grade level. In this study only preservice elementary science teachers were used as sample, the results may be different in secondary level. Because secondary teachers specialize in a particular subject area while elementary teachers tend to be generalist.

The other area that requires further research related to this study is the boundaries of the TPACK framework. As this study, there are some other studies aim to validate the framework; however, it is still a controversial issue. Some of the components of the TPACK diminish in these studies. There is a need for more research to validate the TPACK framework and to understand its structure.

Moreover, one of the problems in TPACK studies is that the framework is used in studies without understanding it in detail. More studies can be conducted to explain the meaning of each component of the framework. By this way, the fuzzy boundaries among the components can become clearer for researchers, teachers and teacher educators.

The results indicated the complex interrelationship among content, pedagogy and technology, and their intersections. This shows the needs for teacher education programs to develop preservice teachers' TPACK in an integrated manner. Instead of giving technology course, content course and pedagogy course separately, the courses should be design to integrate the development of all these three in single courses.

This study also showed the relationship between content knowledge and the components of TPACK. This shows the importance of having content knowledge in gaining TPACK. Therefore, it is important for preservice teachers to gain enough content knowledge in every topic they will teach. The teacher education programs should provide enough education for preservice teachers to gain content knowledge in their field. By this way they feel more confident themselves in also other knowledge domains.

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APPENDIX A

Teknolojik Pedagojik Alan Bilgisi (TPAB) Anketi

Teknolojik Pedagojik Alan Bilgisi (TPAB) öğretmenlerin teknoloji bilgilerini ve öğretmenlik bilgilerini belli disiplinleri öğretirken nasıl kullandığıyla ilgili düşünme biçimidir. Aşağıda her bir bilgi türüyle (Teknoloji Bilgisi gibi) ilgili sorulardan iki veya daha fazla bilgi türünün birleşmesiyle oluşturulan sorulara doğru ilerleyen bir dizi soru bulunmaktadır.

Lütfen, anlamadığınız sorular olduğunda sormakta tereddüt etmeyin. Cevaplarınız gizli tutulacak ve ders notlarınızı etkilemeyecektir. Anketi doldurmanız yaklaşık 20 dakikanızı alacaktır. Anketi doldurmaya zaman ayırdığınız için teşekkür ederim.

Kişisel Bilgiler

1. Cinsiyet : ☐ Bay ☐ Bayan

2. Not ortalaması : ______(örn. 3,45)

3. Sınıf : ☐ 1. Sınıf ☐ 2. Sınıf ☐ 3. Sınıf ☐ 4. Sınıf

4. Kaç tane öğretim yöntemleri dersi aldınız? ______(1 dönem süren dersleri dikkate alınız.)

5. Kaç tane staj dersi aldınız? ______

6. Kaç tane teknoloji dersi aldınız? ______

7. İlgilendiğiniz teknoloji alanları nelerdir? Size uyan birden fazla seçeneği işaretleyebilirsiniz.

☐ Enerji Teknolojileri ☐ Ulaşım

☐ Biyoteknoloji, Biyoenformatik ☐ Bilgi Teknolojisi

☐ Robot Teknolojisi ☐ İletişim Teknolojisi

☐ Diğer Lütfen belirtiniz:

8. Kaç saat öğretmenlik deneyiminiz var?

Resmi kurumlar (e.g., Dershane, Okullar)

☐ Hiç ☐ 0-50 saat ☐ 50-100 saat ☐ 100-200 saat ☐ 200 saatten fazla

Diğer kurumlar (e.g., Müze eğitimi, Özel ders)

☐ Hiç ☐ 0-50 saat ☐ 50-100 saat ☐ 100-200 saat ☐ 200 saatten fazla

9. İleride eğitim teknolojilerini derslerinizde ne kadar sıklıkla kullanmayı planlıyorsunuz?

Asla ☐ Nadiren ☐ Bazen ☐ Sıklıkla ☐ Her zaman ☐

10. Eğer ileride sınıflarınızda istediğiniz teknolojilere ulaşma imkânınız olursa, genetik konularını öğretirken hangi teknolojileri kullanmayı planladığınızı kısaca nedenleriyle birlikte açıklayınız.

____

____

____

____

____

Lütfen cevaplarınızı her maddenin yan tarafındaki kutucuk üzerinde yer alan ifadeler doğrultusunda işaretleyiniz.

TB (Teknoloji Bilgisi)

Eğitim Teknolojileri

	Kesinlikle katılmıyorum	**Katılmıyorum**	**Kısmen katılmıyorum**	**Kısmen katılıyorum**	**Katılıyorum**	**Kesinlikle katılıyorum**
1. Öğretim için kullanılabilecek pek çok eğitim teknolojileri tanımlayabilirim.						
2. Pek çok farklı eğitim teknolojileri kullanabilirim.						
3. Eğitim teknolojilerini verimli bir şekilde kullanabilirim.						
4. Yeni eğitim teknolojilerini kendi kendime kullanmayı						

rahatlıkla öğrenebilirim.						
5. Eğitim teknolojileri donanımını nasıl kullanacağımı öğrenebilirim.						
6. Eğitim teknolojileri yazılımını nasıl kullanacağımı öğrenebilirim.						
7. Yeni eğitim teknolojilerini öğrenme konusunda güncel bilgileri takip edebilirim.						
8. Eğitim teknolojileriyle ilgili karşılaştığım problemleri kendim çözebilirim.						

Genetik Teknolojileri

9. Genetik alanında hangi tür teknolojilerin kullanıldığını bilirim.						
10. Genetik teknolojileriyle ilgili gelişmeleri takip etmekte zorlanmam.						
11. DNA parmak izi alma teknolojilerinin ne olduğunu bilirim.						
12. DNA parmak izi alma teknolojisinin uygulama alanlarını bilirim.						
13. Gen terapisinin nasıl yapıldığını bilirim.						
14. Rekombinant DNA'nın nasıl üretildiğini bilirim.						
15. Rekombinant DNA teknolojisinin kullanım alanlarını bilirim.						
16. Gen klonlama teknolojisi hakkında yeterli bilgiye sahibim.						
17. Genetik hastalıkların tedavisiyle ilgili yeterli bilgiye sahibim.						

Proje Temelli Teknoloji

18. Wiki-temelli sistem kullanarak belgeler oluşturabilirim.						
19. Wiki editörü oluşturabilirim.						
20. Wikilerin başkaları tarafından kullanımını düzenleyebilirim.						
21. Podcast (oynatıcı yayın aboneliği) kaydetmek için gerekli teknoloji donanımını kurabilirim.						
22. Podcast (oynatıcı yayın aboneliği) oluşturmak için gerekli teknoloji donanımını kullanabilirim.						

23. Bir blog (ağ günlüğü) oluşturabilirim.						
24. Bir blogun bazı özelliklerini kullanabilirim (tasarım, fotoğraf gönderme, butonlar kullanma vs).						
25. Başkaları kendi bloglarını oluştururken onlara yardımcı olabilirim.						

AB (Alan Bilgisi)

	Kesinlikle katılmıyorum	Katılmıyorum	Kısmen katılmıyorum	Kısmen katılıyorum	Katılıyorum	Kesinlikle katılıyorum
26. Genetik kavramlarını tartışmakta zorlanmam.						
27. Bilim insanlarının genetik alanında araştırmalarını nasıl yürüttüğünü anlarım.						
28. Genetik alanında daha fazla bilgi öğrenmek için popüler literatürü (gazete, dergi vs.) takip ederim.						
29. Genetik alanındaki var olan kavram yanılgılarının farkındayım.						
30. Genetik konusu ile ilgili soruları cevaplandırmakta zorlanmam.						
31. Genetik ile ilgili bilimsel araştırmalar tasarlayabilirim.						
32. Genetik ile ilgili bilimsel araştırmalar yürütebilirim.						
33. Bilimsel verileri analiz edebilirim.						
34. Genetik ile ilgili bilimsel kavramları günlük yaşantıdaki konularla ilişkilendirebilirim.						

PB (Pedagoji Bilgisi)

	Kesinlikle katılmıyorum	Katılmıyorum	Kısmen katılmıyorum	Kısmen katılıyorum	Katılıyorum	Kesinlikle katılıyorum
35. Öğretme hızımı öğrencilerimin ihtiyaçlarını karşılayacak şekilde ayarlayabilirim.						
36. Ders anlatımımı öğrencilerin anlamadıkları konulara						

bağlı olarak ayarlayabilirim.						
37. Öğretim yöntemlerimi öğrenci farklılıklarına göre düzenleyebilirim.						
38. Yeni ders ve üniteleri rahatlıkla geliştirebilirim.						
39. Çeşitli öğretim metotları kullanabilirim.						
40. Sınıfımı etkili bir şekilde yönetebilirim.						
41. Çeşitli beceri düzeylerine sahip öğrencilere ders anlatmakta zorluk çekmem.						
42. Öğrencilerin öğrenme düzeylerini etkili bir şekilde ölçebilirim.						
43. Öğrencilerin öğrenme düzeylerini çeşitli yollarla ölçebilirim.						

PAB (Pedagojik Alan Bilgisi)

	Kesinlikle katılmıyorum	Katılmıyorum	Kısmen katılmıyorum	Kısmen katılıyorum	Katılıyorum	Kesinlikle katılıyorum
44. Öğrencilerin genetik konusundaki öğrenmelerini destekleyecek etkili öğretim stratejilerini seçebilirim.						
45. Öğrencilerin genetik konusu ile ilgili sahip oldukları kavram yanılgılarını saptayacak öğretim stratejileri kullanabilirim.						
46. Genetik konularını öğretirken çeşitli öğretim stratejilerini rahatlıkla kullanırım.						
47. Öğrenci değerlendirme sonuçlarını genetik konusunu anlatırken kullandığım stratejileri değiştirmek için rahatlıkla kullanırım.						
48. Öğrencilerin genetik konusunda yürüteceği bilimsel araştırmaları etkili öğretim ve öğrenme uygulamalarına dayalı olarak tasarlayabilirim.						
49. Öğrencilerin genetik konusundaki öğrenme düzeylerini değerlendirebilirim.						
50. Fen bilgisi öğrencilerine genetik konusunda etkili öğrenim deneyimleri sağlayabilirim.						
51. Genetik kavramlarını öğrencilerin anlayabileceği şekilde						

açıklayabilirim.						
52. Öğrencileri genetik konusunu öğrenmeye güdüleyebilecek öğrenme ortamları oluşturabilirim.						

TAB (Teknolojik Alan Bilgisi)

	Kesinlikle katılmıyorum	**Katılmıyorum**	**Kısmen katılmıyorum**	**Kısmen katılıyorum**	**Katılıyorum**	**Kesinlikle katılıyorum**
53. Genetik konularını etkili bir biçimde öğretmek için teknolojiyi kullanabilirim.						
54. Teknolojiyi kullanarak öğretebileceğim genetik kavramlarını rahatlıkla belirlerim.						
55. Teknoloji kullanımı gerektiren genetik ile ilgili bilimsel araştırmaları sırasında öğrencilerin sorularına rahatlıkla cevap verebilirim.						
56. Genetik ile ilgili öğrettiğim konuları zenginleştiren teknolojiler seçebilirim.						
57. Öğrencilerin teknoloji kullanarak daha etkili bir biçimde öğrenebilecekleri pek çok genetik kavramı bulabilirim.						
58. Teknoloji kullanarak etkili bir şekilde öğretilebilecek pek çok genetik kavramı bulabilirim.						
59. Teknolojiden etkili bir şekilde yararlanmamı sağlayan genetikle ilgili fen derslerini planlayabilirim.						
60. Genetikle ilgili bir bilimsel araştırma sırasında öğrendiklerini belgelendirebilmek için Wikileri kullanmada öğrencilere rahatlıkla yardımcı olabilirim.						
61. Podcast (oynatıcı yayın aboneliği)'i öğrencilerin genetik konularını öğrenmelerine yardımcı olacak biçimde kullanabilirim.						

TPB (Teknolojik Pedagojik Bilgi)

	Kesinlikle katılmıyorum	Katılmıyorum	Kısmen katılmıyorum	Kısmen katılıyorum	Katılıyorum	Kesinlikle katılıyorum
62. Hangi öğretim yöntemi ile hangi teknolojinin birlikte etkili işleyebileceğini belirleyebilirim.						
63. Ders anlatımımı geliştirebilecek teknolojileri seçebilirim.						
64. Öğrencilerin yeni yollarla öğrenmelerini sağlayacak teknolojileri seçebilirim.						
65. Teknolojiyi kullanırken kullandığım belli öğretme stratejilerimi öğrencilerin öğrenmesi için uyarlayabilirim.						
66. Teknoloji kullanım biçimimi kullandığım belirli öğretim stratejilerine göre uyarlayabilirim.						
67. Öğrencilerimin öğrenmesini sağlamak için derslerimde teknolojiyi kullanırken sınıfı rahatlıkla yönetebilirim.						
68. Eğitim teknolojilerinin kullanıldığı projelerde öğrencilerin öğrenme düzeyini etkili bir biçimde değerlendirebilirim						
69. Öğrencilerin mevcut anlama düzeylerine bağlı olarak teknoloji kullanımımı etkili bir şekilde uyarlayabilirim.						
70. Öğrencilerin hâlihazırda anlayamadıkları konulara bağlı olarak teknoloji kullanımımı etkili bir şekilde uyarlayabilirim.						

TPAB (Teknolojik Pedagojik Alan Bilgisi)

	Kesinlikle katılmıyorum	Katılmıyorum	Kısmen katılmıyorum	Kısmen katılıyorum	Katılıyorum	Kesinlikle katılıyorum
71. Genetik konularını, teknolojileri ve öğretim stratejilerini etkili bir biçimde bir araya getirebilecek dersler *tasarlayabilirim*.						
72. Genetik konularını, teknolojileri ve öğretim stratejilerini etkili bir biçimde bir araya getirebilecek dersler						

anlatabilirim.						
73. Sınıfta kullanmak üzere öğrencilerimin öğrenme düzeylerini ve yaklaşımlarını geliştirebilecek teknolojiler seçebilirim.						
74. Genetik alanındaki bir fen dersinin hem içeriğini hem de öğretim stratejilerini geliştirebilecek teknolojileri seçebilirim.						
75. Teknolojiyi ve çeşitli öğretim stratejilerini kullanarak genetik konularını etkili bir şekilde öğretebilirim.						
76. Öğrencilerin genetik konularını anlama düzeyini değerlendirmek için teknolojiyi etkili bir şekilde kullanabilirim.						
77. Genetik bilgimi, öğrencilerimin farklılıklarını ve öğretim programının amaçlarını birlikte dikkate alarak fen bilgisi derslerini rahatlıkla *tasarlayabilirim*.						
78. Genetik bilgimi, öğrencilerimin farklılıklarını ve müfredatın kazanımlarını göz önünde bulundurarak fen bilgisi derslerini rahatlıkla *anlatabilirim*.						
79. Diğer öğretmenlerin fen konularını, teknolojileri ve öğretim stratejilerinin kullanmalarını koordine etmelerine yardımcı olabilirim.						

APPENDIX B

Genetik Kavramlar Testi

Lütfen aşağıdaki sorularda cevabı size en yakın olan şıkkın yanındaki harfi daire içerisine alınız.

1. Aşağıdakilerden hangisi genetik materyal İÇERMEZ?

   a. Mantar   b. Oksijen   c. Domates   d. Ağaç   e. Virüs

2. Aşağıdaki insan hücrelerinden hangisi ya da hangileri DNA içerir?

   I. kan hücreleri   II. Beyin hücreleri   III. Karaciğer hücreleri   IV. Üreme hücreleri

   a. Yalnız I

   b. Yalnız I ve IV

   c. Yalnız II ve IV

   d. Yalnız I, II ve IV

   e. I, II, III ve IV

3. Aşağıdaki birden çok gen tarafından belirlenen genetik karakterler hakkındaki ifadelerden hangisi doğrudur?

   a. Bu karakterlerin kalıtım olasılıkları genellikle tahmin edilebilir.

   b. Bu karakterler genellikle baskın aleller tarafından kontrol edilir.

   c. Bu karakterler genellikle cinsiyete bağlıdır.

   d. Bu karakterlerin genellikle bir çok fenotipi vardır.

4. Aşağıdaki ifadelerden hangisi genlerin fonksiyonunu en iyi açıklar?

   a. genler DNA üretimini kontrol eder

   b. genler protein sentezini kontrol eder

   c. genler hücresel hareketleri kontrol eder

   d. genler beyin aktivitesini kontrol eder

5. DNA hücrenin neresinde bulunur? (Hücrenin ökaryotik olduğunu varsayınız.)

a. sitoplazma

b. hücre zarı

c. çekirdek

d. ribozom

e. golgi cisimciği

6. Aşağıda verilen genetik hastalıklarla ilgili ifadelerden hangisi yanlıştır?

a. Genetik hastalıklar bulaşıcı etmenlerden kaynaklanır.

b. Genetik hastalıklar ebeveynlerden çocuklara geçer.

c. Genetik hastalıklar bir tek genden kaynaklanabilir.

d. Genetik hastalıklar uzun yıllar kuluçka döneminde kalabilir.

Belirli bir hayvan türünün sinir hücreleri 20 kromozom içermektedir. Bu bilgiyi 7-10. soruları cevaplarken kullanınız.

7. 7. Bu türe ait döllenmemiş bir yumurta hücresinde kaç kromozom bulunur?

a. 0 b. 5 c. 10 d. 20 e. 40

8. Bu türe ait döllenmiş bir yumurta hücresinde kaç kromozom bulunur?

a. 0 b. 5 c. 10 d. 20 e. 40

9. Bu türe ait bir deri hücresinde kaç kromozom bulunur?

a. 0 b. 5 c. 10 d. 20 e. 40

10. Bu türe ait herhangi bir birey babasından kaç kromozom alır?

a. 0 b. 5 c. 10 d. 20 e. 40

11. Aşağıdakilerden hangisi her bir insan için özgündür (tek yumurta ikizleri hariç) ?

a. kromozom sayısı

b. DNA zinciri

c. gen sıralaması

d. protein sıralaması

e. yukarıdakilerin hepsi

12. Aşağıdaki gruplardan hangisi ya da hangileri DNA'ya sahiptir?

I. Hayvanlar II. Bakteriler III. Mantarlar IV. Mineraller V. Bitkiler

a. Yalnız I ve V

b. Yalnız I, II ve V

c. Yalnız I, III ve V

d. Yalnız I, II, III ve V

e. I, II, III, IV ve V

13. Kas hücrelerimiz, sinir hücrelerimiz ve kan hücrelerimiz farklı gözükürler çünkü her hücre çeşidi

a. farklı tür genler içerir

b. vücudun farklı bölgelerinde bulunur

c. farklı genleri aktifleştirir

d. farklı miktarda gen içerir

e. farklı mutasyonlara uğramıştır

14. Aşağıdaki genetik yapıları boyutlarına göre en büyükten en küçüğe doğru sıralayınız:

Kromozom, gen, genom, nükleotit

a. genom, kromozom, gen, nükleotit
b. genom, gen, kromozom, nükleotit
c. kromozom, genom, gen, nükleotit
d. kromozom, nükleotit, genom, gen
e. kromozom, nükleotit, gen, genom

İnsan yüzünde çillerin varlığı 2 alelli bir gen tarafından kontrol edilir. 'Çillilik' aleli 'çilsizlik' aleline baskındır. (Bu senaryoda baskınlığın tam baskınlık olduğunu düşününüz.) Bu bilgileri 15 & 16. soruları cevaplamak için kullanınız.

15. Mehmet ve Emel çillidir, fakat onların kızları Ayşe çilli değildir. Bu bilgi neyi gösterir?

   a. Anne veya babadan biri 'çilsizlik' geni taşır.

   b. Hem anne hem baba 'çilsizlik' geni taşır.

   c. Anne ve babadan hiç biri 'çilsizlik' geni taşımaz.

   d. Ayşe en az 1 'çillilik' geni taşır.

   e. Bir sonuca varabilmek için yeterli bilgi verilmemiştir.

16. Eğer Mehmet ve Emel'in başka çocukları olsaydı, çocuklarının çilli olma olasılığı ne olurdu?

   a. %0 b. %25 c. %50 d. %75 e. %100

17. Gen tedavisi aşağıdakilerden hangisinden kaynaklanan durumlar için daha başarılıdır?

   a. tek bir kromozom

   b. tek bir gen

   c. çevresel faktörler

   d. çoklu kromozomlar

   e. çoklu genler

18. İnsan kanı geni 3 alellidir (A, B, & 0). A ve B birbiri üzerine eşbaskındır ve hem A hem B, 0'a baskındır. Eğer bir kadın AB grubu kana sahipse ve bir erkek A grubu kana sahipse, çocukları aşağıdaki kan gruplarından hangisine sahip olabilir?

   a. Yalnız A

   b. Yalnız A veya B

   c. Yalnız A veya AB

   d. Yalnız A veya B veya AB

   e. A veya B veya AB veya O

19. Hemofili insanlarda X kromozomunda taşınan çekinik bir hastalıktır. Eğer bir çiftin ikisi de hemofili hastası değilse ve hemofili hastası bir oğulları varsa kızlarının da hemofili hastası olması olasılığı nedir?

   a. %100 b. %75 c. %50 d. %25 e. %0

20. İnsanlarda boy uzunluğu en azından kısmen kalıtsal bir özelliktir. Ancak, çevre koşulları sabit tutulduğu zaman bile, insanların boy uzunluğu oldukça çok çeşitlilik gösterir (sadece biraz kısa, orta ve uzun değil). Bu bilgiden çıkarılabilecek en iyi sonuç nedir?

    a. Boy büyük olasılıkla iki alelli tek genden etkilenmektedir.

    b. Boy büyük olasılıkla eşbaskın alelli tek genden etkilenmektedir.

    c. Boy büyük olasılıkla birçok özelliği etkileyen genlerden etkilenmektedir.

    d. Boy büyük olasılıkla bir çok genden etkilenmektedir.

Katılımınız için teşekkür ederim.

APPENDIX C

GÖNÜLLÜ KATILIM FORMU

Merhaba,

Ben Meltem SAVAŞ. Orta Doğu Teknik Üniversitesi Eğitim Fakültesi, İlköğretim Bölümü'nde araştırma görevlisi olarak çalışıyorum. Aynı zamanda İlköğretim Fen ve Matematik Eğitimi Anabilim Dalı'nda devam ettiğim yüksek lisans eğitimimde tez aşamasına gelmiş bulunuyorum. Bu çalışmada, tez danışmanım Doç. Dr. Özgül YILMAZ TÜZÜN ile birlikte üniversite öğrencilerinin genetik konusu üzerine teknolojik pedagojik alan bilgilerini incelemeyi amaçlıyoruz.

Çalışmaya katılımınız, seçilen örneklemin hedeflenen evreni temsil edebilmesi bakımından oldukça önemlidir. İki anketten oluşan bu çalışmada sorulan sorulara cevap vermeniz yaklaşık 20 dakikanızı alacaktır. Konuyla ilgili sorulan soruları cevaplandırmanız katılımcı olarak size herhangi bir zarar vermeyecektir. Çalışmaya katılım gönüllü olduğundan çalışmaya katılmamanız veya herhangi bir sebepten ötürü katılmaktan vazgeçmeniz durumunda olumsuz herhangi bir sonuçla karşılaşmanız muhtemel değildir. Çalışma sırasında elde edilen bütün bilgilerin gizliliği araştırma ekibinin sorumluluğundadır. Bilgilere sadece belirtilen araştırma ekibinin erişimi mümkün olacaktır ve elde edilecek bilgiler bilimsel yayımlarda kullanılacaktır.

Araştırmamıza yönelik sorularınız olması durumunda benimle ve/veya tez danışmanımla iletişime geçebileceğiniz bilgiler aşağıdaki gibidir:

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Amacı konusunda bilgilendirildiğiniz bu çalışmaya gönüllü olarak katılmayı kabul ediyorsanız, lütfen aşağıda belirtilen yere isminizi ve tarihi yazarak imzalayınız.

Teşekkür ederim.

Ad-Soyad: İmza:

Tarih:

APPENDIX D

Reliability Statistics for TPACK on Genetics Instrument

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Teknoloji bilgisi_eğitim teknolojileri_1	313,2526	1985,395	,439	,967
Teknoloji bilgisi_eğitim teknolojileri_2	313,1537	1986,042	,468	,967
Teknoloji bilgisi_eğitim teknolojileri_3	312,9614	1984,251	,503	,967
Teknoloji bilgisi_eğitim teknolojileri_4	313,1287	1987,318	,410	,967
Teknoloji bilgisi_eğitim teknolojileri_5	312,6862	1990,734	,430	,967
Teknoloji bilgisi_eğitim teknolojileri_6	312,8294	1988,821	,413	,967
Teknoloji bilgisi_eğitim teknolojileri_7	312,7490	1985,866	,478	,967
Teknoloji bilgisi_eğitim teknolojileri_8	313,3001	1984,542	,501	,967
Teknoloji bilgisi_genetik teknolojileri_9_	313,8576	1979,124	,501	,967
Teknoloji bilgisi_genetik teknolojileri_10	313,5680	1978,407	,500	,967
Teknoloji bilgisi_genetik teknolojileri_11	313,5712	1973,289	,478	,967

Teknoloji bilgisi_genetik teknolojileri_12	313,5406	1974,047	,483	,967
Teknoloji bilgisi_genetik teknolojileri_13	314,6830	1989,059	,343	,967
Teknoloji bilgisi_genetik teknolojileri_14	314,4779	1983,504	,333	,967
Teknoloji bilgisi_genetik teknolojileri_15	314,6154	1985,461	,337	,967
Teknoloji bilgisi_genetik teknolojileri-_16	314,0121	1975,155	,453	,967
Teknoloji bilgisi_genetik teknolojileri_17	314,0193	1974,711	,477	,967
Teknoloji bilgisi_proje temelli teknoloji_18	314,6702	1979,764	,377	,967
Teknoloji bilgisi_preoje temelli teknoloji_19	314,8656	1985,189	,363	,967
Teknoloji bilgisi_proje temelli teknoloji_20	314,8600	1988,000	,341	,967
Teknoloji bilgisi_proje temelli teknoloji_21	314,9212	1989,230	,337	,967
Teknoloji bilgisi_proje temelli teknoloji_22	314,9075	1989,796	,327	,967
Teknoloji bilgisi_proje temelli teknoloji_23	314,3282	1977,467	,360	,967
Teknoloji bilgisi_proje temelli teknoloji_24	313,5704	1973,102	,393	,967
Teknoloji bilgisi_proje temelli teknoloji_25	314,0459	1970,248	,409	,967
Alan bilgisi_26	313,4980	1968,548	,569	,967
Alan bilgisi_27	313,4344	1967,964	,593	,967

Alan bilgisi_28	313,3789	1970,229	,528	,967
Alan bilgisi_29	313,7908	1974,729	,507	,967
Alan bilgisi_30	313,7747	1970,629	,557	,967
Alan bilgisi_31	314,1158	1967,273	,558	,967
Alan bilgisi_32	313,9622	1968,726	,532	,967
Alan bilgisi_33	313,6629	1965,692	,573	,967
Alan bilgisi_34	313,1883	1968,754	,590	,967
Pedagoji bilgisi_35	312,4755	1982,353	,551	,967
Pedagoji bilgisi_36	312,3532	1987,583	,533	,967
Pedagoji bilgisi_37	312,4529	1985,981	,529	,967
Pedagoji bilgisi_38	312,6018	1983,208	,539	,967
Pedagoji bilgisi_39	312,3427	1984,248	,545	,967
Pedagoji bilgisi_40	312,3419	1982,921	,542	,967
Pedagoji bilgisi_41	312,5800	1984,121	,527	,967
Pedagoji bilgisi_42	312,5414	1985,817	,537	,967
Pedagoji bilgisi_43	312,4256	1986,559	,529	,967
Pedagojik alan bilgisi_44	312,9002	1968,773	,653	,966
Pedagojik alan bilgisi_45	312,9807	1974,860	,616	,967
Pedagojik alan bilgisi_46	312,9887	1966,982	,677	,966
Pedagojik alan bilgisi_47	313,0426	1971,363	,632	,967
Pedagojik alan bilgisi_48	313,1062	1967,388	,667	,966

Pedagojik alan bilgisi_49	312,7924	1972,313	,633	,967
Pedagojik alan bilgisi_50	312,8214	1968,261	,665	,966
Pedagojik alan bilgisi_51	312,6774	1970,755	,649	,966
Pedagojik alan bilgisi_52	312,6879	1969,328	,657	,966
Teknolojik alan bilgisi_53	312,6412	1977,011	,287	,968
Teknolojik alan bilgisi_54	312,7820	1969,668	,653	,966
Teknolojik alan bilgisi_55	313,0137	1966,402	,672	,966
Teknolojik alan bilgisi_56	312,8777	1966,739	,674	,966
Teknolojik alan bilgisi_57	312,9284	1966,767	,667	,966
Teknolojik alan bilgisi_58	312,9541	1966,865	,645	,966
Teknolojik pedagojik bilgi_62	313,0121	1971,445	,623	,967
Teknolojik pedagojik bilgi_63	312,6058	1978,596	,629	,967
Teknolojik pedagojik bilgi_64	312,6235	1977,377	,631	,967
Teknolojik pedagojik bilgi_65	312,6637	1979,462	,611	,967
Teknolojik pedagojik bilgi_66	312,7804	1977,956	,614	,967

Teknolojik pedagojik bilgi_67	312,6557	1979,736	,584	,967
Teknolojik pedagojik bilgi_68	312,7257	1981,975	,581	,967
Teknolojik pedagojik bilgi_69	312,7361	1978,813	,594	,967
Teknolojik pedagojik bilgi_70	312,7305	1978,622	,593	,967
Teknolojik pedagojik alan bilgisi_71	313,2953	1963,955	,651	,966
Teknolojik pedagojik alan bilgisi_72	312,9992	1964,874	,676	,966
Teknolojik pedagojik alan bilgisi_73	312,8753	1970,198	,652	,966
Teknolojik pedagojik alan bilgisi_74	312,8978	1972,841	,632	,967
Teknolojik pedagojik alan bilgisi_75	312,8842	1967,713	,692	,966
Teknolojik pedagojik alan bilgisi_76	312,9099	1971,876	,634	,967
Teknolojik pedagojik alan bilgisi_77	313,0925	1967,210	,641	,966
Teknolojik pedagojik alan bilgisi_78	312,8528	1968,422	,652	,966
Teknolojik pedagojik alan bilgisi_79	312,9220	1969,694	,635	,967