

INVESTIGATING SCIENCE TEACHERS' TECHNOLOGICAL
PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) COMPETENCIES:
A MIXED METHOD STUDY

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A MIXED METHOD STUDY**

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ABSTRACT

INVESTIGATING SCIENCE TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) COMPETENCIES: A MIXED METHOD STUDY

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Master of Science, Science Education in Mathematics and Science Education

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The purpose of the present study was to investigate science teachers' technological pedagogical content knowledge (TPACK) in terms of different variables. Specifically, the purpose was to examine science teachers' TPACK competency levels according to their gender, experience years and determine their TPACK indicators based on TPACK-Deep factors, namely design, exertion, ethics, and proficiency. The current study was followed by explanatory sequential mixed methodology and composed of two stages: survey research and multiple case study respectively. Participants were 136 science teachers from a small province located in Central Anatolia region of Turkey. In addition, three teachers who had different levels of TPACK competency were selected from the sample for the multiple case study. Data sources were TPACK-Deep scale, classroom observations, video recordings of the classroom instruction, and semi-structured interviews. For the analysis, descriptive statistics, independent sample t-test, and one-way ANOVA were used for the quantitative data; deductive and inductive analysis were used for the qualitative data. The findings of the current study showed that science teachers' TPACK competency levels were high. Moreover, there were no significant

differences in TPACK levels in terms of teachers' gender and experience years. Considering TPACK-Deep factors, teachers' scores were highest in the ethics factor and lowest in the proficiency factor. On the other hand, teacher who had high TPACK competency level showed more TPACK indicators; low competency level showed less TPACK indicators. In addition, participant teachers' TPACK indicators provided rich information about TPACK-Deep factors for different TPACK competency levels.

Keywords: TPACK, Science Teachers, Meiosis, Gender, Experience Years.

ÖZ

FEN BİLİMLERİ ÖĞRETMENLERİNİN TEKNOLOJİK PEDAGOJİK ALAN BİLGİ (TPAB) YETERLİKLERİNİN İNCELENMESİ: BİR KARMA YÖNTEM ARAŞTIRMASI

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Bu çalışmanın amacı, fen bilimleri öğretmenlerinin teknolojik pedagojik alan bilgilerini (TPAB) farklı değişkenler açısından incelemektir. Bu amaç kapsamında fen bilimleri öğretmenlerinin TPAB yeterlikleri, cinsiyet ve deneyim yılı bakımından incelenmiştir. Ayrıca, öğretmenlerin TPAB göstergeleri, Teknopedagojik Eğitim Yeterlik (TPACK-Deep) ölçeğinin alt boyutları olan tasarım, uygulama, etik ve uzmanlaşma faktörleri odağında araştırılmıştır. Çalışma, sırasıyla betimsel tarama yöntemi ve çoklu durum çalışması olmak üzere iki aşamadan oluşan sıralı açıklayıcı karma yöntem çalışmasıdır. Betimsel tarama çalışması için araştırmaya İç Anadolu bölgesinde gelişmekte olan bir ilde görev yapan 136 fen bilimleri öğretmeni katılmıştır. Çoklu durum çalışmasının örneklemini ise, farklı TPAB yeterlik düzeylerine göre seçilmiş üç fen bilimleri öğretmeni oluşturmaktadır. Veri kaynağı olarak TPACK-Deep ölçeği, ders gözlemleri, video ders kayıtları ve yarı yapılandırılmış görüşmeler kullanılmıştır. Nicel verilerin analizi için, betimsel istatistik, bağımsız örneklem t-testi ve tek yönlü varyans analizi (ANOVA); nitel verilerin analizi için ise tümdengelim ve tümevarım

yöntemleri kullanılmıştır. Çalışmanın bulgularına göre, fen bilimleri öğretmenlerinin TPAB yeterlik düzeyleri yüksektir. Ayrıca, öğretmenlerin cinsiyet ve deneyim yılı değişkenine göre, TPAB yeterlik düzeylerinde anlamlı bir farklılık bulunmamıştır. TPACK-Deep faktörlerine bakıldığında, fen bilimleri öğretmenlerinin ortalama puanları etik faktöründe en yüksek, uzmanlaşma faktöründe ise en düşük bulunmuştur. Bunun yanı sıra, TPAB yeterlik düzeyi yüksek olan öğretmen daha fazla TPAB göstergesine sahipken, TPAB yeterlik düzeyi düşük olan öğretmenin daha az TPAB göstergesine sahip olduğu bulunmuştur. Ayrıca, katılımcı öğretmenlerin TPAB göstergeleri, sahip oldukları farklı yeterlik düzeyleri için tasarım, uygulama, etik ve uzmanlaşma faktörleri hakkında zengin bilgiler sağlamıştır.

Anahtar Kelimeler: TPAB, Fen Bilimleri Öğretmenleri, Mayoz, Cinsiyet, Deneyim Yılı.

To All Children

To The Justice

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CHAPTER 1

INTRODUCTION

“The more I read, the more I acquire, the more certain I am that I know nothing.”

Voltaire

1.1 Background of the Study

Change is rapid and inevitable. While the discovery of the tire was counted as the most important technological development at the time, today, we are talking about computers, smart devices, space shuttles, and such advanced technologies. In this day and time, technology is an inseparable part of our life. Up to now, important milestones have existed in the history of industrialization which causes “paradigm shifts” (Lasi et al., 2014, p.239). Respectively, mechanization is considered the first industrial revolution; electrification is counted as the second industrial revolution; automation is considered the third industrial revolution; and digitalization, namely industry 4.0 which is the fourth industrial revolution (Lasi et al., 2014). In addition, industry 5.0 which enables the cooperation of humans and robots is discussed nowadays. That is to say, change is continuous, and it turns into a more complex form day by day. Having such digital transformations would also give insight into future developments. In other words, technological advancements will unmistakably continue in the future. Therefore, the value given to the knowledge, especially scientific and technological knowledge, should be high to follow such improvements.

In addition to rapid technological advancements which are the most important fact in today's world, the way of using such technologies is also momentous. To make life easier, different types of emergent technologies with different purposes are used in various areas such as communication, medical, information, space, and educational technologies. For example, as stated by Woolf (2010) emerging technologies are important and necessary for learning and instruction. Moreover, the classification of educational technologies was identified by Bruce and Levin (1997) as inquiry, communication, construction, and expression. To illustrate, virtual reality environments were examples of technology for inquiry, spreadsheets were defined as technology for communication, robotics were examples of technology for the construction, and animation software was described as a technology for expression. These various technologies are required to be implemented and integrated by teachers for teaching and learning. Therefore, teachers are the main and key element for the efficient use of educational technologies (Huang, Spector, & Yang, 2019). In this sense, being capable of using emergent technologies involves various skills, including basic computer skills and complex skills related to software design. In other words, to be able to use the technologies effectively, one should have a combination of these skills primarily. To illustrate, a teacher needs to know how to connect a computer with a smartboard, how to open and use simulation related to teaching, how to integrate this simulation into their lesson for effective teaching.

When we are focusing on education and teaching, teachers play the most prominent role. For that reason, it is not surprising to find abounding research about teachers' knowledge emphasized in the literature (Grossmann, 1990; Shulman, 1986). Concerning this, Shulman (1986) identified pedagogical content knowledge (PCK) as "the ways of representing and formulating the subject that make it comprehensible to others" (p. 9). Pedagogical and content knowledge is valuable, though the knowledge of technology also comes into prominence considering the requirements of today's world. In this regard, Koehler and Mishra (2005) included a new dimension to Shulman's PCK which is the technology and presented initially the technological pedagogical content knowledge (TPCK) as a framework to identify the

knowledge base that teachers need to have for technology integration. In other words, for the integration of technology, teachers are required to be competent in the domains of technology, pedagogy, and content (Koehler & Mishra, 2009). Therefore, the most significant point is to blend and integrate all these knowledge domains (Sang et al., 2016; Schmidt et al., 2009).

Cox (2008) stated that if technologies become “transparent”, in other words, common and wide, technological pedagogical content knowledge (TPACK) turns into PCK. Thus, emergent technologies are at the heart of TPACK rather than transparent ones. Since these new technologies are needed to be integrated into education (Niess, 2005), teachers’ skills and competencies also become at the forefront. In other words, the learning of the students depends on teachers’ knowledge and skills especially in technology-enhanced learning environments (Tondeur et al., 2017). Specifically, teachers are required to have digital competencies to shape students that are ready for the future digital world. Considering this, on a large scale, different policies have been developed to reach the aim. At an international level, International Society for Technology in Education (ISTE) standards (2017) include digital competencies and digital citizenship standards for educators and students, respectively. As a specific example, it is expected from teachers that support students’ active and meaningful learning with the use of technological tools and digital resources. Besides, in Turkey, the major aim of the Movement of Enhancing Opportunities and Improving Technology (FATİH) Project is to improve technology in schools by effective use of information and communications technologies (ICT) (MoNE, n.d.). These imply that there exist transformations in the learning environments towards technology-enhanced environments. For example, eight main competencies were defined by National Qualifications Framework (2015) in Turkey. These competencies were also found in the Turkish science curriculum (MoNE, 2018) which refer to the use of ICTs for communication, producing, and transferring information. In addition, science teachers are expected to select and use appropriate technological tools to support their teaching (MoNE, 2018).

Having close relationships between science and technology necessitates effective use and integration of educational technologies in science education because “the science classroom is a natural place for technology use since so much of science today depends on technology” (McCrary, 2008, p.193). However, it is complicated to provide efficient technology integration (Tondeur et al., 2017). In this sense, science teachers have great responsibilities. In addition to be knowledgeable about technology, pedagogy, and science content, it is important to have skills about the practical use of various modern technologies that can be used in science classrooms like computers and mobile applications. In other words, “knowing the affordances of ICTs is not the whole picture of TPACK” (Yeh et al., 2015, p.78), yet teachers need to consider proper selection and integration of technology for their science teaching. To illustrate, simulations can be used to make abstract concepts concrete; virtual science laboratory applications can be used for dangerous experiments and dissections of animals or organs; sensors and probes, like dissolved oxygen probes, can be used for rapid data collection. In consequence of effectively blending TPACK in science classrooms would improve students’ understanding of science, provide meaningful and concrete learning and motivate students towards science. In addition, students can develop higher levels of thinking and problem-solving skills (Bybee, Powell, & Trowbridge 2008). Therefore, it is necessary to understand science teachers’ TPACK and technology integration practices for mainly improving students’ scientific literacy and skills.

On the other hand, there are different methods to assess and understand teachers’ TPACK including self-assessments, observations, lesson plans, and interviews (Canbazoglu-Bilici & Baran, 2015; Chai, Koh, & Tsai, 2013). Koehler, Shin, and Mishra (2012) stated that self-reported assessments were the commonly used method for measuring TPACK levels. Considering these measures, the literature has shown that teachers have different levels of TPACK competencies including high levels (Bagdiken & Akgunduz, 2018; Coklar & Ozbek, 2017; Mai & Hamzah, 2016) and average levels (Bas & Senturk, 2018; Bingimlas, 2018). Nevertheless, because TPACK is “unique, temporary, situated, idiosyncratic, adaptive, and specific and

will be different for each teacher in each situation” (Cox, 2008, p. 47), it is hard to classify teachers’ TPACK levels. Moreover, in the literature, there were different results for the teachers’ TPACK competency levels for gender variable. To illustrate, in terms of TPACK levels, female science teachers rated themselves higher than males (Irmak & Yilmaz-Tuzun, 2019); male science teachers rated themselves higher than females (Jang & Tsai, 2013; Lin et al., 2013); there was no statistically significant differences between male and female teachers (Ay, Karadag, & Acat, 2016; Bagdiken & Akgunduz, 2018; Jang & Tsai, 2012). In addition, similar discrepancies existed in terms of teachers’ experience years considering TPACK competency levels. For example, novice teachers’ TPACK levels were higher than experienced teachers (Bagdiken & Akgunduz, 2018; Jang & Tsai, 2013; Yeh et al., 2013); experienced teachers in Turkey had higher levels of TPACK (OECD, 2019). Reviewing the literature about TPACK studies considering gender and experience year variables, both the context of the study and participants might affect the findings of the studies. Therefore, to contribute TPACK literature and understand teachers’ knowledge, gender and experience years variables are needed to be investigated with further research. In these research, detailed definition of the sample and its characteristics are also important.

In addition, there existed discrepancies between science teachers’ self-assessment and actual teaching levels (Jen et al., 2016). Therefore, for supporting and classifying teachers’ TPACK competency levels, their actual classroom performance indicators would give more valuable information and clear understandings of their TPACK. Although teachers attributed themselves competent in TPACK with the results of self-assessment surveys, their actual teaching performances about technology integration need to be investigated. In other words, to understand science teachers’ TPACK, detailed observations, explanations, and reasons for teachers’ actual implementation of TPACK in science classrooms are needed to be researched. For that reason, the aim of the present study was to identify teachers’ TPACK competency levels, and more importantly understand their technology integration indicators, practices, and reasoning behind the implementation. Within this scope, to

examine middle school science teachers' TPACK competencies and their classroom indicators, the present study used TPACK-Deep framework and scale developed by Kabakci-Yurdakul et al. (2012). The TPACK-Deep was based on the transformative model of TPACK which accepts TPACK as a "unique body of knowledge" (Angeli & Valadines, 2009, p.154). For that reason, the transformative TPACK-Deep scale has four factors which are design, exertion, ethics, and proficiency. The design factor implies teachers' proficiencies regarding designing technology-enhanced instruction. Moreover, the exertion factor refers to teachers' competencies in terms of practicing their teaching with integrating technology to their instruction. In addition, the ethics factor implies teachers' competencies in terms of ethical issues while they integrate technology into their teaching. Moreover, the proficiency factor refers teachers' competencies to integrate technology and solve possible technological problems. Therefore, in the present study, science teachers' TPACK competency levels were investigated with the use of the TPACK-Deep scale. Also, their classroom indicators were determined by the factors of TPACK-Deep, which are design, exertion, ethics, and proficiency.

1.2 Purpose of the Study

The purpose of the present study was to investigate middle school science teachers' TPACK competency levels and their classroom indicators while they integrate technology into their instruction. For that reason, explanatory sequential mixed method design was followed by survey research methodology and multiple case study, respectively. Data were collected from a small city located in Central Anatolia, Turkey. For the case study, participants were selected on the purpose that they had different TPACK levels. Also, the researcher was careful about the schools that teachers work in with regards to having various technological opportunities such as smart board, computer, projection, and internet connection. In this regard, the research questions and null hypotheses were as follows:

1. What are the TPACK levels of science teachers?
2. Is there a statistically significant mean difference between male and female science teachers' TPACK?
 H_0 : There is no significant mean difference between female and male science teachers' TPACK.
3. Is there a statistically significant mean difference between science teachers' TPACK regarding their experience years?
 H_0 : There is no significant mean difference between science teachers' TPACK in terms of experience years.
4. What are the indicators of science teachers' TPACK regarding the "meiosis" topic considering TPACK-Deep factors, namely design, exertion, ethics, and proficiency?

1.3 Significance of the Study

Since TPACK has thought to build upon PCK, problems regarding PCK also cause some incomprehensibility regarding the TPACK framework (Graham, 2011). Thus, for contributing to solving the lack of clarity in TPACK, the need for further research is obvious. In this regard, there were different reasons to conduct the present research.

To begin with, there is no consensus between TPACK and its domains (Cox & Graham, 2009), and boundaries between the constructs are not clear (Sang, Tondeur, Chai, & Dong, 2016). For example, while defining the technology dimension of TPACK, Angeli and Valanides (2005) consider only computer-based technology, which is also named as an ICT-related PCK. However, according to Koehler and Mishra (2005), the technology dimension includes both digital and standard technologies. Therefore, there is a need to make the dimensions of TPACK clear, their relationships, and examples for implementation. Therefore, researchers conducted several studies to make the framework clear and understand teachers' TPACK. Basically, there are integrative and transformative models regarding

TPACK. Although the integrative model proposes seven knowledge domains (Mishra & Koehler, 2006) including Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK) and TPACK, the research revealed that less than seven factors can exist (e.g., Archambault & Barnett, 2010; Chai et al., 2011; Kartal & Afacan, 2017). On the other hand, discussion about the integrative model, especially demarcation of the domains, brings a transformative model of TPACK, which accepts TPACK as a “unique type of knowledge” (Angeli & Valadines, 2009, p.154). For example, according to the transformative TPACK-Deep model (Kabakci-Yurdakul et al., 2012), teachers’ TPACK consisted of four factors, namely design, exertion, ethics, and proficiency. To understand teachers’ knowledge and practices, there is a need to conduct further research to promote the framework. For that reason, the current study aimed to contribute to TPACK literature in terms of investigating science teachers’ TPACK adopting the transformative model. Within this scope, the present study explored science teachers’ TPACK according to transformative TPACK-Deep scale and considering gender and experience years where these variables need to be investigated urgently (Chai, Koh & Tsai, 2016) because science teachers’ TPACK competency levels can differ by gender and experience years. To illustrate, considering gender variable, male teachers rated themselves more competent than female teachers (Jang & Tsai, 2013; Kartal & Afacan, 2017); on the contrary, there were no significant differences between male and female science teachers TPACK competency levels (Ay, Karadag, & Acat, 2016; Bagdiken & Akgunduz, 2018). Therefore, to contribute to TPACK literature, the present study explores whether there existed significant differences between science teachers in terms of gender and experience years.

When focusing on science education, teachers’ TPACK levels and their classroom practices need to be investigated for several reasons. Firstly, with the inclusion of technological knowledge which converts TPACK to a more complex framework, what teachers need to know also shows an alteration. Thus, teachers’ TPACK

competencies are required to be researched. Secondly, teachers' technology integration practices differ according to the subject matter in a particular classroom environment (Koehler & Mishra, 2009). Therefore, subject-specific, and topic-specific investigations are at the heart of TPACK to get meaning. Since TPACK is "idiosyncratic" and "different for each teacher in each situation" (Cox, 2008, p.47), it should be investigated in more specific contexts like science education rather than in general contexts. Regarding this, Jimoyiannis (2010) stated that there was a need to enlarge and understand the science teachers' perceptions and competencies about TPACK. Therefore, the current study investigated science teachers' TPACK.

In literature, science teachers TPACK were investigated in quantitative research studies (Jen et al., 2016; Kafyulilo et al., 2015; Kadioğlu-Akbulut et al., 2020; Kartal & Afacan, 2017; Lin et al., 2013; Wright & Akgunduz, 2018) and qualitative research studies (Canbazoglu-Bilici, Guzey, & Yamak, 2016; Ocak & Baran, 2019; Yeh et al., 2015). In these research, preservice science teachers' TPACK was researched mainly in Turkey (Canbazoglu-Bilici, Guzey, & Yamak, 2016; Kafyulilo et al., 2015; Kartal & Afacan, 2017; Wright & Akgunduz, 2018). Moreover, in Turkey, as stated by Baran and Canbazoglu-Bilici (2015), the integrative model is used more than the transformative model in general. While focusing on research existed in Turkey, Ocak and Baran (2019) observed science teachers' TPACK indicators in different topics and private schools based on transformative view. Therefore, there is an obvious need to investigate science teachers' TPACK competency levels and their TPACK indicators according to the transformative TPACK model in the same topic and in public schools in Turkey. Thus, the current research will contribute to science teacher education in terms of specifying science teachers' competencies regarding technology integration. In other words, it is vital to understand teachers' competencies in self-assessments and verify their competencies in their actual teaching because there could be a gap between them. Consequently, the results of the present study can contribute to science teacher education by providing valuable feedbacks so that science teachers can be educated in terms of higher levels of TPACK both for theoretical and practical aspects.

In addition, using only self-reported data does not give detailed information and explanations about teachers' TPACK and their actual classroom practices (Koh & Chai, 2014). Even though teachers had high self-confidence in content, pedagogy, and technology, they see technology as a tool for teaching (DeCoito & Richardson, 2018) and do not integrate technology into the teaching process effectively. Moreover, although the analysis of self-reported data provides statistical descriptions about teachers' TPACK, "linking self-report scores and the indicators from observed teachers' practical mastery in instructional artifacts and classroom applications" (Jen et al., 2016, p.47) would give more comprehensive understanding. In other words, observation of instruction provides valuable and important information about the teaching (Good & Brophy, 2000). In addition, to understand teachers' knowledge and behaviors regarding technology, blending classroom observations and interviews is a necessity for research (Cox & Graham, 2009). That is to say because the nature of TPACK is experience-driven, teachers' self-assessments results and interviews are needed to be triangulated with their classroom performances and indicators. Similarly, in addition to survey research, Kartal and Afacan (2017) suggested using different data collection tools for eliciting elaborated results about TPACK. For that reason, rather than determining teachers' TPACK levels, there is a need to examine teachers' classroom practices regarding technology integration in the classroom (Yeh et al., 2017). Therefore, the aim of the current research was also to focus on real classroom instruction of science teachers by investigating their TPACK and technology integration practices. Thus, the present study provides data triangulation with the self-reported data and classroom observations, video recordings, semi-structured interviews to understand science teachers' TPACK by explaining how and why they integrate technology into their instruction. Understanding teachers' reasoning and explanation may give some clarification for the TPACK. In other words, these investigations will provide detailed data and explanations for technology-integrated practices of teaching. Since scientific investigations involve observations to understand behaviors and events, collecting data that could not be gathered from the self-assessment measures will provide

practical information about teachers' technology integration. For example, observation of instruction can provide information about teachers' actual classroom management strategies, and role of the teacher and students in the lesson. Moreover, TPACK-Deep framework had four factors including design, exertion, ethics, and proficiency; the results of the study will find out teachers' competencies regarding different TPACK-Deep factors. For example, teachers could be low competent in design factor. In other words, they could have lower competencies while designing technology-enhanced instruction. Also, it is important to understand how science teacher who have low TPACK competency level integrate technology to their teaching because the analysis will give information about teachers' practical indicators of TPACK. In that way, the missing competency areas of science teachers can be completed by the teacher education programs or professional development programs. Thus, linking quantitative data with qualitative ones will provide rich descriptions of science teachers' TPACK practices with different competencies regarding technology integration.

In other respects, there were research and implications for subject specific TPACK for science disciplines (Jimoyiannis, 2010) including preservice science teachers (Chai, Koh, & Tsai, 2010; Jang & Chen, 2010; Tanak, 2020) and in-service science teachers (Graham et al., 2009; Guzey & Roehrig, 2009; Jang & Tsai, 2013; Lin et al., 2013; Yeh et al., 2015). Yet, it was thought that there is a deficiency in the literature considering content-specific examination of TPACK constructs (Chai, Koh, & Tsai, 2013). For example, self-assessment surveys mostly focused on technology and pedagogy; therefore, measuring teachers' content-specific knowledge remained deficient (Voogt et al., 2013). Since TPACK is contextualized, content knowledge investigations have been seen as a need especially in science teaching (Lin et al., 2013). In addition, having experience-based nature, teachers' actions, and reasoning behind why they integrate technology in science teacher education is required to understand their TPACK. Therefore, the meiosis topic under the cell and division unit was selected for the present study for the following purposes:

- (1) There is a lack of subject-specific investigations of science teachers' TPACK in the topic of meiosis. Therefore, it is a need to investigate teachers' knowledge about the meiosis subject considering the TPACK framework.
- (2) The cell division unit which includes mitosis and meiosis is the prerequisite for future subjects like genetic and reproduction (Atilboz, 2004).
- (3) There exist different misconceptions regarding meiosis (Atilboz, 2004; Gunes & Gunes, 2005) that teachers need to eliminate if their students have.
- (4) Since the meiosis topic is abstract and hard to understand by students (Atilboz, 2004; Gunes & Gunes, 2005; Lewis, Leach, & Wood-Robinson, 2000), this topic is selected for the current study because the researcher believed that meiosis is a suitable topic to observe teachers' technology integration practices. In other words, there exist various technologies that teachers can benefit from to make topics concrete to observe their classroom indicators.

All in all, for the reasons that are referring to the research gap, the current research would give valuable contributions to science education and TPACK research in terms of providing concrete examples for the science teachers' TPACK indicators in the specific science topic, which is meiosis, considering contextual features. More specifically, the results of the current study can contribute to the literature by rendering science teachers' TPACK competencies and actual classroom indicators regarding transformative TPACK.

1.4 Definitions of Important Terms

- **Pedagogical Content Knowledge (PCK):** PCK was proposed by Shulman (1986) as “the ways of representing and formulating the subject that make it comprehensible to others” (p.9).
- **Technological Pedagogical Content Knowledge (TPACK):** TPACK is a framework proposed by Koehler and Mishra (2009) as the inclusion of technology knowledge to Shulman’s PCK and implies effective teaching with the integration of technology.
- **Transformative model of TPACK:** The model which TPACK has clarified as “a unique body of knowledge that is constructed from the interaction of its individual contributing knowledge bases” (Angeli & Valadines, 2009, p.154).
- **Integrative model of TPACK:** The model in which TPACK is researched by its domains (TK, PK, CK) and intersections of these domains (TPK, TCK, PCK) (Mishra & Koehler, 2006).
- **Science teachers:** In the current study, science teachers refer to the graduate teachers who work in a public school in a small province located in Central Anatolia.

CHAPTER 2

LITERATURE REVIEW

The purpose of the literature review chapter is to provide an overview of TPACK literature. Firstly, the emergence of the TPACK framework will be presented. Then, different TPACK models will be explained. After that, measurement of teachers' TPACK particularly in science education context will be provided. Finally, indicators of science teachers' TPACK will be presented.

2.1 Emergence of TPACK

Theoretical roots of TPACK were based on the PCK framework (Shulman, 1986). Shulman (1987, p.8) defined PCK as a “blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction.” Considering changing today's world, it is inevitable to combine and blend teachers' PCK especially with modern-day technologies. Supporting this argument, there were implications for integrating technology to teachers' PCK and education in the literature (Beaudin & Hadden, 2004; Hughes, 2004; Keating & Evans, 2001; Margerum-Leys & Marx, 2002; Niess, 2005; Pierson, 2001; Zhao, 2003). However, they were not presented and described as a framework. Considering rapidly developing technologies, in 2005, Koehler and Mishra added a new domain to Shulman's PCK, which is Technology Knowledge (TK). As a result, Technological Pedagogical Content Knowledge (TPCK) was presented as a framework to identify teachers' knowledge about the integration of technology into their instruction (Koehler & Mishra, 2005). Mishra and Koehler (2006, p. 1025)

defined TPCK as “the interplay between three domains of knowledge (TK, PK, and CK) and their intersections (TPK, TCK, and PCK) and in a specific context.” Based on Koehler and Mishra’s (2006) integrative model, TPCK was composed of seven knowledge domains. Meantime, the acronym TPCK became TPACK to pronounce easily (Thompson & Mishra, 2007).

According to Koehler and Mishra (2009), each TPACK domain referred to different knowledge. For example, the TK component represented “teachers’ knowledge about information technologies” (p. 64), PK referred to “teachers’ deep knowledge about the process and practices or methods of teaching and learning” (p. 64), and CK represented “teachers’ knowledge about subject matter” (p. 63). Considering intersections of these three components, PCK pointed out changing subject matter for teaching, TCK indicated the use of significant technologies for the subject matter, and TPK referred to adapting or effectively using particular technologies according to teaching (Koehler & Mishra, 2009). Finally, TPACK represented the use of technologies for effective teaching for the subject matter (Koehler & Mishra, 2009). In addition to these domains, the diagram of the TPACK contained “contexts” in the outer circle (Figure 2.1).

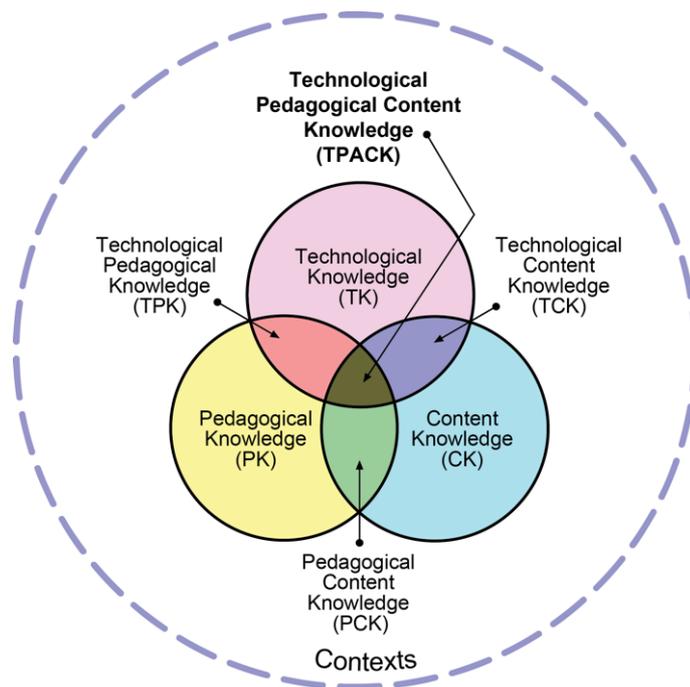


Figure 2.1 TPACK Framework

(Retrieved from “What is Technological Pedagogical Content Knowledge?” by M. J. Koehler and P. Mishra, 2009, *Contemporary Issues in Technology and Teacher Education*, 9(1), p. 63)

Although researchers implied the importance of contexts in technology education, (Hechter, Phyfe & Vermette, 2012; Koh, Chai & Tay, 2014; Porras-Hernández & Salinas-Amescua, 2013; Rosenberg & Koehler, 2015; Swallow & Olofson, 2017), contexts were not defined as a knowledge domain before. In this sense, Mishra (2019) argued that every enclosed space in the diagram represented some aspect of teacher knowledge. Thus, the outer circle was described as a new knowledge domain represented as “Contextual Knowledge” (its acronym is XK) for the revised TPACK framework in 2019 (Figure 2.2). This XK domain included “everything from a teacher’s awareness of available technologies to the teacher’s knowledge of the school, district, state or national policies they operate within” (Mishra, 2019, p.76). Being a “highly applied type of knowledge” TPACK has various implications for practice according to a different context (Graham et al., 2009, p. 212; Harris & Hofer, 2011).

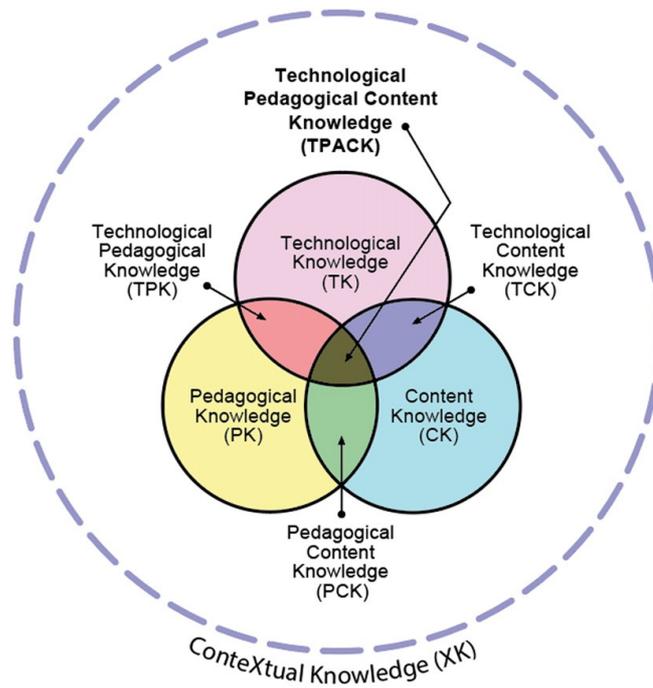


Figure 2.2 Revised Version of TPACK Framework

(Retrieved from “Considering Contextual Knowledge: The TPACK Diagram Gets and Upgrade” by P. Mishra, 2019, *Journal of Digital Learning in Teacher Education, Contemporary Issues in Technology and Teacher Education*, 35:2, p. 77)

2.2 TPACK Models

Different TPACK models and views have improved in time (Angeli & Valadines, 2009; Cox & Graham, 2009; Lee & Tsai, 2010; Mishra & Koehler, 2006; Niess, 2005). Integrative and transformative models regarding the TPACK framework have been researched mostly in the literature. In the integrative model, the domains of TPACK have been identified separately, including TK, PK, CK, TPK, TCK, PCK, and TPCK, and integration of these domains forms TPCK (Mishra & Koehler, 2006). On the other hand, in the transformative model, TPACK has been clarified as “a unique body of knowledge that is constructed from the interaction of its individual contributing knowledge bases” (Angeli & Valadines, 2009, p.154).

2.2.1 Integrative Model of TPACK

In the scope of the integrative model, “three domains of knowledge and their intersections formed TPACK” (Mishra & Koehler, 2006, p.1025). In other words, TPACK has been seen as an interaction between TK, PK, and CK and their intersections TPK, TCK, and PCK according to the integrative model. The development of one domain contributes to TPACK development as well. In the light of the integrative view, research was conducted based on different TPACK constructs. To illustrate, Chai, Koh, and Tsai (2010) investigated preservice teachers’ TPACK perceptions considering TK, PK, CK, and TPACK constructs. In another study, Koehler, Greenhalgh, Rosenberg, and Keenan (2017) used teachers’ portfolios to analyze teachers’ TK, TCK, TPK, and TPACK. Moreover, Lin et al. (2013) examined science teachers’ TPACK perceptions considering seven TPACK components.

Due to contextual factors, research focusing on science education has gained significance. Considering the integrative model of TPACK, Jimoyiannis (2010) proposed and implemented the “Technological Pedagogical Science Knowledge (TPASK)” model for science teachers’ professional development about effective

technology integration. Science-specific knowledge domains containing Pedagogical Science Knowledge (PSK), Technological Science Knowledge (TSK), TPK, and TPASK were separately defined as knowledge and descriptive components in the scope of integrative view. To practice the TPASK framework, “general theory modules” and “ICT in science education modules” were formed. After designing the TPASK course, the TPASK model was implemented into science teachers based on an authentic learning approach. For analyzing the TPACK model, semi-structured interviews were conducted with three physics teachers and one chemistry teacher. Although science teachers had difficulties in integrating technology into their lessons, the study of Jimoyiannis (2010) implied that teachers showed increased TPASK. Also, the educational system and condition of schools affected teachers’ views about integrating technology into science classrooms.

In another study in the integrative model, Jang and Tsai (2012) proposed contextualized TPACK model considering mathematics and science teachers. Concerning this model, a TPACK questionnaire was also developed. In addition, four components, namely CK, TK, PCK in Context (PCKCx), and TPACK in Context (TPCKCx) were defined. With the use of contextualized TPACK model, Jang and Tsai (2013) investigated secondary school science teachers’ TPACK. Questionnaires were implemented to 1210 science teachers. Results of the study implied that science teachers were less confident in TK and technology-related components. In addition, male teachers and novice teachers were more confident in TK and TPCKCx in Taiwan.

2.2.2 Transformative Model of TPACK

It has appeared in the literature that the distinction between each TPACK domain is difficult (Archambault & Barnett, 2010). Moreover, TPACK and its constructs are not obvious for research, and the boundaries between them are unclear (Cox & Graham, 2009). In addition, although seven components of TPACK were defined and explained, research showed that there might be less than seven factorial

structures in TPACK (Chai et al., 2011; Koh, Chai, & Tsai, 2010). Taking these critiques into consideration, Angeli and Valanides (2009, p.158) proposed transformative model which explained TPACK as a “unique and distinct body of knowledge” that forming a new type of knowledge rather than a combination or intersection of three domains.

Considering the transformative model, Jang and Chen (2010) developed and investigated the effects of “TPACK Comprehension, Observation, Practice, Reflection (TPACK-COPR)” model on pre-service science teachers. Participants were an educator and 12 pre-service science teachers. A course was designed as four stages TPACK comprehension, observation of instruction, the practice of instruction, and reflection of TPACK to investigate the effect of the TPACK-COPR model on pre-service teachers’ TPACK development. The results of the data including interviews, video recordings of the lesson, written assignments, and reflective journals implied that four staged authentic activities helped teachers to develop their TPACK. In other words, the transformative TPACK-COPR model facilitated teachers’ work while teaching abstract subjects like buoyancy and current, and also it provided effective integration of technology to instruction by observing experienced teachers.

In another study, Kabakci-Yurdakul et al. (2012) developed a TPACK-Deep framework and scale which is based on the transformative TPACK model. In this framework, there exist four factors, namely design, exertion, ethics, and proficiency. The design factor implies teachers’ proficiency regarding designing instruction, whereas the exertion factor implies teachers’ proficiency in terms of practicing and evaluating teaching with the use of technology. In addition, the ethics factor implies preservice teachers’ proficiencies regarding ethical issues while using technology, and the proficiency factor show teachers’ ability to integrate technology and solve possible problems (Kabakci-Yurdakul et al., 2012).

In a different study in the transformative model, Yeh et al. (2014) proposed and validated TPACK-Practical (TPACK-P) framework considering science teachers’

classroom practices by using the Delphi survey techniques including model generation and model validation. The consensus of expert panels implied that the framework included eight dimensions, namely “using ICT to understand students, using ICT to understand the content, planning ICT-infused curriculum, using ICT representations, using ICT-integrated teaching strategies, applying ICT to instructional management, infusing ICT into teaching contexts, and using ICT to assess students” (Yeh et al., 2014, p.9) and its indicators in five pedagogical areas including practical teaching, curriculum design, subject content, learners and assessment. Indicators validated for science teachers for TPACK-Practical represented critical practical implications.

2.2.2.1 TPACK-Deep

Based on the transformative model of TPACK, Kabakci-Yurdakul et al. (2012) developed a TPACK-Deep framework. The framework was proposed for determining pre-service teachers’ competencies in terms of technology integration. Figure 2.3 represents the factors of the TPACK-Deep framework which are design, exertion, ethics, and proficiency. The design factor implies teachers’ proficiencies in designing technology-enhanced lessons. In addition, the exertion factor includes teachers’ competencies regarding selecting and using appropriate technologies for their instruction. Moreover, the ethics factor refers to the ethical use and integration of technologies to instruction. In addition, the proficiency factor implies teachers’ abilities to integrate technology and solve possible technology-related problems.

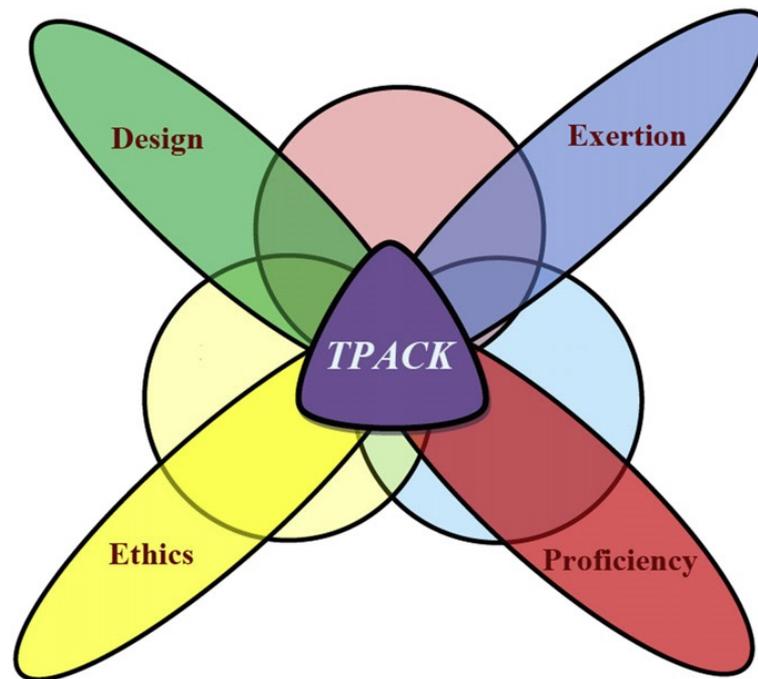


Figure 2.3 The TPACK-Deep Framework

Adapted from “The development, validity, and reliability of TPACK-deep: A technological pedagogical content knowledge scale” by I. Kabakci-Yurdakul, H. F. Odabasi, K. Kilicer, A. N. Coklar, G. Birinci, A. A. Kurt, 2012, *Computers and Education*, 58(3), p. 964-977 (<https://doi.org/10.1016/j.compedu.2011.10.012>).

2.3 Measurement of Teachers’ TPACK

Because of the situated nature of TPACK, the way of measuring TPACK has become more complex (Jen et al., 2016). Also, there have been existed controversies and disagreements on TPACK and its constructs (Niess, 2011; Cox & Graham, 2009). For those reasons, various approaches have been suggested to find out teachers’ TPACK (Angeli & Valanides, 2009; Jang & Chen, 2010; Jang & Tsai, 2013; Koehler & Mishra, 2006; Koh & Divarahan, 2011; Marino, Sameshima, & Beecher, 2009; Kabakci-Yurdakul et al., 2012; Yeh et al., 2014). In other words, because of the complex nature of TPACK (Graham, 2011), researchers emphasized the measurement of teachers’ TPACK. Therefore, researchers have been attempted to

develop and use different methods to find out teachers' TPACK. In many studies, teachers' TPACK was measured through self-assessment surveys (Archambault & Barnett, 2010; Canbazoglu-Bilici et al., 2013; Kabakci-Yurdakul et al., 2012; Lee & Tsai, 2010; Sahin, 2011; Schmidt et al., 2009), classroom observations (Schmidt-Crawford et al., 2016), assessment of lesson products (Koh, 2013), and a combination of different instruments, such as video recording of instruction, pre- and post-interviews, and surveys (Yeh et al., 2017). According to Koehler, Shin, and Mishra (2012) self-reported assessments, which do not reflect teachers' classroom practices, were widely used methods for measuring TPACK levels. Similarly, in Turkey, surveys were the most dominant data collection tool (Baran & Canbazoglu-Bilici, 2015).

2.3.1 Measurement of TPACK in Science Education

Since TPACK is context-dependent, research focusing on science education had become more of an issue. Research and measurement about teachers' TPACK can be divided into two considering TPACK models, which are integrative and transformative. Table 2.1 shows the summary of the research papers in terms of the measurement of science teachers' TPACK in the integrative model.

Table 2.1 *Summary of Research Papers regarding the Measurements of Science Teachers' TPACK in the Integrative Model*

<i>Research Reference</i>	<i>Participants</i>	<i>Data Sources</i>
Graham et al. (2009)	In-service science teachers	Survey
Guzey and Roehrig (2009)	In-service science teachers	Survey, interview, classroom observation, and lesson plan
Jang and Tsai (2013)	In-service science teachers	Survey
Lin et al. (2013)	Pre-service and in-service science teachers	Survey
Canbazoglu-Bilici, Yamak, Kavak and Guzey (2013)	Pre-service science teachers	Questionnaire, Survey
Lehtinen, Nieminen and Viiri (2016)	Pre-service science teachers	Survey
Mai and Hamzah (2016)	In-service science teachers	Survey
Aydin-Gunbatar, Boz and Yerdelen-Damar (2017)	Pre-service science teachers	Survey
Bagdiken and Akgunduz (2018)	In-service science teachers	Survey
Kiray, Celik and Colakoglu (2018)	In-service science teachers	Survey
Irmak and Yilmaz-Tuzun (2019)	Pre-service science teachers	Survey
Muhaimin et al. (2019)	In-service science teachers	Survey, interview

In the view of the integrative model, Graham et al. (2009) developed “TPACK in Science Survey” to determine science teachers’ confidence levels in TK, TPK, TCK, and TPACK. 11 elementary and 4 secondary education science teachers attended to SciencePlus professional development program. The result of the pre- and post-survey data showed that scores of the participants increased considerably for four

constructs. In addition, teachers were more confident in TK and significantly less confident in the TCK construct. The results implied that although teachers felt confident about TK, they needed to improve their knowledge about content-specific technologies and how to integrate technologies into their content-specific instruction.

On the other hand, Guzey and Roehring (2009) investigated the effect of technology-focused professional development programs on science teachers. To analyze TPACK development, four secondary science teachers attended to study. The result of the data including surveys, interviews, classroom observations, and lesson plans showed that the professional development program, Technology Enhanced Communities (TEC) which was designed in the scope of situated learning supported teachers' practical knowledge and use of technological tools by implementing inquiry-based activities, helped teachers' TPACK development. Moreover, reported significant and influencing factors for teachers' TPACK development were school context and teachers' pedagogical reasoning.

In another research, Jang and Tsai (2013) examined secondary school science teachers' TPACK according to contextualized TPACK model. The main purposes were (1) to decide whether the contextualized TPACK model can be applied in secondary school teachers, and (2) to investigate whether secondary school science teachers' TPACK differ according to their teaching experience and gender. In the scope of these aims, 1292 science teachers in Taiwan participated in the study of Jang and Tsai (2013). Data collection instrument was TPACK questionnaire that included 30 items in total and consisted of four components, namely CK, TK, pedagogical content knowledge in context (PCKCx), and technological content knowledge in context TPCKCx. The results of the study indicated that the contextualized TPACK model could be applied in the context of secondary school science teachers with four factors, namely TK, CK, PCKCx, and TPCKCx. The results showed that the mean of the technology-related factors like TK and TPCKCx was lower in general. In addition, male teachers' TK were significantly higher than female science teachers. Moreover, experienced teachers' CK and PCKCx were

significantly higher than less experienced science teachers. On the contrary, novice teachers TK and TPCKCx were significantly higher than experienced science teachers.

In addition, Lin et al. (2013) investigated preservice and in-service science teachers' technology integration to their instruction considering seven domains of TPACK. The survey which was developed by Schmidt et al. (2009), was adapted to the science education context and used as a data collection instrument. The result of the study showed that synthesized knowledge of technology, pedagogy, and content (TPC) was highly correlated with technology-related factors, including TCK, TPK, and TK. It implies that if science teachers were confident in TPC, they would also be confident in technology-related constructs. In addition, only CK and PK of the in-service science teachers were higher than pre-service teachers. This may be due to the real classroom experience of the in-service teachers. However, the result showed that in-service science teachers were not confident in technology-related domains. On the other hand, results implied that female science teachers showed lower self-confidence in TK but higher PK than males.

In a different research, Canbazoglu-Bilici et al. (2013) developed pre-service science teachers' TPACK self-efficacy beliefs scale (TPACK-SeS). The distinctive characteristic of the scale was the addition of contextual knowledge items. In this regard, EFA and CFA showed that the scale consisted of eight factors including TK, PK, CK, TCK, PCK, TPK, TPACK, and contextual knowledge (CxK). The implementation of this scale with 808 pre-service science teachers showed a high correlation between TK, TCK, TPK, PCK, and TPACK factors.

In another study, Lehtinen, Nieminen and Viiri (2016) investigated pre-service science teachers' TPACK development in four domains, namely CK, PK, TK, and TPACK. Data collection tool was the TPACK survey which was adapted from Lin et al.'s (2013) and Zelkowski et al.'s (2013) studies. Moreover, 36 pre-service science teachers participated in this study. In addition, to measure science teachers' TPACK development, pre-service teachers were instructed about the use of

simulations and tried PHET simulations. The result of the study implied that pre-service science teachers' TPACK scores were higher in the post-test and this difference was significant. On the other hand, only the difference between pre and post-test in the TK domain was not significant.

On the other hand, Mai and Hamzah (2016) investigated primary science teachers' TPACK levels in Malaysia. Data were collected from 133 science teachers and through the TPACK survey developed by Schmidt et al. (2009). The instrument included 47 questions and seven factors, namely TK, PK, CK, TCK, TPK, PCK, and TPACK. The analysis of the survey data showed that science teachers had a high TPACK confidence level. In addition, there was no statistically significant difference between science teachers' TPACK according to gender and age.

In another study, Aydin-Gunbatar, Boz, and Yerdelen-Damar (2017) investigated pre-service science teachers' TPACK self-efficacy (TPACK-SE) beliefs to verify the factor structure of TPACK-SE by using TPACK-SeS developed by Canbazoglu-Bilici et al. (2013). With the exclusion of context knowledge, 606 senior pre-service science teachers' data showed seven factorial structures of TPACK-SE. In addition, there was a high relationship between TPK and TPACK-SE with a high effect size; however low relation existed between TCK and PCK constructs with TPACK-SE. The results showed that there is a need for relating teachers' content knowledge with technology and pedagogy.

In another study, Bagdiken and Akgunduz (2018) measured science teachers' TPACK self-confidence levels. TPACK Self-confidence scale developed by Graham et al. (2009) adapted to Turkish context by Timur and Tasar (2011a) was used as a data collection tool. The analysis of data obtained from 218 science teachers implied that science teachers had high self-confidence levels for TPACK, TPK, TCK, and TK constructs. In addition, it was indicated that the experience years of teachers affected their TPACK self-confidence level with medium effect size. Namely, science teachers who had fewer years of experience had high self-confidence levels in examined TPACK domains.

On the other hand, Kiray, Celik, and Colakoglu (2018) conducted a study considering science teachers' self-efficacy beliefs regarding TPACK and its sub-dimensions by using TPACK-Science Self-efficacy Scale developed by Kiray (2016a). The result of the data collected from 563 science teachers showed that TCK, TPK, and PCK were positively and significantly related to TPACK. The most important result was that TPACK was affected mainly by PCK. In other words, for effective technology integration, science teachers need to know how to teach the content effectively.

Distinctively, Irmak and Yilmaz-Tuzun (2019) investigated pre-service science teachers' perceived TPACK in genetics subject with different and additional technological knowledge domains including Educational TK (ETK), Project Specific TK (PSTK), and Perceived Genetic TK (GTK). Although the results of the study implied that pre-service teachers had a moderate perception of TPACK in genetics, their perceived PSTK was the lowest. In other words, their competency in using specific technologies like wikis, blogs was the lowest. Moreover, male pre-service teachers had higher scores in the perceived PSTK domain only. The results also supported the idea that TPACK is situated. Thus, TPACK research should focus on specific subject areas to acquire more comprehensive knowledge about teachers' TPACK.

In a different study, Muhaimin et al. (2019) conducted a mixed method research to explore science teachers' TPACK levels according to gender, age, and experience years. In this regard, data collection tools were survey and interview. The TPACK survey was adapted from the study of Lin et al. (2013) and included seven factors, namely TK, CK, PK, PCK, TCK, TPK, and TPACK. Moreover, semi-structured interview questions were formed by using survey items. Three hundred fifty-six science teachers participated in the survey, and eight teachers participated for the interview. The results of the study showed that science teachers' TPACK scores were the lowest among all domains. Also, male science teachers TPACK levels were significantly higher than female teachers. On the other hand, there was no significant difference in TPACK scores in terms of experience years.

Table 2.2 *Summary of Research Papers regarding the Measurements of Teachers' TPACK in the Transformative Model*

<i>Research Reference</i>	<i>Participants</i>	<i>Data Sources</i>
Jang (2010)	In-service science teachers	Written assignments, reflective journals and interviews
Canbazoglu-Bilici, Guzey and Yamak (2016)	Pre-service science teachers	Lesson plan, microteaching observation
Yeh et al. (2015)	In-service science teachers	Interview
Yeh et al. (2017)	In-service science teachers	Questionnaire
Jen et al. (2016)	In-service and pre-service science teachers	Questionnaire
Kabakci-Yurdakul et al. (2012)	Pre-service teachers	Video records, audio records, documents, survey (for instrument development)
Kadioglu-Akbulut, Cetin-Dindar, Kucuk and Acar-Sesen (2020)	Pre-service science teachers	Survey

Table 2.2 shows the summary of the research papers regarding the measurement of science teachers' TPACK in the transformative model.

In the view of the transformative model, Jang (2010) investigated four science teachers' TPACK according to the interactive whiteboard (IWB)-based TPACK Comprehension, Observation, Instruction, and Reflection (TPACK-COIR) model. According to this model, firstly, science teachers were instructed about TPACK, IWB hardware, and software in the scope of TPACK Comprehension stage. Secondly, in the TPACK Observation stage, science teachers observed experienced teachers who were competent in using IWB. Thirdly, in the TPACK Instruction stage, science teachers designed and implemented IWB infused lessons on the topic

of heat and temperature. Lastly, in the TPACK Reflection stage, science teachers reflected on their own teaching and TPACK. The data sources were written assignments collected from each stage, reflective journals, and interviews. The analysis of qualitative data showed that the IWB-based TPACK-COIR model developed science teachers' TPACK. Moreover, science teachers reported that their purpose of using IWBs was teaching subject matter. In addition, the use of IWBs provided effective use of visual representations and instructional methods.

In a different study, Canbazoglu-Bilici, Guzey, and Yamak (2016) investigated pre-service science teachers' TPACK development regarding orientations towards science teaching and knowledge of assessment, curriculum, and instructional strategies. Twenty-seven pre-service science teachers received training in TPACK focused science methods course. The results pointed out that pre-service science teachers were inadequate in lesson planning in terms of knowledge of the assessment. In general, technology-focused science method courses influenced preservice science teachers' TPACK.

In another study, Yeh et al. (2015) classified science teachers' TPACK proficiency levels based on the different domains of TPACK-P; assessment, planning and design, and practical teaching. In order to classify science teachers' level of TPACK-P, 40 chemistry, physics, biology, and earth science teachers who integrate technology in their teaching participated in the study. The result of the semi-structured interviews revealed that science teachers who integrated technology in their instruction were at the simple adoption level and did not reach infusive or reflective application levels. In other words, teachers were aware of ICT; nevertheless, they did not integrate technology into their instruction. In addition, their instruction was mainly teacher-centered.

In another study, Yeh et al. (2017) analyzed biology, chemistry, physics, and earth science teachers' TPACK based on their practical knowledge in knowledge, comprehension, application, analysis, synthesis, and evaluation levels. The results of the online TPACK questionnaires showed that application/analysis levels did not

contribute to their TPACK at higher levels. In other words, teachers' rate of technology implementation into instruction does not indicate higher levels of TPACK.

On the other hand, Jen et al. (2016) investigated in-service and preservice science teachers' TPACK-P to compare their level of knowledge and application. Lack of use (Level 1) indicated that teachers have a simple knowledge of technology because either they have no willingness to use technology in their classroom or do not believe in the effectiveness of the technology. Simple Adoption (Level 2) represented that science teachers integrate more teacher-centered technologies into their instruction. On the other hand, Infusive Application (Level 3) indicated more student-centered technology integration. Finally, Reflective Application (Level 4) represented the highest level of TPACK-P indicated that teachers are "adept at using their experience-based TPACK to employ ICTs in assisting their students in learning about science" (Jen et al., 2016, p. 48). The result of the study showed that the TPACK-P levels of pre- and in-service teachers were similar. In addition, although participants' knowledge levels were 2 and 3; the level of application was at 1 showing only simple knowledge of technology.

In a different study, Kabakci-Yurdakul et al. (2012) developed TPACK-Deep Scale in order to measure pre-service teachers' TPACK. Exploratory factor analysis (EFA) showed that the scale consists of four factors, including design, exertion, ethics, and proficiency. In addition, considering four factors of the framework, TPACK competencies and indicators were improved by the experts in the field of educational technology. Focusing directly on the TPACK factor based upon transformative view, this approach is significant among other approaches. Based on this measure, Kadioglu-Akbulut, Cetin-Dindar, Kucuk, and Acar-Sesen (2020) adapted the TPACK-Deep scale into the science education context by considering emergent technologies specific to science education. The developed ICT-TPACK Science Scale consisted of five factors, namely "Planning ICT-integrated science instruction, designing materials for ICT-integrated science instruction, implementing ICT-integrated science instruction, ethics in ICT-integrated science instruction,

proficiency in ICT-integrated science instruction” (Kadioglu-Akbulut, Cetin-Dindar, Kucuk & Acar-Sesen, 2020, p.363).

In their literature review, Voogt et al. (2013) implied that further and detailed research is necessary to give meaning to the complicated relationships between TPACK (teacher knowledge), teachers’ beliefs, and their practical knowledge. Thus, considering previous research, the present study aims to investigate science teachers’ TPACK competency levels and their TPACK indicators in the actual classroom environment.

2.4 Indicators of TPACK

In order to identify teachers’ TPACK, research in practical contexts is required. That is to say, it is important to find out how and why teachers integrate technology into their lessons rather than their knowledge about technology integration. For that reason, it is preferable to investigate teachers’ practical experiences in real classrooms to understand their TPACK.

To understand teachers’ general and content-specific technology integration practices, Graham et al. (2009) categorized science teachers’ TCK (general) and TPACK (content-specific) activities by asking open-ended questions. Teachers’ answers were coded based on general and content-specific activities as well as considering the use of technologies in the classroom environment. Indicators of TCK and TPACK were specified based on teachers’ responses. To illustrate, “Using PPT for presentation” was specified as a TCK example; “Science animations and interactive content” was defined as a TPACK example. The results implied that teachers used general activities more than content-specific activities in their lessons. Moreover, the analysis showed that teachers’ technology integration practices were more teacher-centered. In other words, students had less opportunity to directly use technology in science classroom.

In a different study, while developing the TPACK-Practical framework and survey, Yeh et al. (2014) identified indicators of TPACK-P for each knowledge dimension. To illustrate, “Know how to use ICT to identify students’ learning difficulties” was an example indicator for “Using ICT to understand students” dimension. The indicators were formed as a result of the research and expert panels.

In another study, Yeh et al. (2015) researched science teachers’ proficiency levels and their TPACK models in the classroom. Semi-structured interview questions were formed depending upon 17 indicators of TPACK-P (Yeh et al., 2014). The analysis of the interviews conducted with 40 science teachers indicated that three different patterns were observed in teachers, namely “Technology-Infusive, Technology Transitional, and Planning and Design” (Yeh et al., 2015, p.78). Technology-Infusive teachers integrate technology in higher levels, and they were student-centered. On the other hand, Technology Transitional teachers were teacher-centered. In addition, Planning and Design teachers showed a low level while integrating technology into their practice but a high level of planning and designing technology infusive instruction. Overall, based on indicators of TPACK, teachers’ proficiency levels were not identified in higher levels.

In a different study, Kabakci-Yurdakul et al. (2014) identified teachers’ TPACK competencies and indicators based on the transformative TPACK-Deep scale and its factors. These performance indicators for each competency were also defined as a result of workshop documents, video recordings, and research journals. Within six competency fields, namely designing instruction, implementing instruction, opening to new ideas, following ethical rules, problem-solving, and proficiency, 20 teacher competencies and 120 performance indicators were confirmed. Among all these competencies, indicators for designing and implementing instruction were emphasized mostly, implying the importance of effective technology integration in teaching.

Additionally, Ocak and Baran (2019) examined indicators of science teachers’ TPACK by using interviews and video recordings of the lesson. Two elementary

science teachers and two physics teachers participated in the study. The results of the analysis implied that emerged main themes were the design of the lesson, use of instructional strategies, classroom management, and assessment. The most remarkable result was that although science teachers used technology in their classrooms, their technology integration was teacher-centered.

2.5 Summary of Literature Review

Based on the literature review, self-reported measures were abounding in science education TPACK research (Graham et al., 2009; Lin et al., 2013; Yeh et al., 2017). Although research about scale development and relationship among TPACK constructs were dominant (Aydin-Gunbatar, Boz & Yerdelen-Damar, 2017; Canbazoglu-Bilici et al., 2013), the science education TPACK literature was in a tendency to investigate teachers' practices (Canbazoglu-Bilici, Guzey, & Yamak, 2016; Jen et al., 2016). Research also pointed out the importance of technology integration decisions and behaviors of teachers (Graham et al., 2009; Yeh et al., 2015; Kabakci-Yurdakul et al., 2014). The overall results showed that when teachers were researched based on their practice, their TPACK levels in the application were lower and their instructions were teacher-centered. Therefore, the purpose of the present study was to both quantitatively and qualitatively examine science teachers' TPACK in order to get detailed information.

CHAPTER 3

METHODOLOGY

The purpose of the methodology chapter is to provide deep information about the present study. In this chapter, firstly, the research design, research questions, and the context of the study will be presented. Then, the data collection procedure will be explained. After that, the data analysis procedure will be provided. Finally, ethical considerations, assumptions, and limitations will be covered.

3.1 Research Design

The purpose of this study was to examine science teachers' TPACK. In this regard, explanatory sequential mixed methods design was followed by quantitative survey research methodology and qualitative multiple case study, respectively. In mixed methods designs, not only quantitative but also qualitative data are collected. Moreover, those two "strands" are combined, amalgamated, and joined (Creswell, 2012, p.535). In the scope of the present research, quantitative results are deeply explained by qualitative results (Creswell, 2012).

3.1.1 Quantitative Part

The major purpose of the survey research methodology is to find out the typical features of the population (Fraenkel, Wallen & Hyun, 2012). To generalize results or get a general picture, it is important to use survey research. For that reason, the current study primarily utilized the survey research methodology to determine, describe and reveal science teachers' TPACK competency levels and also their TPACK competency levels based on gender and experience years. In this respect,

data were collected by the online version of the TPACK-Deep scale to save time, energy, and money.

3.1.2 Qualitative Part

According to Merriam (2009), “Qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences” (p.5). In other words, qualitative studies provide detailed information. Although there are different types of qualitative research methodologies, multiple case study which is a type of case study was selected for the current study. In this regard, Merriam (2009) defined a case study as a detailed description and investigation of a case. On the other hand, according to Creswell (2012), the case may be one or more individuals, a program, events, or activities. In that vein, multiple case studies included collecting data from different individual cases (Merriam, 2009). Yin (2002) stated that “Every case should serve a specific purpose within the overall scope of inquiry” (p.47). For that reason, three cases with different TPACK competency levels were selected for the second part of the study. Thus, the aim of the multiple case study part could be considered to reveal multiple perspectives and obtain detailed information from participants about their TPACK in their classroom teaching.

3.2 Research Questions

The purpose of this study was to investigate science teachers’ TPACK in terms of different variables. These variables were science teachers’ TPACK levels, gender, experience years for the quantitative part, and science teachers’ TPACK indicators for the qualitative part. With this respect, Table 3.1 displays the research questions, methodologies, and instruments used in the present study.

Table 3.1 *Research Questions, Methodologies, and Instruments Used in the Study*

<i>Research Questions</i>	<i>Methodology</i>	<i>Data Collection Instruments</i>
RQ 1. What are the TPACK levels of the science teachers?	Quantitative	TPACK-Deep Scale (Kabakci-Yurdakul et al., 2012)
RQ 2. Is there a statistically significant mean difference between male and female science teachers' TPACK?	Quantitative	TPACK-Deep Scale (Kabakci-Yurdakul et al., 2012)
RQ 3. Is there a statistically significant mean difference between the scores of science teachers' TPACK regarding their experience years?	Quantitative	TPACK-Deep Scale (Kabakci-Yurdakul et al., 2012)
RQ 4. What are the indicators of science teachers' TPACK regarding the "meiosis" topic considering TPACK-Deep factors, namely design, exertion, ethics, and proficiency?	Qualitative	Pre-interview Classroom Observation Video Recording Post-interview

3.3 The Context of the Study

3.3.1 Settings

The first part of the study was conducted by web-based questionnaire included demographic information part and TPACK-Deep Scale. The main purpose was to discover TPACK competency levels of science teachers from a small province located in the Central Anatolia Region in Turkey. The second part of the study included pre- and post-interviews, classroom observations, and video recordings of the lessons for the selected science teachers. The purpose of this part was to describe the TPACK indicators of three science teachers with different TPACK levels.

Participants were from three different middle schools located in the same province. The basic characteristics of schools were given in Table 3.2.

Table 3.2 *Characteristics of Selected Schools that Science Teachers Work*

<i>Teachers</i>	<i>Location of the School</i>	<i>Context of the Study</i>
Luke (High TPACK Competency Level)	Small town, 24 km far from the city center	There is not any science and computer laboratory. Internet connection and smartboard exist.
Albert (Medium TPACK Competency Level)	Village, 20 km far from the city center	Science laboratory exists, but there are not any microscopes; computer laboratory exists, but there are old computers and not used. Internet connection and smartboard exist.
Nancy (Low TPACK Competency Level)	County, 8 km far from the city center	Science laboratory and computer laboratory exist. Internet connection and smartboard exist.

Before actual classroom observations, the researcher communicated with participants via telephone. In addition, the researcher requested to monitor teachers' one lesson before actual classroom observations. However, only one teacher accepted to be monitored by the researcher before the actual observation. For classroom observation, one science lesson hour on the topic of meiosis was observed for each participant. The researcher decided on camera location before the lesson. The important criterion was to record teachers and their classroom behaviors clearly.

Since research about contextual understandings of the TPACK has gained prominence (Koh, Chai, & Tay, 2014; Mishra, 2019; Porras-Hernández & Salinas-Amescua, 2013; Swallow & Olofson, 2017), the researcher also believed that results

of the qualitative part of the study will contribute the current literature because selected three schools had different opportunities as described in Table 3.2.

3.3.2 Participants

3.3.2.1 Participants of the Questionnaire

The target population of this study was all science teachers that currently work in middle schools in Turkey. On the other hand, the accessible population was all science teachers that work in middle schools in a small province located in the Central Anatolia Region of Turkey. Since participants of survey research were selected by using convenience sampling methodology, a web-based survey was sent to easily accessible teachers. As a result, the sample consisted of 136 science teachers who worked in middle schools in a province located in Central Anatolia.

In convenience sampling, individuals were selected because they were available (Fraenkel, Wallen & Hyun, 2012). The participants were invited to the online version of the TPACK-Deep survey (Kabakci-Yurdakul et al., 2012) by using e-mail. The respondents were science teachers ($N=136$) who worked in middle schools in a small province located in the Central Anatolia Region of Turkey. Table 3.3 shows the gender distribution and Table 3.4 shows the work experience of science teachers who participated in the present study. The categorization of experience years was based on National Center for Education Statistics (NCES, n.d.).

Table 3.3 *Gender Distribution of Science Teachers Participated in the Study*

	<i>Male</i>	<i>Female</i>	<i>Total</i>
Number of science teachers	51	85	136

Table 3.4 *Work Experience of Science Teachers Participated in the Study*

	<i>0-4 years of experience</i>	<i>5-9 years of experience</i>	<i>10-14 years of experience</i>	<i>More than 15 years of experience</i>
Number of science teachers	37	46	35	18

3.3.2.2 Participants of the Classroom Observations

Three of the survey participants were observed in the classroom and video recorded voluntarily after the administration of the web-based questionnaire in order to examine their TPACK deeply. In this regard, purposeful and convenience sampling techniques were used for the selection.

Purposeful sampling was defined as “selecting *information-rich* cases for the study in-depth” (Patton, 2002, p.230). Moreover, convenience sampling is defined as “selecting a sample based on time, money, location, availability of sites or responders” (Merriam, 2015, p. 98). Therefore, following these definitions, the participants were selected by using convenience sampling procedures voluntarily because of time and availability of location. Considering these two sampling methods, convenient science teachers were selected for multiple case study based on different criteria on purpose. Firstly, the teachers had different TPACK competency levels, namely high, medium, and low based on web-based survey results. Their levels were determined by the study of Kabakci-Yurdakul et al. (2012) (as shown in Table 3.8). Secondly, diversity in gender was considered by selecting one female and two male participants (Table 3.5). Thirdly, all teachers were willing to participate in the research and signed informed consent.

Table 3.5 *Cases for the Classroom Observation*

<i>Characteristics of the cases</i>	
Case 1 - Luke	Male 3,5 years of work experience High TPACK Competency Level (Score: 134)
Case 2 - Albert	Male 13 years of work experience Medium TPACK Competency Level (Score: 122)
Case 3 - Nancy	Female 13 years of work experience Low TPACK Competency Level (Score: 93)

Case 1 – Luke: Luke had 3,5 years of work experience as a middle school science teacher and has worked in public schools. He also had a master’s degree in science education. He has not taken any special professional development regarding technology. In addition, Luke mostly integrates various technologies into his lessons, such as word clouds, animations, interactive presentations, and online file-sharing platforms.

Case 2 – Albert: Albert had 13 years of work experience as a middle school science teacher. He has worked in public schools. Also, he had a masters’ degree in science education. He participated in professional development programs given by the Ministry of National Education, including the use of technology in education and programming. Also, Albert enriched his lesson by using different technologies, including online file-sharing programs, mind-mapping tools, animations, videos, and online learning platforms.

Case 3 – Nancy: Nancy had 13 years of work experience as a middle school science teacher. She has worked in public schools. She has not taken any special professional development regarding technology. Moreover, she had a bachelorette degree in science education.

3.4 Data Collection

Before collecting the data, necessary permissions were acquired from firstly Human Subjects Ethics Committee of Middle East Technical University (METU HSEC) (see Appendix H), secondly Ministry of National Education (see Appendix I), and thirdly Aksaray Provincial Directorate of National Education (See Appendix J).

3.4.1 TPACK-Deep Scale

For the current study, quantitative data were collected by using the TPACK-Deep scale (see Appendix A), which was developed by Kabakci-Yurdakul et al. (2012). The scale was a five-point Likert type (“I can easily do it”, “I can do it”, “I can partly do it”, “I can’t do it” and “I certainly can’t do it”) and was used to define TPACK-competency levels of pre-service teachers. Moreover, it consisted of 33 items without any reverse coded items and four factors. These factors are design, exertion, proficiency, and ethics. The design factor implies teachers’ abilities for designing technology integrated lesson. Moreover, the exertion factor refers to teachers’ competencies regarding selecting and integrating technologies for their instruction. Also, the ethics factor implies ethical use of technologies. In addition, the proficiency factor implies teachers’ abilities to integrate technology and solve possible technology-related problems. Table 3.6 represents the TPACK-Deep factors, the explanations of these factors, and example items from the scale for each factor.

Table 3.6 *TPACK-Deep Scale Factors, Items, Explanations, and Sample Items*

<i>TPACK-Deep factors</i>	<i>TPACK-Deep items</i>	<i>Explanations of factors</i>	<i>Example item</i>
Design	1-10	Teachers' proficiency regarding designing instruction.	3. I can use technology to develop activities based on students' needs to enrich the teaching and learning process.
Exertion	11-22	Teachers' proficiency in terms of practicing and evaluating teaching with the use of technology.	13. I can apply instructional approaches and methods appropriate to individual differences with the help of technology.
Ethics	23-28	Teachers' proficiency regarding ethical issues while using technology.	25. I can use technology in every phase of the teaching and learning process by considering the copyright issues.
Proficiency	29-33	Teachers' ability to integrate technology and solve possible problems.	30. I can troubleshoot any kind of problem that may occur while using technology in any phase of the teaching-learning process.

On the other hand, the TPACK-Deep scale was developed in two stages containing exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Table 3.7 shows the Cronbach's alpha reliability coefficients for the Kabakci-Yurdakul et al.'s study and the current study. In the study of Kabakci-Yurdakul et al. (2012), Cronbach's alpha coefficient for the whole scale was 0.95, and for the design factor $\alpha=0.92$; for the exertion factor $\alpha=0.91$; for the ethics factor $\alpha=0.86$; for the proficiency factor $\alpha=0.85$. In addition, the test-retest reliability coefficient was 0.80 for the scale (Kabakci-Yurdakul et al., 2012). Since the TPACK-Deep scale was used for determining pre-service teachers' TPACK competency levels, Albayrak-Sari et al. (2016) conducted a study using the TPACK-Deep scale for in-service teachers. In the present study, Cronbach's alpha coefficient was 0.97 for the whole scale. For

the present study, Cronbach's alpha coefficient for the whole scale was 0.97; for the design factor $\alpha=0.94$; for the exertion factor $\alpha=0.94$; for the ethics factor $\alpha=0.91$; for the proficiency factor $\alpha=0.87$ (Table 3.7). The results implied that the scale is reliable (Pallant, 2007).

Table 3.7 *TPACK Deep Factors and Cronbach's Alpha Coefficients*

<i>TPACK- Deep factors</i>	<i>Cronbach's alpha coefficients</i>	
	<i>Kabakci-Yurdakul et al., 2012</i>	<i>Present study</i>
Design	0.92	0.94
Exertion	0.91	0.94
Ethics	0.86	0.91
Proficiency	0.85	0.87
Whole Scale	0.95	0.97

For the current study, the instrument was implemented online. Data that include both demographic information and scale were collected by the convenience sampling method. Moreover, participants were invited to research via e-mail. Based on statistical results, science teachers' TPACK competency levels were classified as high, medium, and low based on participants' average scores, as shown in Table 3.8.

Table 3.8 *TPACK Scores and Competency Levels*

<i>TPACK score</i>	<i>TPACK competency level</i>
Lower than 95	Low Level
96 - 130	Medium Level
Higher than 131	High Level

Note. Adapted from "The development, validity, and reliability of TPACK-deep: A technological pedagogical content knowledge scale" by I. Kabakci-Yurdakul, H. F. Odabasi, K. Kilicer, A. N. Coklar, G. Birinci, A. A. Kurt, 2012, *Computers and Education*, 58(3), p. 964-977 (<https://doi.org/10.1016/j.compedu.2011.10.012>).

3.4.2 Pre-Interview

The main purpose of the pre-interview (Appendix B) was to learn participant teachers' planning decisions for the lesson. Based on this, semi-structured pre-interview questions were generated by using the TPACK-Deep Scale and its factors. Initially, the researcher formed an item pool considering four factors of the scale: design, exertion, proficiency, and ethics. Then, the final protocol was reviewed and finalized by an experienced researcher in the area of TPACK. In pre-interview, the researcher wanted to obtain information regarding designing technology-enhanced lesson because this information cannot be gathered from lesson observation. Therefore, the questions were mainly about the design factor. In addition to the design factor, interview questions contained exertion, ethics, and proficiency factors. Sample question from pre-interview was:

10. While planning your lesson, what did you pay attention? (Alternative question: what are the factors that you pay attention while planning today's lesson?). Probing questions: Curriculum objectives, subject content, knowledge of the students, and physical conditions.

The participants of the pre-interview were three science teachers selected from quantitative part of the study according to their different TPACK competency levels. Pre-interviews were planned to implement face-to-face before classroom observation. However, because of the time limitation of one teacher, one pre-interview was conducted as a phone interview. The other interviews were conducted in teachers' offices. Before collecting data, the researcher informed participant teachers about the research, and teachers were signed an informed consent form voluntarily. Moreover, they permitted audio recordings. Each interview lasted 30 minutes on average.

3.4.3 Classroom Observation

The purpose of the classroom observation was to determine science teachers' TPACK indicators considering the TPACK-Deep scale and its factors. Besides, another aim was to reveal whether science teachers' practices showed consistency with their survey results. Before collecting data, the researcher met with the participants and asked them to sign informed consent forms to ensure voluntary participation.

Observational data were collected by classroom observations and video recordings of science teachers' one lesson in meiosis subject, which is abstract and suitable for technology integration. Moreover, the aim of the research determines the role of the researcher and the type of participation. If the researcher did not attend any classroom activities or did not interact with the teacher and students in the classroom, the role of the observer was described as a non-participant (Spradley, 1980). Therefore, classroom observations were conducted as a non-participant because the researcher aimed to investigate teachers' authentic TPACK indicators without manipulating teachers or students. Moreover, these observational data were analyzed by the Table of Indicators and Competencies of Technopedagogical Education (see Appendix N) developed by Kabakci-Yurdakul et al. (2012).

3.4.4 Post-Interview

Since the purpose of the qualitative part was to investigate science teachers' TPACK deeply, semi-structured post-interviews (Appendix C) were planned to obtain rich information from participants considering four factors of TPACK-Deep. By doing post-interviews, participants rethought their classroom teaching, planning as well as ethics and proficiency, and reflect on themselves. In addition, the most important reason for post-interviews was to check the meaning-making. Sample question from post-interview was:

3. How could you integrate technology into your instruction more? Probing questions: Teaching methods, strategies, techniques, students' prior knowledge, possible misconceptions, student-centered instruction, measurement, and assessment.

Post-interview questions were formed after analyzing each pre-interview and video recording in the expectation that participants could answer what and why they did or did not during their instruction. In this sense, interview protocols were finalized by an experienced researcher in the area of TPACK.

3.5 Data Analysis

3.5.1 Analysis of Quantitative Data

Quantitative data were analyzed by descriptive statistics and inferential statistics. Since TPACK-Deep scale was a five-point Likert type, the participant who selected "I can easily do it" option got 5 points; "I can do it" option got 4 points; "I can partly do it" option got 3 points; "I can't do it" option got 2 points; "I certainly can't do it" option got 1 point for each item. The total score of the participants indicated their TPACK competency levels as shown in Table 3.8. In addition, t-test was used to analyze gender variable; ANOVA was used to analyze the experience year variable.

3.5.2 Analysis of Qualitative Data

Mainly, qualitative data could be analyzed by inductive and deductive analysis. While inductive analysis represents finding out themes or categories in data, deductive analysis involves analysis in consideration of existing framework (Patton, 2002). In order to decide whether teachers demonstrated any sign of competency in their teaching, the "Table of Indicators and Competencies of Technopedagogical Education" (See Appendix N) developed by Kabakci-Yurdakul et al. (2012) was used. Since the "Table of Indicators and Competencies of Technopedagogical

Education” was formed according to factors of the TPACK-Deep scale, data were analyzed considering these factors as themes. In addition, for analyzing observational and interview data, content analysis is useful (Fraenkel, Wallen & Hyun, 2012). For that reason, the observational and interview data were further analyzed based on content analysis in order to ensure whether participants showed additional or different indicators or competencies.

In this sense, firstly, pre- and post-interview recordings were transcribed verbatim. Since the TPACK-Deep scale contained four factors and qualitative investigations were made in that vein, the researcher accepted these four factors as themes. However, the possibility of emerging new coding categories and themes was considered. That means the researcher also sought new themes from the qualitative data because qualitative data analysis is a continuum (Patton, 2002). The primary analysis of pre-interviews was made based on the “Table of Indicators and Competencies” (see Appendix N). The researcher analyzed each case whether they show any sign of competencies. If necessary, transcriptions were read again and again. After that, one researcher who is an expert in TPACK coded the same data independently, and two researchers’ analyses were compared. This strategy also served to decrease the potential bias for single-person analysis (Patton, 2002).

Secondly, video recordings were transcribed second-by-second. Similarly, the factor of the TPACK-Deep Scale was accepted as themes, and primary analyses were made considering the “Table of Indicators and Competencies” (See Appendix N). The researcher further analyzed each case in order to find out new themes or indicators based on content analysis. In the same way with interview analysis, one researcher who is an expert in TPACK coded video data independently, and two researchers’ analyses were compared. To determine inter-rater reliability, the percent agreement method was used. After coding data individually, observers compared data coding, and 87 % agreement was found for interviews and classroom observation. To measure the percentage of agreement, agreed data were divided into overall data.

3.6 Internal, External Validity and Trustworthiness of the Study

Since the current study followed mixed method design, internal and external validity for the quantitative part and trustworthiness for the qualitative part will be covered in this section.

3.6.1 Internal Validity

Fraenkel, Wallen, and Hyun (2012) defined internal validity as “any relationship observed between two or more variables should be unambiguous as to what it means rather than being due to *something else*” (p.166). There were possible threats to internal validity for the current study.

Subject characteristics threat occurs when some participants have distinct characteristics unintentionally that affecting the variables of the study (Fraenkel, Wallen & Hyun, 2012). In the current study, participants who received a lot of training about technology can be accepted as subject characteristics threat. However, this was controlled by survey questions. A mortality threat occurs when participants do not complete the survey (Fraenkel, Wallen & Hyun, 2012). Since the sampling strategy was convenience sampling, participants were willing to attend the study voluntarily. Also, to decrease mortality threat, the researcher reminded participants to complete the online scale via e-mail. On the other hand, instrumentation could be a possible threat to the study. Instrumentation decay occurs when there existed changes in the instrument (Fraenkel, Wallen & Hyun, 2012). To eliminate instrumentation decay, the TPACK-Deep scale was implemented as five points Likert-type as in its original form.

3.6.2 External Validity

Fraenkel, Wallen, and Hyun (2012) defined external validity as “The extent to which the results of a study can be generalized determines external validity of the study”

(p.103). For a determining representative sample, Krejcie and Morgan's (1970) table was used. Since the accessible population was all science teachers that work in middle schools in a small province located in the Central Anatolia Region of Turkey, the representative sample was selected by convenience sampling. However, convenience sampling can be a threat to external validity. Fraenkel, Wallen, and Hyun (2012) suggested using replication when random sampling is not applicable. In this regard, ecological generalizability was defined as "...the result of a study can be extended to other settings or conditions" (Fraenkel, Wallen, and Hyun, 2012, p. 105). For that reason, ecological generalizability is reasonable because the setting of the study is described in detail.

3.6.3 Trustworthiness of the Study

In qualitative research, the quality of the study is evaluated by the trustworthiness of the study. The followings are components of the trustworthiness for the second part of the study.

3.6.3.1 Credibility

In qualitative research, credibility refers to internal validity (Fraenkel, Wallen & Hyun, 2012). Lincoln and Guba (1985) proposed basic techniques to increase the credibility of the study. In that vein, prolonged engagement refers to spending sufficient time with the participants to build trust and learning about culture (Lincoln & Guba, 1985). For that purpose, the researcher engaged with participants in a project and got their contact information for the qualitative part of the study. The researcher continuously communicated with the participants before collecting interview and video recording data to learn more about school culture and teachers. In addition, the researcher participated and observed teachers' classrooms before data collection to get familiar with them. However, one of the teachers accepted a classroom visit to his classroom. In the current study, triangulation was another

strategy for credibility. Denzin (1978) proposed four ways of triangulation including different sources, methods, observers, and theories. For data triangulation, observations, pre- and post- interviews were used together for confirming the data.

3.6.3.2 Transferability

Transferability refers to external validity. According to Merriam (2009), it is “the extent to which the findings of a study can be applied to other studies.” (p.223). Since the main aim of the study was not to make generalizations, transferability will contribute to future research by giving rich and thick descriptions about the study context and participants.

3.6.3.3 Dependability

Dependability refers to reliability in qualitative methodologies. To increase dependability, the researcher who is an expert in TPACK coded and analyzed interview and video transcriptions. Moreover, from the beginning of the study, the researcher recorded memos in every step of the research.

3.7 Ethical Considerations

While conducting the research with humans, three main issues should be considered in an ethical perspective: “protecting participants from harm, the confidentiality of research data, and deception of subjects” (Fraenkel, Wallen & Hyun, 2012, pp.63-65). In order to protect participants from harm, the researcher obtained necessary permissions from the METU HSEC. In addition, informed consent forms were signed by all voluntary participants (see Appendix D and E). For ensuring the confidentiality of research data, participants did not indicate their names or any personal information. Moreover, the researcher protected the research data and did not share these except with the supervisors. Although children were not a participant

in this study, parents also signed informant consent forms (see Appendix F) because of the video recordings of classrooms.

3.8 Assumptions and Limitations

In the quantitative part of the study, the TPACK-Deep scale, which is a self-reported survey, was used. Because of the nature of the scale, participants may have scored themselves higher or lower. Therefore, the researcher assumed that all participants answered questions intimately and honestly. Besides, classroom observations were scheduled one week before data collection, and teachers were knowledgeable about the subject. Consequently, teachers may have changed their lesson plans. The researcher assumed that teachers taught their lessons without making revisions. Moreover, it was assumed that teachers were not affected by the researcher and video camera.

Fraenkel, Wallen, and Hyun (2012) stated that convenience sampling limits generalizability. Detailed descriptions of the sample are suggested if random sampling is not applicable. For that reason, the researcher collected detailed information from survey participants. In addition, the study was limited to middle school science teachers who worked in a public school and small province located in the Central Anatolia Region of Turkey. Moreover, the present study was limited to one class hour observation of participant science teachers' lesson on the topic of meiosis.

CHAPTER 4

RESULTS

In this chapter, firstly, science teachers' TPACK levels were reported. Then, indicators of participating science teachers' TPACK were explained. TPACK indicators were reported based on factors of the TPACK-Deep scale, namely design, exertion, proficiency, and ethics.

4.1 TPACK Levels of Science Teachers

RQ 1. What are the TPACK levels of science teachers?

The purpose of the first research question was to investigate science teachers' TPACK levels. In that vein, a five-point Likert-type TPACK-Deep scale which has 33 items was implemented. The answers of the participants were analyzed by descriptive statistics. To interpret the results, Table 3.8 was used. According to Table 3.8, TPACK competency levels based on participants' total scores according to the study of Kabakci-Yurdakul et al. (2012). Since the scale consisted of 33 items with a five-point Likert-type, total scores can be obtained between 33 and 165. Additionally, lower than 95 points implied a low level, points between 96 and 130 indicated a medium level, and more than 131 points implied a high level of TPACK (Kabakci-Yurdakul et al., 2012). In other words, higher scores indicate higher TPACK levels, and lower scores indicate lower TPACK levels.

Table 4.1 *Descriptive Analysis for Science Teachers' TPACK Scores according to TPACK-Deep Scale*

	<i>Mean</i>	<i>SD</i>	<i>Median</i>	<i>Min.</i>	<i>Max.</i>	<i>Skewness</i>	<i>Kurtosis</i>
TPACK	132.32	17.17	132.00	93.00	165.00	-.07	-.45

Table 4.1 shows the descriptive statistical analysis of science teachers' TPACK scores according to TPACK-Deep scale. According to Table 4.1, science teachers' mean TPACK scores ($M = 132.32$) implied moderately high TPACK levels because, as shown in Table 3.8, the scores that are higher than 131 refers to the high TPACK levels. Moreover, the minimum score was 93 and the maximum score was 165 for the selected sample of science teachers according to Table 4.1.

Table 4.2 *Frequency and Percentage of Science Teachers' TPACK Scores and Competency Levels*

<i>TPACK Score</i>	<i>TPACK Competency Levels</i>	<i>Frequency</i>	<i>Percent</i>
Lower than 95	Low Level	1	0.74 %
96 - 130	Medium Level	58	42.65 %
Higher than 131	High Level	77	56.62 %

Table 4.2 shows the frequency of science teachers' TPACK scores. Considering the TPACK scores and the TPACK competency levels, 0.74% of the science teachers were at a low TPACK competency level. Moreover, 42.65 % of the science teachers were medium level. In addition, 56.62% of the science teachers had a high TPACK competency level. In other words, more than half of the participants were in high TPACK competency level.

Table 4.3 *Descriptive Analysis of Science Teachers' TPACK Scores according to Items and Factors of the TPACK-Deep Scale*

<i>TPACK-Deep factors</i>	<i>Items</i>	<i>Mean scores</i>
Design	1-10	3.91
Exertion	11-22	4.08
Ethics	23-28	4.24
Proficiency	29-33	3.75

Also, considering TPACK-Deep factors, which are design, exertion, ethics, and proficiency, Table 4.3 shows science teachers' mean scores for those factors. Since the number of items for each factor is different, the mean scores for the TPACK-Deep factors were analyzed over five because the scale was 5 point-Likert type. According to descriptive analysis shown in Table 4.3, science teachers had highest mean scores in the ethics factor. Following that, the second-highest mean score belonged to exertion factor. Moreover, science teachers had third higher mean score in the design factor. Lastly, the lowest mean scores belonged to the proficiency factor. In other words, science teachers had the highest proficiencies regarding ethical issues while integrating technology into their instruction, such as obeying access rights, privacy, and security issues. In addition, science teachers had lowest competencies while integrating technology with the content and pedagogy and solving possible problems.

Moreover, Table 4.4 showed the frequency distribution of participants' responses and mean scores for each item of the TPACK-Deep scale. It is understood from the table that science teachers' mean scores for the items related to the ethics factor (items 23-28) were higher than other items and factors. Also, the highest mean scores belonged to item 24 which was in the ethics factor. On the other hand, according to Table 4.5, science teachers' mean scores for the proficiency factor (items 29-33) were the lowest. Moreover, their lowest mean scores considering each item belonged to item 29 which represents the proficiency factor.

Table 4.4 *Frequency Distribution of Participants' Responses to the Items and Mean Scores of each Item*

	<i>I can't certainly do it</i>	<i>I can't do it</i>	<i>I can partly do it</i>	<i>I can do it</i>	<i>I can easily do it</i>	<i>Mean scores of the item</i>
1.I can update an instructional material (paper based, electronic or multimedia materials, etc.) based on the needs (students, environment, duration, etc.) by using technology	1	4	40	52	39	3.91
2.I can use technology to determine students' needs related to content area in the pre-teaching process.	0	5	27	67	37	4.00
3. I can use technology to develop activities based on student needs to enrich the teaching and learning process.	1	5	23	68	39	4.02
4.I can plan the teaching and learning process according to available technological resources.	0	1	23	72	40	4.11
5.I can conduct a needs analysis for technologies to be used in the teaching and learning process to increase the quality of teaching.	2	6	38	69	21	3.74
6.I can optimize the duration of the lesson by using technologies (educational software, virtual labs, etc.)	1	11	57	46	21	3.63
7.I can develop appropriate assessment tools by using technology.	0	5	39	62	30	3.86
8.I can combine appropriate methods, techniques, and technologies by evaluating their attributes to present the content effectively.	0	3	26	74	33	4.01
9.I can use technology to appropriately design materials to the needs for an effective teaching and learning process.	0	8	31	63	34	3.90
10.I can organize the educational environment in an appropriate way to use technology.	0	4	34	62	36	3.96

Table 4.4 (cont'd)

11.I can implement effective classroom management in the teaching and learning process in which technology is used.	0	1	19	73	43	4.16
12.I can assess whether students have the appropriate content knowledge by using technology.	1	5	37	62	31	3.86
13 I can apply instructional approaches and methods appropriate to individual differences with the help of technology.	0	8	35	74	19	3.76
14.I can use technology for implementing educational activities such as homework, projects, etc.	0	1	28	67	40	4.07
15.I can use technology-based communication tools (blog, forum, chat, e-mail, etc.) in the teaching process.	0	8	14	68	46	4.12
16. I can use technology for evaluating students' achievement in related content areas.	0	2	25	72	37	4.06
17. I can be an appropriate model for the students in following codes of ethics for the use of technology in my teaching.	0	0	22	66	48	4.19
18. I can guide students in the process of designing technology-based products (presentations, games, films, etc.).	0	1	17	71	42	4.21
19. I can use innovative technologies (Facebook, blogs, twitter, podcasting, etc.) to support the teaching and learning process.	0	1	20	64	51	4.21
20. I can use technology to update my knowledge and skills in the area that I will teach.	0	0	20	71	45	4.18
21.I can update my technological knowledge for the teaching process.	0	0	26	78	32	4.04
22. I can use technology to keep my content knowledge updated.	0	0	22	80	34	4.09
23. I can provide each student equal access to technology.	0	0	15	78	43	4.21

Table 4.4 (cont'd)

24. I can behave ethically in acquiring and using special/private information -which will be used in teaching a subject area - via technology (audio records, video records, documents, etc.)	0	0	8	67	61	4.39
25. I can use technology in every phase of the teaching and learning process by considering the copyright issues (e.g., license)	0	2	22	68	44	4.13
26. I can follow the teaching profession's codes of ethics in online educational environments (WebCT, Moodle, etc.).	0	4	14	70	48	4.19
27. I can a guidance to students by leading them valid and reliable digital sources.	0	2	15	72	47	4.21
28.I can behave ethically regarding the appropriate use of technology in educational environments.	0	1	11	68	56	4.32
29.I can troubleshoot problems that could be encountered with online educational environments (WebCT, Moodle, etc.)	1	19	55	44	17	3.42
30.I can troubleshoot any kind of problem that may occur while using technology in any phase of the teaching-learning process	0	8	53	55	20	3.64
31.I can use technology to find solutions to problems (structuring, updating, and relating the content to real life, etc.).	0	3	42	62	29	3.86
32. I can become a leader in spreading the use of technological innovations in my future teaching community.	1	6	30	67	32	3.90
33. I can cooperate with other disciplines regarding the use of technology to solve problems encountered in the process of presenting content.	0	0	39	65	32	3.95

Table 4.5 *Descriptive Analysis for Science Teachers' TPACK in terms of Gender*

<i>Gender</i>	<i>Mean</i>	<i>SD</i>	<i>Median</i>	<i>Min.</i>	<i>Max.</i>	<i>Skewness</i>	<i>Kurtosis</i>
Female	131.95	17.32	132.00	93.00	165.00	-.06	-.45
Male	132.94	10.07	132.00	96.00	165.00	-.08	-.36

Table 4.5 shows descriptive statistical analysis of science teachers' TPACK-Deep scores according to their gender. As shown in Table 3.8, the scores that higher than 131 refers to the high TPACK competency levels. Considering Table 3.8 and Table 4.6, both male ($M = 132.94$, $N = 51$) and female ($M = 131.95$, $N = 85$) science teachers had high level of TPACK. However, male science teachers' TPACK scores were slightly higher than female science teachers.

Table 4.6 *Descriptive Analysis for Science Teachers' TPACK in terms of Experience Years*

<i>Experience Years</i>	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>95% Confidence Interval for Mean</i>		<i>Minimum</i>	<i>Maximum</i>	<i>Skewness</i>	<i>Kurtosis</i>
				<i>Lower Bound</i>	<i>Upper Bound</i>				
0-4 years	37	137.73	15.20	132.66	142.80	99.00	165.00	.11	-.12
5-9 years	46	130.46	17.77	125.11	135.67	96.00	165.00	.06	-.71
10-14 years	35	129.51	17.77	123.50	135.70	93.00	162.00	-.13	-.33
More than 15 years	18	131.44	17.12	122.93	139.96	108.00	165.00	.55	-.69
TOTAL	136	132.32	17.17	129.41	135.23	93.00	165.00		

Table 4.6 shows descriptive statistical analysis of the science teachers' TPACK-Deep scores according to their experience years. Teachers who had 0-4 years of experience have the highest mean scores ($M = 137.73$). On the other hand, teachers who had 10-14 years of experience have lower mean scores ($M = 129.60$). In addition, mean scores of 5-9 years experienced teachers ($M = 130.39$) are lower than most experienced teachers with more than 15 years ($M = 131.44$). According to descriptive analysis shown in Table 4.6, teachers who had less experience had the highest mean scores on the TPACK-Deep scale. Following that, the second highest mean score belonged to the most experienced teachers with more than 15 years of experience. Lastly, the lowest mean scores belonged to the teachers who had 10-14 years of experiences.

4.2 Science Teachers' TPACK Levels based on Gender

RQ 2. Is there a statistically significant mean difference between male and female science teachers' TPACK?

The purpose of the second research question was to investigate whether male and female science teachers' mean TPACK scores differ significantly. For that purpose, the independent sample t-test was implemented. Before conducting the t-test, assumptions were checked primarily. In this regard, for research question 2, the dependent variable was TPACK-Deep scores, and the independent variable was gender.

According to Pallant (2007, pp.123-125), independent sample t-tests have five assumptions including "the level of measurement, random sampling, independence of observation, normality, and homogeneity of variances." To check these assumptions, below mentioned stages were followed;

1. *Level of measurement:* Since the dependent variable, which was TPACK-Deep scores is continuous, the first assumption was not violated.

2. *Random sampling*: The convenience sampling technique was used because of the time and availability of participants. Therefore, the assumption of random sampling was violated. However, Pallant (2007, p. 203) stated that using random sampling technique "...is often not the case in real-life research". Therefore, convenience sampling was seen as acceptable.
3. *Independence of observation*: The researcher included demographic information form in the online survey in order to get detailed information from subjects. This form had distinctive items including the school location and the name of the school that teachers work. Therefore, the possibility of participating in a survey more than once was eliminated by looking at teachers' demographic information. In other words, independence of observation was ensured.
4. *Normality*: For the normality, skewness and kurtosis values, and histograms were checked. Skewness and kurtosis values were in between -2 and +2 (See Table 4.5). In addition, the shape of the histogram implied normal distribution (see Appendix L). Thus, the assumption of normality is ensured.
5. *Homogeneity of variances*: For homogeneity of variances, Levene's test was conducted as a part of the t-test. The significance value was greater than .05 (see Table 4.7). It implies that variances for female and male participants are equal. Therefore, homogeneity of variances is ensured.

Table 4.7 Independent Sample t-test Results for Male and Female Science Teachers

		<i>Levene's Test for Equality of Variances</i>		<i>t-test for Equality of Means</i>						
		<i>F</i>	<i>Sig.</i>	<i>t</i>	<i>df</i>	<i>Sig. (2- tailed)</i>	<i>Mean Difference</i>	<i>Std. Error Difference</i>	<i>95% Confidence Interval of the Difference</i>	
									<i>Lower</i>	<i>Upper</i>
TPACK	Equal variances assumed	.06	.81	-.32	134	.75*	-.99	3.05	-7.02	5.05
	Equal variances not assumed			-.32	106.63	.75	-.99	3.04	-7.01	5.04

*p < .05.

After checking assumptions, an independent-samples t-test was conducted to compare the TPACK scores for males and females. According to Table 4.7, there was not a statistically significant difference in scores for males ($M = 132.94$, $SD = 17.07$) and females ($M = 131.95$, $SD = 17.31$), $t(134) = -.32$, $p = .75$ (two-tailed). The magnitude of the differences in the means (mean difference = $-.95$, 95% CI: -7.02 to 5.05) was very small (eta squared = $.0008$). These results suggested no significant difference between males and females in terms of their TPACK-Deep scores.

4.3 Science Teachers' TPACK Levels based on Experience Years

RQ 3. Is there a statistically significant difference between the scores of science teachers' TPACK regarding their experience years?

The purpose of the third research question was to investigate whether science teachers' TPACK scores significantly differ according to their experience years. For that purpose, one-way between-groups ANOVA was implemented. Before conducting the test, assumptions for ANOVA were checked primarily.

According to Pallant (2007, pp.123-125), similar to the independent sample t-tests, one-way between-groups ANOVA has five assumptions, including “the level of measurement, random sampling, independence of observation, normality, and homogeneity of variances.”

1. *Level of measurement:* Since the dependent variable which was TPACK-Deep scores is continuous, the first assumption was not violated.
2. *Random sampling:* Rather than random sampling, the convenience sampling technique was used because of the time and availability of participants. Therefore, the assumption of random sampling was violated. However, Pallant (2007, p.203) stated that using random sampling technique “...is often not the case in real-life research”. Thus, convenience sampling was seen as acceptable.

3. *Independence of observation*: The researcher included demographic information form in the online survey in order to get detailed information from subjects. This form had distinctive items, including the school location and the name of the school that teachers work. Therefore, participating in a survey more than once was eliminated by looking at teachers' demographic information. In other words, independence of observation was ensured.
4. *Normality*: For the normality, skewness and kurtosis values, and histograms were checked. Skewness and kurtosis values were in between -2 and +2 (See Table 4.6). The shape of the histogram implied normal distribution (see Appendix M). Thus, the assumption of normality is ensured.
5. *Homogeneity of variances*: For homogeneity of variances, Levene's test for homogeneity of variances was conducted as a part of ANOVA. The significance value is greater than .05 (see Table 4.9), so variances in scores of four groups having different experience years are considered to be equal. Therefore, homogeneity of variances is ensured.

Table 4.8 *One-way ANOVA Results for Experience Years*

	<i>Sum of Squares</i>	<i>df</i>	<i>Mean Square</i>	<i>F</i>	<i>Sig.</i>
Between Groups	1526.67	3	508.89	1.76**	.16
Within Groups	38257.09	132	289.83		
TOTAL	39783.76	135			

** $p < .05$.

After checking assumptions, a one-way between-groups ANOVA was conducted to compare TPACK-Deep scores of participants having different experience years. Subjects were divided into four groups according to their experience years (Group 1: 0-4 years, Group 2: 5-9 years, Group 3: 10-14 years, Group 4: more than 15 years).

According to Table 4.8, there was not a statistically significant difference at $p < .05$ level in TPACK scores for four groups: $F(3, 132) = 1.76, p = .16$. The actual difference in mean scores between groups was quite small ($\eta^2 = .04$). These results suggested that there is no significant difference between teachers' TPACK scores in terms of their experience years.

4.4 Indicators of Science Teachers' TPACK

RQ 4. What are the indicators of science teachers' TPACK regarding "meiosis" subject considering TPACK-Deep factors?

The aim of the fourth research question was to investigate science teachers' TPACK indicators. For this purpose, participants were selected according to their different TPACK-Deep levels.

Table 4.9 *TPACK Scores of Observed Participants*

	<i>Teacher Luke</i>	<i>Teacher Albert</i>	<i>Teacher Nancy</i>
TPACK Score	134	122	93
TPACK Level	High Level	Medium Level	Low Level

Table 4.9 shows the observed science teachers' TPACK scores and TPACK levels. These levels were determined according to the study of Kabakci-Yurdakul et al. (2012). Moreover, to determine science teachers' TPACK levels, Table 3.8 was used. According to the results, Luke had high a TPACK competency level; Albert had a medium TPACK competency level; Nancy had a lower TPACK competency level.

Table 4.10 *Mean Scores of TPACK-Deep Scale Factors for the Science Teachers' Participated in Qualitative Part of the Study*

	<i>Design</i>	<i>Exertion</i>	<i>Ethics</i>	<i>Proficiency</i>
Luke (High Level)	4.20	4.00	4.00	4.00
Albert (Medium Level)	4.00	4.00	2.67	3.60
Nancy (Low Level)	3.00	2.75	2.83	2.60

Moreover, considering TPACK-Deep factors which are design, exertion, ethics, and proficiency, Table 4.10 shows the mean scores of the science teachers who participated in the qualitative part of the study. Since the number of items for each factor is different, the mean scores for the TPACK-Deep factors were analyzed over five because the scale was 5 point-Likert type. Considering TPACK-Deep factors, Luke who had a high level of TPACK competency had high mean scores for the design factor. In other words, he felt himself highly competent while designing technology-enhanced lesson. On the other hand, Albert who had medium level TPACK competency had the lowest mean scores for the ethics factor. In addition, he had the highest mean scores for the design and exertion factor. Namely, Albert had lower competency in ethical issues like ethics of teaching and ethics of technology while integrating technology into his lesson. However, Albert felt himself more competent in designing and practicing the technology-infused lessons. Nancy, who had a low level of TPACK competency, had the lowest mean score for the proficiency factor. In other words, she was less competent integrating technology and solving technology-related problems in her lesson. Similarly with Luke and Albert, Nancy had the highest mean score in the design factor which implies the higher competency while designing technology-integrated lessons.

In order to analyze interviews and classroom instruction, the Table of Indicators and Competencies of Technopedagogical Education (see Appendix N) was used (Kabakci-Yurdakul et al., 2012). In this table, indicators and competencies were determined according to factors of the TPACK-Deep Scale, which were design, exertion, ethics, and proficiency. Besides, under these four factors, six competency areas, 20 competencies, and 120 performance indicators were determined by Kabakci-Yurdakul et al. (2012).

In the present study, science teachers' TPACK indicators were analyzed by using the Table of Indicators and Competencies of Technopedagogical Education. In this regard, both inductive and deductive analyses were used. Mainly, TPACK-Deep factors were considered as themes for the study. In addition to this, the researcher in the present study used content analysis to reveal different indicators if possible. Table 4.11 shows the TPACK-Deep factors, TPACK competency areas, and TPACK competencies.

Table 4.11 *TPACK-Deep Factors, TPACK Competency Areas and Competencies*

<i>TPACK-Deep Factors</i>	<i>TPACK Competency Areas</i>	<i>TPACK Competencies</i>
Design	Designing instruction	<ol style="list-style-type: none"> 1. Analyzing existing situation before teaching 2. Determining appropriate methods, techniques, and technologies to be used in teaching 3. Preparing suitable environment, activities, materials, and measurement tools to be used in teaching 4. Making arrangements on the media and materials to be used in teaching 5. Planning for teaching
Exertion	Implementing instruction	<ol style="list-style-type: none"> 1. Practicing the teaching 2. Measuring and evaluating the effectiveness of the teaching process
Ethics	Ethical Awareness	<ol style="list-style-type: none"> 1. Obeying access rights in the use of technology 2. Obeying technology-based intellectual property rights 3. Obeying the accuracy of technology-based information 4. Obeying technological privacy and security issues 5. Paying attention to the ethics of teaching.
Proficiency	Innovativeness	<ol style="list-style-type: none"> 1. Following up-to-date information about the content 2. Following up-to-date information about the technologies 3. Following up-to-date information about the teaching process 4. Integrating real-life innovations with the teaching process.
	Problem-solving	<ol style="list-style-type: none"> 1. Solving technology-related problems 2. Solving problems related to teaching process 3. Solving problems related to content knowledge
	Field specialization	<ol style="list-style-type: none"> 1. Leading by using subject area expertise

Note. Adapted from “*Öğretmen Adayları için Teknopedagojik Eğitimin Etkisi ve Teknopedagojik Eğitime Yönelik bir Yapı Önerisi*” by I. Kabakci-Yurdakul, 2012, TÜBİTAK 1001: Bilimsel ve Teknolojik Araştırma Projelerini Destekleme Programı, Proje No: 109K191.

4.4.1 Design

The design factor implied teachers' proficiencies regarding the use of technology while designing instruction before the actual teaching (Kabakci-Yurdakul et al., 2012). Under the design factor, there were five sub-themes emerged according to the study of Kabakci-Yurdakul et al. (2012). However, in the current study, four sub-themes were found out in semi-structured interviews and classroom observations, namely: (1) Analyzing existing situation before teaching, (2) Determining appropriate methods, techniques, and technologies to be used in teaching, (3) Preparing suitable environment, activities, materials, and measurement tools to be used in teaching, (4) Planning for teaching. Table 4.12 shows indicators of participant science teachers' TPACK resulting from an analysis of design factors.

Table 4.12 *TPACK Indicators from the Analysis of Design Factor*

<i>Competency Areas</i>	<i>TPACK Competencies</i>	<i>Performance Indicators</i>	<i>Video</i>	<i>Interviews</i>
Designing Instruction	Analyzing existing situation before teaching	Analyzing requirements for technologies to be used in the teaching process	-	Luke, Albert
	Determining appropriate methods, techniques, and technologies to be used in teaching	Choosing the most suitable technologies by evaluating the features of technologies for the effective teaching	-	Luke, Albert, Nancy
		Choosing the most suitable technologies in order to prepare a teaching environment providing up-to-date information	-	Albert, Nancy
	Preparing suitable environment, activities, materials, and measurement tools to be used in teaching	Using technology to create a teaching-learning process based on a learning theory	Albert	Luke, Albert
		Using information and communication technologies in the organization of content presentation	-	Luke, Albert
		Using technology while preparing the appropriate measurement tool	Albert	Luke
	Making arrangements on the media and materials to be used in teaching	-	-	-
	Planning for teaching	Using searching strategies to access resources in online environments in the planning of the lesson content	-	Luke
		Using technology to create a lesson plan to gain knowledge and skills related to the content	-	Luke, Nancy
		Using technology to plan teaching for the presentation of content	-	Luke, Albert

4.4.1.1 Analyzing Existing Situation before Teaching

Before teaching the meiosis subject, teachers were expected to analyze students' readiness with technology and also analyze requirements for technologies that will be used in instruction. Being the scope of this research, this competency was analyzed by using pre-interviews mainly. Luke and Albert expressed that they analyzed requirements for technologies according to subject content and student's needs. As a result, they decided on technological materials to be used in the lesson. In this regard, Luke expressed that:

In previous years, meiosis was in the 8th grade curriculum. However, the topic is in 7th grade now, and it is complicated. Considering my students' needs, I will use animation in my lesson to make the topic concrete. Therefore, I need a computer and internet connection (Pre-interview).

Similar to Luke, Albert considered the nature of the content when analyzing requirements for technologies. He believed it is necessary to make meiosis concrete for students. For that reason, Albert expressed requirement for technologies that:

If we had a laboratory, I would use a microscope for this lesson. Unfortunately, we do not have one. I have to visualize meiosis because it is too abstract. Thus, I prefer to use a smartboard and internet connection in my lesson (Pre-interview).

Since teachers had limited opportunities in terms of technologies, they analyzed requirements in a more specific way. Specifically, updated curriculum, the abstractness of the subject, and students' learning styles were considered by teachers during selecting technologies.

4.4.1.2 Determining Appropriate Methods, Techniques and Technologies to be used in Teaching

All participant teachers reported that while determining technologies, techniques, and methods, the nature of the subject influenced their decisions. Since meiosis is abstract, they considered visualization and concretization of the subject. Therefore, they prefer to use visual technologies. In addition, Luke reported that he selected attractive ones. For example, Luke stated that:

Since meiosis is abstract and unobservable, my students have difficulty in learning this subject. Considering my students' needs, I will use animation in my lesson to make meiosis concrete. While choosing technologies, I also preferred to use attractive ones. For instance, I will use my personal computer so that it increases my students' curiosity (Pre-interview).

Albert also mentioned the nature of the topic and students' needs while determining technologies. Different from Luke, Albert mentioned time management and student's motivation for determining technologies. In this regard, Albert expressed that:

I decided on methods and technologies based on the subject and my students' needs. For example, I will use the Antropi Teach program because it will save my lesson time. I could draw meiosis phases to the blackboard, but it will take my lesson time. Also, using this program will help students learning because its visual quality will motivate my students (Pre-interview).

Similarly, Nancy stated that concretization of the subject is an important criterion for selecting technologies. In addition, she stated that technologies must be compatible with the curriculum. Nancy stated that:

I will use technology for the concretization of the subject. In addition, it should be compatible with the curriculum. For example, I could not select any video from the internet because it may include high school objectives. Therefore, I select a video that covers 7th grade objectives (Pre-interview).

The answers imply that teachers mostly mentioned determining technologies rather than determining appropriate methods for their instructions.

4.4.1.3 Preparing Suitable Environment, Activities, Materials, and Measurement Tools to be used in Teaching

Preparing classroom, activities, materials, and measurement tools for teaching is an important step for lesson design and crucial for students' learning. While preparing activities and materials, Luke used accessible and useful ones. In this regard, Luke stated that:

I will use my personal computer and smartboard for the lesson. These are accessible for my school, and they are practical (Pre-interview).

In addition, Luke mentioned that he considered constructivism theory while preparing lesson activities and materials. However, there was not any performance indicator observed in his lesson. Luke said in pre-interview that:

I will pose inquiry-based questions to my students while watching the animation. At the same time, with the use of questioning, I expect from my students that they will construct their knowledge. I design my lesson based on constructivism which is suggested in the science curriculum (Pre-interview).

Moreover, Luke mentioned that he benefited from technologies to prepare his instruction. Regarding this, Luke stated that:

As you know, the curriculum has changed. For that reason, I use technology to follow this change. For example, I search and select updated animation for the meiosis subject. In addition, I use programs to prepare online tests to assess my students' knowledge (Pre-interview).

Although Luke stated that he will use an online test for measuring students' understanding, he did not use it in his instruction because of the time management problem. On the other hand, Albert used a smartboard and the Antropi Teach program in his instruction. In his lesson, Albert also made connections between mitosis, students' existing knowledge, and meiosis subject by using technologies. These technologies included colorful visuals, including phases of mitosis and meiosis. Albert also reported that:

I designed my lesson based on constructivism because it is the basis of the curriculum. As I said before, the topic is abstract. I use the Antropi Teach program to make it more concrete. While doing this, I always try to make a connection between the previous topic, which is mitosis. I mean that I constructed new knowledge based on mitosis (Pre-interview).

To conclude, rather than preparing a suitable environment and measurement tools for instruction, teachers focused on preparing suitable activities and materials.

4.4.1.4 Planning for Teaching

Lesson planning includes the use of technology while planning the instruction. For example, using searching strategies to access resources in online environments while planning the lesson, using technology to create a lesson plan to gain knowledge and skills related to the content and using technology to plan teaching for the presentation of content are defined performance indicators for this competency. In this respect, teachers reported how they use technology while planning their instruction. To illustrate, Luke mentioned searching strategies:

For planning my teaching, I always use my personal computer and specific websites. To illustrate, for the meiosis subject, I looked for the animations, videos, online quizzes in Education Information Network (EBA) and Morpa Campus (Pre-interview).

Related to the use of technology for planning teaching, Albert reported that:

For the meiosis subject, I use the Antropi Teach program in my lesson. Before the lesson, I prepare visuals including phases of meiosis in my personal computer (Pre-interview).

Nancy stated that she prepared an online lesson plan. In addition, she reported if students' achievement levels and readiness are variable, she changes the lesson plan.

In this regard, Nancy stated that:

While arranging my lesson plan, I use a computer. Firstly, I research instructional resources. My students' prior knowledge and readiness affect

my decision. I generally change my lesson plan online if I need to (Pre-interview).

In addition to existing performance indicators, new indicators emerged according to the analysis of classroom instruction and interviews. For planning teaching, teachers reported that they consider high school examinations holding by MoNE.

In this regard, Luke stated that:

With the exams and tests that we implement in smartboard, we can easily determine the students who have grasped the subject, who does not understand the topic, or who has misunderstood some points of the subject. Unfortunately, because our educational system is exam-oriented, we prepare our students for the exam. Before my lessons, actually, before the units, I looked for the previously asked exam questions from my computer and considered these questions while planning my lesson (Pre-interview).

Moreover, in the classroom observation of Luke, he posed some questions which were previously asked in high school examinations. To illustrate, the differences between gametes and germ cells.

Despite having different purposes, teachers used personal computers, different technological resources, and tools during instructional planning.

4.4.2 Exertion

Exertion factor implies teachers' proficiencies regarding practicing teaching with the use of technology. It also refers to the measurement and evaluation of the teaching (Kabakci-Yurdakul et al., 2012). In this factor, two sub-themes emerged in the study of Kabakci-Yurdakul et al. (2012), namely: (1) Practicing the teaching and (2) Measuring and evaluating the effectiveness of the teaching process. Nevertheless, in the current study, only one sub-theme emerged from the analysis of interviews and video, which was practicing the teaching. Table 4.13 shows indicators of participant science teachers' TPACK resulting from analysis of exertion factor.

Table 4.13 *TPACK Indicators from the Analysis of Exertion Factor*

<i>Competency Areas</i>	<i>TPACK Competencies</i>	<i>Performance Indicators</i>	<i>Video</i>	<i>Interviews</i>
Implementing Instruction	Practicing the teaching	Reflecting the semantic relationships for new learning with the help of technology	Luke	-
		Constructing the relationship between concepts by using technology	Luke	-
		Applying suitable teaching methods and techniques through technology	Luke	Albert
		Guiding students to use technology effectively for research and inquiry	-	Luke
		Using technological learning environment (WebCT, Moodle, etc.) for teaching content	Albert	Luke
		Using technology for students' motivation in the teaching-learning process	Luke	Luke, Nancy
		Use technological resources for transferring content knowledge to the teaching-learning process	Luke, Albert, Nancy	Luke, Albert, Nancy
		Transferring the solution of technological problems to the teaching-learning process	Luke	Luke, Albert, Nancy
		Using technology effectively while measuring and evaluating students' performances	Albert	-
		Making self-evaluation about the use of technologies in the teaching-learning process	-	Luke, Nancy

4.4.2.1 Practicing the Teaching

For the analysis of the exertion factor, classroom observations were used mainly because this factor implies how teachers practice their teaching with the use of technology. In addition to this, answers to the interview questions gave information about teachers' intention for the practice. For guiding students for effective use of technology and supporting student motivation, Luke entered a classroom with his personal computer. In this respect, Luke stated that:

I want to be a model to my student for using technology. In other words, I want to show how to use technology on purpose. I use different technological sources like videos, animations to enlarge my students' vision. On the other hand, I believe when I enter the classroom with my personal computer, they are motivated (Pre-interview).

In his lesson, Luke used animation for reviewing mitosis at first. This animation included visual representations of phases of mitosis and also transitions of them. While reviewing the previous topic, Luke always stopped the animation and asked questions to different students. After that, he used a blackboard to draw phases of meiosis. In these drawings, he gave information about each phase. Also, Luke mentioned about purposes of meiosis, including causing genetic variations and maintaining a constant number of chromosomes (Figure 4.1).

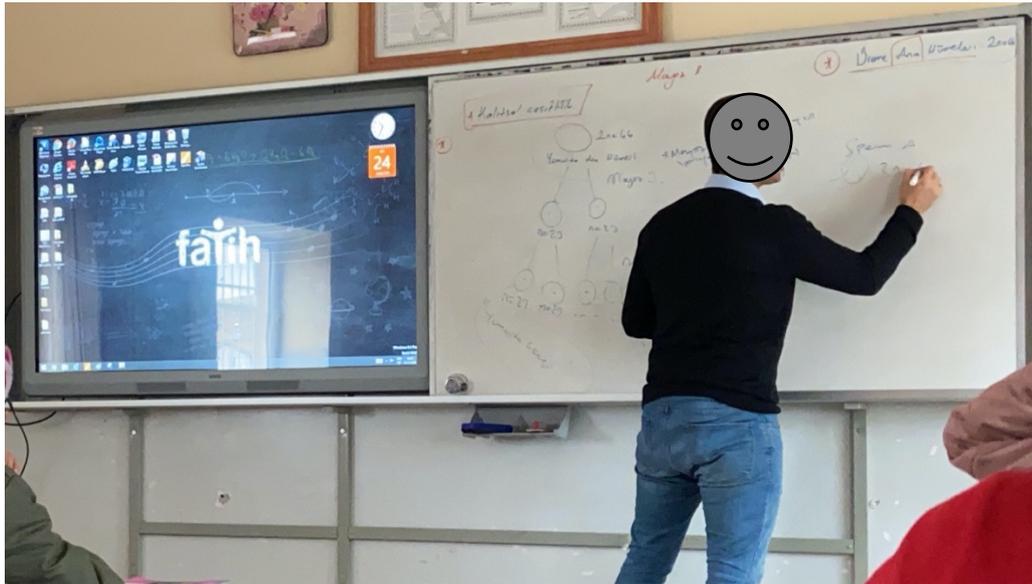


Figure 4.1. Snapshot of classroom instruction of Luke

Then, he reviewed meiosis phases by using animation. While he was covering meiosis on the smartboard, he stopped the animation and asked similarities and differences between mitosis and meiosis by posing questions to different students. Although teaching could be conducted as student-centered, Luke preferred to carry out his lesson mostly teacher-centered. Additionally, Luke stated that if he had different opportunities, he would use technology more. He reported in the interview that:

If my students have personal tablets or telephones, I will use virtual reality programs. In doing so, meiosis becomes more concrete for them (Post-interview).

On the other hand, Albert reviewed the mitosis subject by questioning. In addition, he drew the first and last phases of mitosis for a diploid ($2n$) cell to the blackboard. After that, he moved on to meiosis and stated the importance of living things. Rather than drawing each phase of meiosis, he used the Antropi Teach program which included a mixed drawing of each phase. By comparing and contrasting with mitosis, he arrayed meiosis phases on the smartboard as shown in Figure 4.2. For

reinforcement, he also used a video from Morpa Campus. Considering technologies that he used during instruction, Albert stated that:

Antropi is a useful program because I can show and array different phases with colored visuals interactively. In addition, I use a video from Morpa Campus directly without making any changes. It shows phases of meiosis in 3D. Also, for the assessment, I will use a matching game. It is also present in Morpa Campus. Students will solve questions one by one by using a smartboard (Pre-interview).

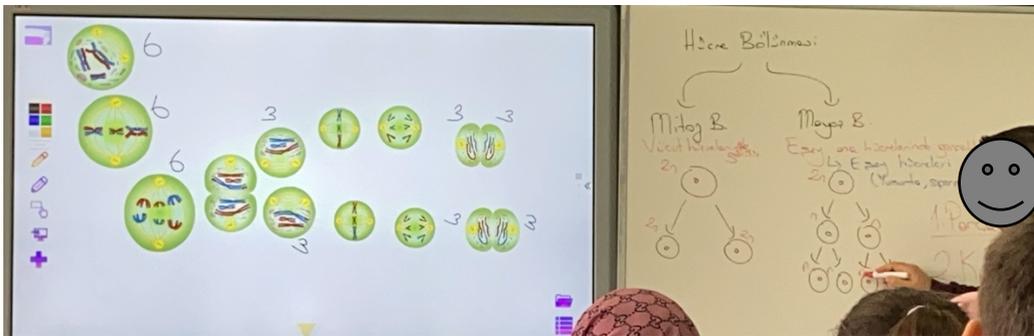


Figure 4.2. Classroom instruction of Albert

In other respects, Nancy reviewed mitosis at the beginning of the lesson. While she asked purpose and significance of mitosis, she drew phases on the blackboard and wrote information regarding each phase. After that, she showed an animation without asking or commenting. For the meiosis, Nancy showed a video from EBA which was related to phases of meiosis. While the video was moving on, she stopped and asked questions to students. In addition, Nancy reported that she used technology to motivate students. In this regard, Nancy stated that:

I will use video animation to attract my students' attention as well as motivate them to learn. Videos are effective for children (Pre-interview).

While evaluating her teaching about the use of technologies, Nancy criticized her instruction. In order to provide more student-centered instruction, Nancy proposed alternative technologies. Additionally, she made a self-evaluation about assessment. Nancy stated that:

I could use Z Library or a smart notebook for meiosis. The smart notebook includes some blank space to fill while the teacher teaches the subject from the smartboard. This would be beneficial for my students' learning because they involve in the teaching process more. In addition, for the assessment part, rather than using paper and pencil tests, I could use Vitamin or EBA (Post-interview).

Data sources implied that although teaching could be conducted as student-centered, teachers' observed technology integration processes and practices were dominantly teacher-centered. Students participated in the lesson process only by questioning. For example, Albert used the Antropi Teach program on his own. Besides, Nancy and Luke used animation. On the other hand, participants mostly used technology for reinforcement rather than teaching new content with technology. This implied that although designing technology-rich instruction is variable, teachers demonstrated similar patterns and indicators despite their different TPACK levels.

4.4.3 Ethics

The ethics factor implies teachers' proficiencies regarding ethical issues while using technology (Kabakci-Yurdakul et al., 2012). In this factor, five sub-themes emerged in the study of Kabakci-Yurdakul et al. (2012), namely: (1) Obeying access rights in the use of technology (2) Obeying technology-based intellectual property rights, (3) Obeying the accuracy of technology-based information, (4) Obeying technological privacy and security issues and (5) Paying attention to the ethics of teaching. Similarly, in the current study five themes were observed after analysis of videos and interviews. Table 4.14 shows indicators of participant science teachers' TPACK resulting from analysis of ethics factor.

Table 4.14 *TPACK Indicators from the Analysis of Ethics Factor*

<i>Competency Areas</i>	<i>TPACK Competencies</i>	<i>Performance Indicators</i>	<i>Video</i>	<i>Interviews</i>
Ethical awareness	Obeying access rights in the use of technology	Providing equal access to the technological sources in the teaching and learning process	Albert	Luke
	Obeying technology-based intellectual property rights	Considering copyright of digital resources when designing teaching material	-	Luke, Albert, Nancy
		Using presentation/display software ethically while transferring content	Luke	Luke, Albert, Nancy
		Using digital resources ethically while structuring content	-	Luke, Albert, Nancy
		Being aware of the ethical rules in the use of examples obtained from digital media and used in teaching	-	Luke, Nancy
	Obeying the accuracy of technology-based information	Being aware of the transfer of correct information while preparing technology-supported real-life activities in the teaching-learning process	-	Luke, Albert, Nancy
		Guiding students to reliable Internet resources during the teaching-learning process	-	Luke
		Guiding students to access correct information in digital resources during the teaching process	-	Luke
	Obeying technological privacy and security issues	Being aware of the security of private information while presenting real-life examples in the teaching process through technology	Luke	-
	Paying attention to the ethics of teaching	Being open to professional development regarding the technology-based teaching process	-	Nancy
Enabling students to use technologies in the teaching environment ergonomically		Albert	-	

4.4.3.1 Obeying Access Rights in the Use of Technology

Providing equal access to technological sources in the process of teaching is a significant indicator of the ethics factor. Since students did not have personal technological devices in observed lessons, teachers provided equal access to existing technologies. For example, for the assessment part, Albert used a technology-based activity from Morpa Campus. Students answered matching, true-false and completion activities by using smartboard one-by-one. On the other hand, Luke commented access rights by looking from a broader perspective. In this regard, he gave the following explanations in the interview:

I use technology in all science classrooms. I mean, I use the same animation for different classrooms. Also, I try to give equal rights to speak in my lessons as well as while using technology. For example, in this lesson, when I stop animation, I will ask questions to different students (Pre-interview).

As it is understood from the data, because of the school and classroom opportunities, Albert and Luke provided equal rights to speak while using technology in terms of access rights. In addition, different from Albert, Luke's consideration for equal access can be described as the use of the same technology for each classroom.

4.4.3.2 Obeying Technology-Based Intellectual Property Rights

Intellectual property rights are related to copyright and ethical use of digital resources. Based on the definition, all teachers reported that they were careful about the copyrights of the resources. According to participants, the most important factor for using technological resources was open to the public. Luke mentioned taking permission if the source is not open. Also, he indicated that he prefers to use online sources in the lessons (Figure 4.3). At this point, Luke stated that:

If resources are free and open to use for the public, I use them directly without getting permission. However, if the developer does not give permission, I

contact him to take his allowance. In both cases, I refer to the resources (Pre-interview).

Different from Luke, Albert stated that if the source is not open to the public, he will not use it. In this regard, Albert stated that:

Morpa Campus is open for teachers. For that reason, I use it for my lesson. If there exist restrictions or the developer does not give permission, I do not use this source (Pre-interview).

Similarly, Nancy reported that:

Since the Ministry of National Education recommends EBA, I use it without taking any permission. It is open to teachers.

Although all teachers reported that they are careful about intellectual property rights, observed indicators during the lesson were limited. All teachers used open sources, but in only Luke's animation, the reference was written below (Figure 4.3).



Figure 4.3. Use of reference in Luke's lesson

4.4.3.3 Obeying Accuracy of Technology-Based Information

Teachers were attentive about transferring accurate information to students. In this sense, they reported that they review technologies before teaching especially for avoiding misconceptions. Related to the accuracy of technology-based information, Albert reported that:

Last night, I opened a video related to meiosis. In this video, it was said that meiosis happens in gametes. However, it was a misconception because it happens in germ cells. Therefore, we could not use this video (Pre-interview).

Additionally, Albert pointed out trustworthy websites having particular domain suffixes like .edu and .gov. According to him, these websites included trustable information. With respect to this, Albert reported that:

I try to use free and reliable sources, including an extension of .gov, .edu, and so on. Moreover, I do not prefer to use websites including banners and advertisements. They affect students' behavior or just provide a bad example (Pre-interview).

Similar to Albert, Luke stated the importance of reliable technological sources that:

While planning my instruction, I try to use reliable technological sources. There exist main trustable websites, including eba.gov.tr. Nevertheless, if I use different sources, I research and investigate the accuracy of information (Pre-interview).

According to Luke, students have misconceptions and difficulties in understanding meiosis. He pointed out these difficulties and warned his students throughout the entire lesson. For example, he emphasized differences between gametes and germ cells and told meiosis happens in germ cells. In addition, as a warning, he mentioned differences between the separation of homolog chromosomes and sister chromatids. He always expressed that having reliable and correct information is crucial.

On the other hand, related to transferring correct information, Nancy also mentioned reliable sources. In this regard, Nancy stated that:

Accuracy of information is the most important part of teaching. I consider each word when I teach. In addition, it is important to have correct information in instructional materials. For that reason, I use trustable technological sources suggested by the Ministry of National Education. More than 150 educators reviewed these sources. Therefore, I believe the information is correct in these sources (Post-interview).

Although teachers have different TPACK-Deep scores and competency levels, there is a consensus between them to transfer correct technology-based information.

4.4.3.4 Obeying Technological Privacy and Security Issues

In a rapidly growing technological world, technological privacy and security issues have become more of an issue. Regarding these issues, Luke was aware of the security of private information in the teaching with technology. Before projecting his computer screen onto the smartboard, he froze the smartboard screen. By doing this, he opened the animation directly without reflecting any personal files or information.

4.4.3.5 Paying Attention to the Ethics of Teaching

As a performance indicator, ethics of teaching include enabling students to use technologies in the teaching environment ergonomically. Karwowski (2005) classified ergonomics as physical, cognitive, and organizational. According to Karwowski (2005), physical ergonomics focuses on the anatomical characteristics of humans considering physical activities; cognitive ergonomics deals with mental processes, and organizational ergonomics concentrates on socio-technical systems. In the current study, using technologies ergonomically is considered as physical and cognitive. As a result, only one teacher cares about using technologies ergonomically. Since smart boards are fixed according to student physical condition, physical ergonomics has already been supported for observed classroom context. For example, while students are answering activities on the smartboard, they easily reach

it. On the other hand, considering cognitive ergonomics, Albert selected suitable technological resources according to students' age, ability, as well as lesson objectives covered in his lesson.

In other respects, being open to professional development regarding the technology-based teaching process is defined as a performance indicator for ethics of teaching. (Kabakci-Yurdakul et al., 2012). In relation to this, Nancy mentioned previous training and her plans for new technological training, which imply her passion for developing herself. In this sense, she said that:

I received training in association with FATIİH Project. In this training, I learn how to use the smartboard. In addition, I attended a course related to the use of technology. Now, I am looking for support to buy 3D printer. When I find a sponsor, I will get training on how to use it in my instruction effectively (Pre-interview).

4.4.4 Proficiency

The proficiency factor was defined by Kabakci-Yurdakul et al. (2012) as:

Pre-service teachers' leadership ability to integrate technology into content and pedagogy by becoming experts in the teaching profession, to put forward suggestions for solving problems related to the subject area, the teaching process, and technology, and to choose the most appropriate one among these suggested solutions (p. 970).

In this factor, eight sub-themes emerged in the study of Kabakci-Yurdakul et al. (2012), namely: (1) Following up to date information about the content (2) Following up to date information about technologies (3) Following up-to-date information about teaching process (4) Integrating real-life innovations with the teaching process (5) Solving technology-related problems (6) Solving problems related to teaching process (7) Solving problems related to content knowledge (8) Leading by using subject-area expertise. Although there existed eight themes, three themes emerged in the current study. Table 4.15 shows indicators of participant science teachers' TPACK results from analysis of proficiency factor.

Table 4.15 *TPACK Indicators from the Analysis of Proficiency Factor*

<i>Competency Areas</i>	<i>TPACK Competencies</i>	<i>Performance Indicators</i>	<i>Video</i>	<i>Interviews</i>
Innovativeness	Following up-to-date information about content	Using technology to update knowledge and skills related to the content	-	Luke
		Using technology to keep content knowledge up to date	-	Luke
	Following up-to-date information about technologies	-	-	-
		Following up-to-date information about the teaching process	-	-
Problem-solving	Integrating real-life innovations with the teaching process	-	-	-
		Solving technology-related problems	-	Albert, Nancy
		Solving potential problems that may arise in the technological tools used in the process of teaching	Nancy	Luke, Albert, Nancy
	Solving problems related to the teaching process	Solving technological problems carried out in technology-based environments (WebCT, Moodle, etc.)	-	Albert, Nancy
		-	-	-
Field specialization	Leading by using subject area expertise	Using technologies to solve misconceptions	-	Albert
		-	-	-

4.4.4.1 Following up-to-date Information about Content

Luke reported that he uses technological sources in order to keep content knowledge up to date. To illustrate, he mentioned that so as to be prepared for the lesson and students' questions, he searched for additional information and materials. Luke said that:

While preparing for the lesson, I pay attention to my knowledge about meiosis. I consider whether I can answer students' extreme questions. For that reason, in addition to Ministry of National Education books, I follow some reliable websites which include extra information and materials related to content. In that way, I keep myself up to date (Pre-interview).

4.4.4.2 Solving Technology-related Problems

Participant teachers took into consideration technology-related problems while planning and practicing teaching. For example, internet connection and software problems were mentioned by them. In case of a problem, teachers reported that they produce alternative solutions for their instruction. Traditional teaching was considered as a solution for technology-related troubles. In this regard, Albert stated that:

There may be problems regarding internet connection and Morpa Campus. For example, Morpa Campus has opened slowly in recent times. In these cases, I do not use technology. Of course, I have a plan B. I will use the blackboard by writing and drawing phases of meiosis. However, it will retard my plans (Pre-interview).

On the other hand, Nancy predetermined and prepared alternative activities if there were internet connection problems. As a solution, Nancy reported that:

Internet disconnection is a big problem for us. In addition, the smartboard may freeze. When it freezes, you could not do anything. We have to prepare an alternative program which we make frequently. If I have technological problems in meiosis, I have an alternative activity. We have plates, colorful

straws, rope, and so on. By using the analogy, I can teach meiosis to my students with these materials (Pre-interview).

In their lessons, teachers faced some problems. For example, Luke could not connect his personal computer with the smartboard at first. He used additional wire to solve this problem. On the other hand, Nancy had trouble while opening her personal account in EBA. To solve this problem, she used an alternative sign-in option. Although she had trouble with showing videos in her instruction, she overcame problems in the lesson by reopening the video.

4.4.4.3 Solving Problems related to Content Knowledge

In interviews, teachers mentioned the presence of students' misconceptions about meiosis. It was reported that students think: (1) Meiosis happens in gametes, (2) Separation of sister chromatids happens in meiosis I. In interviews, only Albert reported how to overcome misconception:

My students have misconceptions about the separation of homolog chromosomes. I mean that they confuse about the separation of sister chromatids and homolog chromosomes. As you know, this is a common misconception in science education. To overcome this misconception, I integrate the Antropi Teach program into my instruction for visual and concrete support. In this program, I can easily show the differences between sister chromatids and homolog chromosomes (Pre-interview).

However, the solution to content-related problems was not observed in classroom instruction.

4.5 Summary of the Results

The aim of the study was to investigate science teachers' TPACK. In this regard, an explanatory sequential mixed methods design was followed in order to determine science teachers' TPACK competency levels and also specify TPACK indicators of selected participants.

In the first stage of the study, science teachers' TPACK competency levels were examined. The results showed that science teachers' TPACK levels were high. While focusing on gender, male teachers' TPACK scores were higher than female teachers. However, the results indicated that there is no significant difference between male and female science teachers' TPACK levels. On the other hand, teachers who have 0-4 years of experience had the highest mean TPACK scores and teachers who have 10-14 years of experience had the lowest TPACK scores. The results indicated that there is no significant difference between teachers having different experience years including 0-4 years, 5-9 years, 10-14 years, and more than 15 years.

In the second stage, selected science teachers' TPACK indicators were investigated under the factors of the TPACK-Deep scale which were design, exertion, ethics, and proficiency. For this qualitative part, participants were selected according to their TPACK competency levels.

In the *design* factor, Luke, who had a high level of TPACK competency and had 3,5 years of teaching experience, had the highest mean score for the design factor (see Table 4.10). In other words, he felt himself higher competent while designing technology-enhanced lesson. The analysis of the interviews, classroom observations, and video recordings implied that Luke paid attention to subject content, curriculum adaptation, and students' needs while designing his instruction in the meiosis subject. Also, being abstract in the nature of the content was the main reason for selecting educational technologies because meiosis is abstract. While preparing suitable technological materials, Luke focused on accessible and useful materials. In addition, Luke used his own computer to plan teaching, for example, to access resources in the online environment, to create lesson plans, and to gain knowledge about the content itself. In addition, he considered high school examinations for planning his teaching. On the other hand, Albert who had medium level TPACK competency, had a high mean score for the design factor. Similar to Luke, Albert, who had 13 years of teaching experience, also felt himself higher competent while designing technology-enhanced lesson. The results of the interviews, classroom observations, and video recordings showed that Albert paid attention to content and

students' needs while designing instruction in the meiosis subject. Since meiosis is abstract, Albert aimed to visualize the subject with the integration and help of technology. Also, students' motivation and curriculum adaptation were the main points while determining appropriate technologies and methods to be used in teaching. In addition, to prepare suitable activities, materials, and measurement tools, Albert used their computer for example, to access resources in the online environment. On the other hand, Nancy, who had a low level of TPACK competency and 13 years of teaching experience, had the highest mean score in the design factor (see Table 4.10) which implies the higher competency while designing technology-integrated lessons. Being abstract in the nature of the content and curriculum adaptation was the main reason for selecting specific educational technologies according to Nancy. Moreover, Nancy used personal computer to plan her teaching, and revise the lesson plan if needed.

In the *exertion* factor, Luke, who had a high level of TPACK competency, had lower mean scores than the design factor (See Table 4.10). The indicators in the exertion factor suggested that Luke integrated technology to review the previous subject and repeat new content in practicing the teaching. In other words, firstly he covered the meiosis topic on the board and then he reviewed meiosis subject with the integration of technology. Although Luke reported that he followed student-centered instruction in the light of constructivism, his teaching methods and strategies were teacher-centered. Moreover, he integrated technology for students' motivation. On the other hand, Albert who had medium level TPACK competency had a high mean score for the exertion factor with an equal score with the design factor, as seen in Table 4.10. While implementing his instruction, Albert covered the meiosis topic with the use of various technologies. The main purpose of integrating technology was to transferring content knowledge with the help of technology. In addition, he used technology with the aim of measuring and assessing students' understanding. On the other hand, Nancy's mean score for the exertion factor was lower than the mean scores for the ethics and design factor. In other words, Nancy felt herself less competent in the exertion factor while implementing technology-enhanced lesson. Moreover, while

making self-evaluation about the use of technology in the lesson, Nancy stated to use more student-centered strategies for her future lessons.

In the *ethics* factor, Luke, who had a high level of TPACK competency, had lower mean scores than the design factor (See Table 4.10). In this factor, Luke used software ethically that he integrated into the lesson. Moreover, he reported obeying access rights in the use of technology. In addition, he was careful about the accuracy of technology-based information and the security of private information. On the other hand, Albert, who had medium level TPACK competency, had the lowest mean score for the ethics factor as seen in Table 4.10. In other words, he had lower competency in ethical issues like ethics of teaching and ethics of technology while integrating technology into his lesson according to the TPACK-Deep scale. Considering indicators about ethics, he preferred to use public technologies. Also, the accuracy of technology-based information was concerned by Albert. For example, use of trustworthy websites including domain suffixes like .edu, and .gov. Moreover, he enabled that his students use technologies ergonomically in classroom. On the other hand, Nancy's mean score in the ethics factor was lower than the mean score of the design factor but higher than exertion and proficiency factors. In the scope of this factor, Nancy reviewed technological resources before the lesson to avoid misconceptions. Also, she was open to professional development programs in terms of technology-enhanced teaching. Moreover, she paid attention to copyrights of the resources. In other words, they preferred to use public technologies.

In the *proficiency* factor, Luke, who had a high level of TPACK competency, had lower mean scores than the design factor but his mean scores were equal for the exertion, ethics, and proficiency factors (See Table 4.10). To keep content knowledge up-to-date, Luke reviewed and researched the content before planning the lesson. In addition, he solved technology-related problems occurred in the teaching. On the other hand, Albert, who had medium level TPACK competency, had the lower mean scores in the proficiency factor than design and exertion (see Table 4.10). To overcome misconceptions, Albert focused on visual and concrete technologies to show the exact differences between homologous chromosomes and

sister chromatids. Nancy, who had the low level of TPACK competency, had lowest mean score for the proficiency factor. In other words, she was less competent integrating technology and solving technology related problems in her lesson. Nancy faced connection and software problems in the actual teaching. Although she lost time in the classroom, she solved technology-related problems. For bigger problems, she had additional plans including project-based activities and direct instruction.

Overall, when the teachers' indicators are quantified considering pre- and post-interviews and video recording data, the number of indicators for each factor and the total number of indicators can be seen from the Table 4.16. The total number of indicators determined by Kabakci-Yurdakul et al.'s study was 120 according to the "Table of Indicators and Competencies of Technopedagogical Education" (See Appendix N). In addition, the number of indicators existed in each TPACK-Deep factor were various; 26 indicators for the design factor, 33 indicators for the exertion factor, 28 indicators for the ethics factor, and 33 indicators for the proficiency factor. In the light of this information, science teachers' TPACK competency levels based on the TPACK-Deep scale and their number of indicators regarding these factors showed consistencies. For example, Luke, who had a high TPACK competency level, also had the highest number of indicators. In addition, Nancy who had a low level of TPACK competency, showed the lowest number of indicators. Therefore, the teacher who had a high competency level also showed a higher number of TPACK indicators. However, considering the total number of indicators which was 120, the observed total number of TPACK indicators was relatively low.

Table 4.16 *Total Number of Indicators gathered from each Participants' Data according to TPACK-Deep factors*

	<i>Design</i>	<i>Exertion</i>	<i>Ethics</i>	<i>Proficiency</i>	<i>Total</i>
Luke (High Level)	8	12	10	3	33
Albert (Medium Level)	8	6	6	4	24
Nancy (Low Level)	3	5	6	4	18

CHAPTER 5

CONCLUSION

In this chapter, initially, the results of the current study will be discussed. After that, implications for the research and practice will be mentioned. Finally, recommendations for future research will be specified.

5.1 Discussion

The purpose of the present research was to investigate science teachers' TPACK competencies in terms of gender, experience years and determine teachers' TPACK indicators while they integrate technology into instruction. Accordingly, the current study followed explanatory sequential mixed method design, which is a mixed methodology and composed of two stages: survey research and multiple case study respectively. Chai, Koh, and Tsai (2016) proposed the relationship between TPACK, and demographic variables are needed to be investigated. Thus, in the first stage of the research, which was quantitative, the aim was to examine science teachers' TPACK levels according to their gender and experience years. On the other hand, in the second stage, which was qualitative, science teachers' TPACK indicators were investigated in terms of design, exertion, ethics, and proficiency factors of the TPACK-Deep.

The result of the study showed that science teachers' TPACK competency levels were high. Although male teachers' TPACK scores were slightly higher than females, there was no significant difference between males and females in terms of their TPACK-Deep scores. In addition, teachers who have 0-4 years of experience had the highest TPACK scores. However, the difference between teachers' TPACK scores in terms of their experience years was not significant. Moreover, analysis of

the teachers' classroom instruction, pre- and post-interviews revealed science teachers' TPACK indicators in terms of design, exertion, ethics, and proficiency.

In the following sections, the results of the present study in terms of science teachers' TPACK levels and science teachers' TPACK indicators will be discussed.

5.1.1 Science Teachers' TPACK

Research Question 1: What are the TPACK levels of science teachers?

The aim of the first research question was to investigate science teachers' TPACK competency levels. Accordingly, TPACK competency levels were determined by using the TPACK-Deep Scale (Kabakci-Yurdakul et al., 2012). It is important to keep in mind that the results were based on teachers' self-report data. Since self-report data does not directly reflect teachers' classroom practices regarding technology (Koh & Chai, 2014), survey data was triangulated with classroom observations.

Considering the first research question, the analysis showed that science teachers' TPACK competency levels were high. In other words, teachers felt themselves competent in TPACK. The findings of this study are compatible with the results of previous studies. For example, Bagdiken and Akgunduz (2018) found that science teachers' TPACK self-confidence levels were high. Moreover, using the TPACK-Deep Scale, Coklar and Ozbek (2017) found that teachers' TPACK self-efficacies were high. In addition, according to the study of Albayrak-Sari et al. (2016), teachers' TPACK level was high; science teachers' mean scores were the highest. The high level of TPACK may be due to teachers' constructivist-oriented views that are also emphasized in the 2018 Turkish Science Curriculum. In a similar vein, Gunes and Bahcivan (2016) stated constructivist views cause higher levels of TPACK. Teachers who have constructivist beliefs are highly integrated technology in their instruction (Ertmer, 2005) because technology gives students an opportunity to involve in the teaching process actively. For example, rather than showing the

image of a cell, constructivist teachers tend to make their students use a virtual or real microscope to observe the cell. Therefore, participant teachers having high TPACK levels may adopt constructivism commonly. Moreover, higher levels of TPACK may be due to technology-related professional development programs or training. Teachers who participated in professional development programs or technology-related training have higher TPACK levels (Alayyar, Fisser, & Voogt, 2011; Graham et al., 2009; Kafyulilo, Fisser, & Voogt, 2014). In addition to this, teachers may have higher TPACK levels because they are familiar with the technology excessively. As a result of this, they may become competent in using and integrating technology into their classrooms. Regarding this, studying relationships between TPACK level and digital nativity, Kabakci-Yurdakul (2018) found that pre-service teachers' digital nativity level is an indicator for TPACK levels. According to Prensky (2001), digital natives have higher abilities for using technologies. Therefore, it could be said that high TPACK levels imply higher skills at using technologies.

In other respects, the results of this research are incompatible with previous studies considering the level of TPACK. For example, Bingimlas (2018) found that teachers' TPACK levels were medium. On the other hand, the results of the study of Yeh et al. (2015) implied that science teachers (biology, chemistry, earth, and physics) were at a simple adoption level of TPACK-Practical. In other words, teachers only use technology in their teaching, but do not effectively integrate these technologies in their lesson process. Therefore, teachers' TPACK-Practical levels were low because of the lack of explanations about why and how they integrate technology in their lessons. Moreover, these conflicting results may be due to different research contexts. According to Porras-Hernández and Salinas-Amescua (2013), there can be four different implications for context, which are "the students' characteristics, classroom and institutional conditions for learning, situated teaching activities and teachers' epistemological beliefs" (p.226). Therefore, all these contextual dimensions may create differences in the results between the current study and previous ones. In addition, the nature of different TPACK scales may cause different

results. For example, in integrative scales, teachers' TPACK self-efficacies are investigated considering each factor like TK, CK, TCK, PCK. In this perspective, teachers who feel less competent in content knowledge will rate themselves in all content-related domains, including CK, PCK, TCK, and TPACK. As a result, overall scores will get low because of content-related factors. For the current study, the transformative TPACK-Deep Scale, which has four factors, namely design, exertion, ethics, and proficiency, was used. In other words, there are no particular items regarding different TPACK domains as the integrative TPACK view suggested. To illustrate, item 11 is "I can implement effective classroom management in the teaching and learning process in which technology is used." and it is considered under the factor of exertion. Since the items are blended with all domains of TPACK, participants who feel themselves confident in classroom management even if they do not feel competent in technology may rate themselves higher. On the other hand, in the scales, for example, TPACK-Deep, the items do not contain the specific name of the technologies. To illustrate, item 11 is "I can implement effective classroom management in the teaching and learning process in which technology is used". When participants rate their competency, one may think of common technologies like computers or may think more complex ones like Arduino and data collection probes. Therefore, teachers who assume these technologies as basic ones may score themselves higher. As a result, overall higher ratings may cause higher levels of TPACK competencies.

5.1.2 Science Teachers' TPACK based on Gender

Research Question 2: Is there a statistically significant mean difference between male and female science teachers' TPACK?

The purpose of the second research question was to investigate science teachers' TPACK according to gender. The results of the present study showed that although male science teachers' TPACK scores were higher than female science teachers, the

difference was not significant. In other words, there was no significant difference between male and female science teachers' TPACK levels.

Considering previous TPACK research, gender variable was used in various studies (Ay, Karadag & Acat, 2016; Bagdiken & Akgunduz, 2018; Irmak & Yilmaz-Tuzun, 2019; Jang & Tsai, 2012, 2013; Kartal & Afacan, 2017; Koh, Chai & Tsai, 2010, 2014; Lin et al., 2013). Different from the findings of the present study, there exist research having significant differences in TPACK levels according to gender. Mostly, male science teachers rated themselves higher than females (Jang & Tsai, 2013; Kartal & Afacan, 2017; Lin et al., 2013), especially in technology-related factors. On the contrary, according to the study of Irmak and Yilmaz-Tuzun (2019), female preservice science teachers' TPACK was higher than males. The gender differences in TPACK levels may be due to different contexts (Jang & Tsai, 2013). On the other hand, the differences between male and female TPACK can be the result of the essentialist view (Castéra et al., 2020) which assumes males and females have different particular traits. For example, the use of computers was described as men's work by society (Whitley, 1997). Generally, the social context places males above females in terms of engineering and technology-dominated works and also affects the characteristics of the people in terms of their interest, choice of profession, and so on. Thus, social context may cause differences in teachers' TPACK scores according to gender. Since the effect sizes of the gender differences in computer attitudes were found very small by Whitley's (1997) meta-analysis, it needs further investigations and explanations considering distinctive results that the literature shows.

On the other hand, similar to the current study, Bagdiken and Akgunduz (2018) found no significant difference between male and female science teachers' TPACK levels. In addition, the study of Jang and Tsai (2012) implied no significant difference between elementary science and mathematics teachers' TPACK levels based on gender. Also, using the TPACK-Practical scale, there was no significant difference between male and female teachers (Ay, Karadag, & Acat, 2016). These results may be due to change in social views about technology. In other words,

technology may not be seen as masculine work in society. The study of Irmak and Yilmaz-Tuzun (2019) also supported the idea of changing social views because the results suggested that female preservice science teachers' TPACK was higher than males. Another reason for the nonsignificant difference might be enhanced and extended use of computers in schools (North & Noyes, 2002) independent from teachers' gender. On the other hand, the nonsignificant differences between male and female teachers' TPACK can be unique for the studied group of teachers. Therefore, in order to make detailed conclusions, further research is needed to clarify whether there exist gender differences or not.

5.1.3 Science Teachers' TPACK based on Experience Years

Research Question 3: Is there a statistically significant difference between the scores of science teachers' TPACK regarding their experience years?

The purpose of the third research question was to investigate science teachers' TPACK based on their experience years. The results of the study showed that there is no significant difference between teachers' TPACK scores in terms of their experience years (Group 1: 0-4 years; Group 2: 5-9 years; Group 3: 10-14 years; Group 4: more than 15 years). The results of the study were not consistent with previous studies (Bagdiken & Akgunduz, 2018; Jang & Tsai, 2013; Lin et al., 2013; Yeh et al., 2013), which implied novice teachers' overall TPACK scores were significantly higher than experienced teachers. Since more experienced teachers are thought to be more traditional, the participants of the current study may be innovative and open to new developments in education and technology as well. Also, considering overall TPACK levels were higher, teachers can be considered as constructivist oriented, not traditional (Gunes & Bahcivan, 2016). On the other hand, experienced teachers also tend to integrate various technologies into their lessons (Wetzel, Zambo & Ryan, 2007) which can increase their competency regarding TPACK. Similarly, The OECD Teaching and Learning International Survey (TALIS) 2018 results showed that experienced teachers who have more than 5 years

of teaching experience in Turkey, reported higher levels of TPACK self-efficacy (OECD, 2019). When experienced teachers use common technologies like computers, they can see themselves as competent. However, if newly graduated teachers think about specific and emergent technologies like 3D printers, they may see themselves as less competent. Therefore, the results of the current study could be related to the teachers' perception and use of technology.

5.1.4 Indicators of Science Teachers' TPACK

Research Question 4: What are the indicators of science teachers' TPACK regarding "meiosis" subject considering TPACK-Deep factors?

There exist a limited number of studies regarding the integration of technology in teaching (Ertmer, 2005). Since there are various and unique experiences in each classroom context, observing the environment provides valuable and rich information about teaching and learning (Good & Brophy, 2000). Also, Yeh et al. (2017) stated that the purpose of future research should be revealing the classroom practices of teachers. For these reasons, the aim was to observe and analyze science teachers' technology integration practices in the authentic classroom environment in addition to discovering their TPACK levels. Specifically, the purpose of the fourth research question was to analyze science teachers' TPACK indicators considering TPACK-Deep factors. Since "Using multiple data sources holds promise and value in terms of confirming findings from self-reported investigations" (Schmidt-Crawford et al., 2016), data triangulation was provided by classroom observations, pre-interviews, post-interviews, and TPACK-Deep scale.

Three teachers who participated in the first stage of the study and had different levels of TPACK were selected purposefully and conveniently for classroom observation. TPACK indicators of science teachers were examined considering factors of TPACK-Deep Scale by using Table of Indicators and Competencies of Technopedagogical Education (see Appendix N).

Firstly, science teachers' technology integration practices were investigated considering *design factor*. The results showed that for deciding technological classroom materials, teachers commonly pay attention to curriculum, subject content, and students' needs. In other words, the updated curriculum, students' learning styles, and the nature of the subject had an influence on designing the lesson. Also, since meiosis is an abstract subject, teachers planned to use visual technologies to make the concept concrete and understandable. In this way, teachers also targeted to increase student motivation and manage lesson time. Similarly, Harris and Hofer (2011) stated the content as well as time and available technological opportunities affected teachers' decisions about planning the lesson. For example, accessible and useful technologies such as computers and smartboards are opted by teachers while designing teaching. In addition to existing subthemes, teachers also considered high school examinations to plan technology-enhanced lessons. Although emerged themes showed differences, the results were in parallel with the previous research considering indicators observed in the classroom. To illustrate, Ocak and Baran (2019, p. 43) stated four dimensions in lesson design, namely: "technology selection, curriculum planning, lesson preparation, and assessment." In addition, under the planning and design domain of TPACK-P, Yeh et al. (2015, p.79) reported various dimensions including "Using ICT to understand students and subject content, planning ICT-infused curriculum, using ICT representations to present instructional representations and employing ICT-integrated strategies".

Secondly, science teachers' technology integration practices were investigated considering the *exertion factor*. Observation of actual teaching and post-interviews can give different and additional understanding about teachers' TPACK (Schmidt-Crawford et al., 2016). Therefore, in the current study, the analysis of the exertion factor, which mostly included classroom observations gives important insights into science teachers' TPACK. According to McCrory (2008) technology can be integrated into science lessons in various ways, "Technology which is unrelated to science, such as word processing, graphic software; a technology designed for teaching and learning science, such as WISE and BIODKids; a technology designed

and used to do science, such as microscopes, probes, and scientific calculators” (p.197). Unfortunately, technologies specific to science were not observed in observed classrooms. To illustrate, specifically, teachers used smartboards to show animations and videos in order to review the previous topics and also repeat the new topics. While integrating these technologies into the teaching, they stop, ask questions and explain major points. Commonly, all teachers’ rationale for using particular technologies was to make meiosis concrete and gain time. Guiding students during video and concretization of the concepts were founded in the study of Ocak and Baran (2019) and referred to as “technology-enhanced science-specific strategies”. On the other hand, although participant teachers reported that they follow student-centered instruction in the light of constructivism, their actual teaching strategies were teacher-centered. For example, students participated in lessons only to answer teachers’ questions. Regarding having teacher-centered teaching, participant teachers criticized their own teaching to be more student-centered in the post-interviews. Ocak and Baran (2019) also reported teacher-centered technology integration. This may be due to technology was not inserted and integrated into the teaching process (DeCoito & Richardson, 2018). In other words, teachers may see technology as a tool to use on themselves. Overall, despite having different TPACK levels, the participant teachers demonstrated similar patterns and indicators in their actual teaching in the exertion factor.

Thirdly, science teachers’ technology integration practices were investigated considering the *ethics factor*. The results showed that teachers were careful about technology-based intellectual property rights. In other words, copyrights of the online resources were considered by them. On the other hand, the most important indicator was obeying the accuracy of technology-based information. Hence, teachers reviewed the sources and used trustworthy websites to avoid misconceptions. In addition, participant teachers paid attention to the ethics of teaching and use technologies ergonomically.

Fourthly and lastly, science teachers’ technology integration practices were investigated considering the *proficiency factor*. In general, participant teachers used

technology before the lesson in order to keep content knowledge up to date. To illustrate, they searched different and additional resources for teaching meiosis better. On the other hand, teachers faced connection and software problems in their actual teachings, which were all solved by teachers during teaching. For bigger problems, teachers have additional plans, including project-based activities and turning back to direct instruction.

While combining all results, the reported TPACK-Deep scores and indicators regarding TPACK-Deep factors have inconsistencies. Although participant science teachers' TPACK levels were selected as low, medium, and high, their actual teaching indicators and TPACK competencies showed many similarities, which were contradictory. In other words, there is a gap between teachers' knowledge and their implementation (Yeh et al., 2017). Similar inconsistencies were also found in the literature. For example, teachers' knowledge levels about TPACK-P were higher than their actual application levels (Jen et al., 2016). In addition, there were differences between teachers' knowledge and their actual teaching behaviors (Yeh et al., 2015). Since self-report data does not directly reflect teachers' real classroom technology integration experiences (Koh & Chai, 2014), the contradiction might be observed teachers score themselves over or underestimated in the TPACK-Deep scale.

Another reason can be the lack of practical experiences of the science teachers in terms of technology integration. Although teachers felt competent in TPACK, they might not be comfortable about integration technology into the instruction. In order to improve TPACK-P, teachers need to practice how technologies can be integrated into the science lessons (Jen et al., 2016). The more the teachers integrate technology and become more experienced, the greater their proficiency levels become (Jen et al., 2016). Although teachers are good at using the computer, they need additional support at the "instructional level" (Ertmer, 1999).

On the other hand, another reason might be the existence of barriers to technology integration. There exist various barriers that teachers need to overcome to implement

technology in their lessons. First-order barriers can be the deficiency of computer or internet access and time, whereas second-order barriers can be the teachers' beliefs about technology and situated lesson practices (Ertmer, 1999). On the other hand, Tsai and Chai (2012) proposed third-order barriers as "teachers' lack of design thinking". Although participant teachers achieved some technology-related barriers, there might be some second and third-order barriers for technology integration that affect their actual teaching negatively.

In other respects, the assessment was found as a theme in previous studies (Ocak & Baran, 2019; Yeh et al., 2015), yet the current research does not include observable indicators regarding assessment. This may be due to teachers were focused on only "teaching" in classroom observations and tried to show how they integrate technology into the teaching and ignoring assessment which is also part of the teaching.

5.2 Implications for Research and Practice

In the current study, science teachers' TPACK competency levels were found high, and there were no differences between science teachers' TPACK based on gender and experience years. However, considering teachers' interviews and their actual classroom indicators, there were discrepancies between their self-reported data and teaching.

Considering the findings of the present study, science teachers need professional development programs for integrating technology into their teaching, particularly in meiosis subject. Although science teachers' self-reported data indicated higher TPACK competency, their practice in the classroom showed lower competencies. For this purpose, professional development programs may include practical usage of various and emergent technologies in the context of science education and meiosis subject. For example, science specific technologies like virtual learning simulations and 3D animations can be valuable technologies. In this regard, science teachers can design and implement lesson plans in the light of emergent technologies. Also, the

key point of these programs should be how to design and implement student-centered technology-enhanced instruction. As a result, science teachers' TPACK competencies in the practical context could be promoted.

Another implication for the current study is related to education faculties. Considering the results of the current study, science teachers had a lack of knowledge about technology-infused student-centered instruction and assessment strategies. For that reason, the focus of the science method courses could be technology-enhanced and more student-centered. For example, while teaching project-based learning in the science teaching method courses, microteaching in the practical hours can include science specific technologies adopting student-centered instructions. Moreover, science-specific technologies could be used and integrated into the lessons.

5.3 Recommendations for Future Research

In this part, recommendations for future researchers will be mentioned considering the present study.

Initially, the data were limited to the small city located in Central Anatolia region of Turkey. In addition, the current data were collected from public school science teachers at the middle school level. Considering the technological facilities of these schools, which are generally limited to smart boards and an internet connection, future research can include private schools that have more technological opportunities. It is also strongly recommended for future research that comparing public and private school contexts may add value in order to understand science teachers' TPACK.

In other respect, classroom observations were made only in the meiosis topic and for one lesson hour. The different topics and different grade levels may give additional and deep insights about science teachers' technology integration practices. Moreover, the recommended time for the meiosis topic is six class hours. In order to

get comprehensive and holistic knowledge about teachers' technology integration practices in that topic, observations can be extended as a whole topic.

On the other hand, conducting research with the in-service science teachers had some difficulties. Firstly, it was hard to reach a representative sample for the survey research. Since the survey was online, some teachers left it incomplete. If possible, collecting face-to-face data is recommended for the survey part. Secondly, data collection from an authentic classroom environment has some difficulties. Considering classroom observations and video recordings, having a stranger in the classroom was not usual for teachers and students. Getting familiar with the students and teachers before collecting data is very important. In that way, they may feel more comfortable and act more naturally. In the current research, classroom observations were triangulated with the interviews. In addition to these data collection tools, teachers' lesson plans can be used and analyzed. Different research designs having various data collection instruments can enrich the literature.

Previous studies showed significant differences between science teachers' TPACK according to demographic variables, including gender and experience years. However, in the present study, it was found that there were no significant differences in terms of gender and experience years. To better understand whether there exist differences in TPACK with regards to demographic variables, more research needs to be conducted especially by well-defined samples. In doing so, it may be understood the underlying reason for varied results. Moreover, especially increasing the sample size is strongly recommended for future research.

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APPENDICES

A. TPACK-Deep Scale

Sevgili öğretmenim,

Ben Mine Tanrısevdi. Orta Doğu Teknik Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü yüksek lisans öğrencisi ve Aksaray Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü araştırma görevlisiyim. Ben ve değerli danışmanlarım Prof. Dr. Jale Çakıroğlu ve Doç. Dr. Sedef Canbazoğlu Bilici, yüksek lisans tezim kapsamında “Fen Bilimleri Öğretmenlerinin Teknolojik Pedagojik Alan Bilgilerinin (TPAB) Farklı Değişkenler Açısından İncelenmesi” isimli çalışmayı yürütmekteyiz. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın amacı nedir?

Araştırmanın amacı, siz değerli öğretmenlerimizden teknolojik pedagojik alan bilgilerinize (TPAB) yönelik bilgi toplamaktır.

Bize nasıl yardımcı olmanızı isteyeceğiz?

Araştırmaya katılmayı kabul ederseniz, sizden beklenen, ankette yer alan soruları derecelendirme ölçeği üzerinde yanıtlamanızdır. Bu çalışmaya katılım ortalama 25 dakika sürmektedir. Çalışmaya katılımınız, alan yazındaki eksikleri giderme konusunda hem araştırmacıya yardımcı olacak hem de literatüre katkı sağlayacaktır.

Sizden topladığımız bilgileri nasıl kullanacağız?

Çalışmaya katılımınız tamamen gönüllülük esasına dayanmaktadır. Demografik bilgileriniz ve ankette verdiğiniz yanıtlar tamamen gizli tutulacaktır. Elde edilen veriler araştırmacı ve tez danışmanları dışında hiç kimseye paylaşılmayacaktır. Katılımcılardan elde edilen veriler, sadece bilimsel amaçlarla kullanılacaktır.

Katılımınızla ilgili bilmeniz gerekenler:

Anket, genel olarak kişisel rahatsızlık verecek sorular içermemektedir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakabilirsiniz.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Bu çalışmaya katıldığımız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için ODTÜ Matematik ve Fen Bilimleri Eğitimi Bölümü öğretim üyelerinden Prof. Dr. Jale Çakıroğlu, Aksaray Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü öğretim üyelerinden Doç. Dr. Sedef Canbazoğlu Bilici ya da araştırma görevlisi Mine Tanrısevdi ile iletişim kurabilirsiniz.

Çalışmaya katılmayı kabul ediyorsanız aşağıdaki kutucuğu işaretleyiniz ve anket sorularını yanıtlayınız.

- Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum. Verdiğim bilgilerin bilimsel amaçlı yayımlarda kullanılmasını kabul ediyorum.*

Demografik Bilgi Formu

1. Cinsiyet:

- Kadın
 Erkek

2. En son mezun olduğunuz derece:

- Lise
 Lisans
 Yüksek Lisans
 Doktora

3. Mezun olduğunuz fakülte (Lisans):

- Eğitim Fakültesi
 Fen – Edebiyat Fakültesi
 Diğer: (Lütfen belirtiniz)

4. Formasyon eğitimi aldınız mı? (Eğitim Fakültesi mezunuysanız, lütfen “Evet” seçeneğini işaretleyin)

- Evet
 Hayır

5. Kaç yıldır öğretmenlik yapıyorsunuz?

- 0 – 4 yıl
 5 – 9 yıl
 10 – 14 yıl
 15 yıldan fazla

6. Çalıştığınız okul türü nedir? Lütfen okul adını belirtiniz.

- Devlet okulu: (Okul adını belirtiniz)
 Özel okul: (Okul adını belirtiniz)

**7. Görev yaptığınız okulun bulunduğu yeri tanımlayınız.
(Köy/kasaba okulu mu? Okulun sahip olduğu teknolojik imkanlar nelerdir? gibi.)**

.....
.....

8. Teknoloji kullanımı ile ilgili hizmet içi eğitim aldınız mı?

- Evet
 Hayır

Yanıtınız “Evet” ise lütfen tabloyu doldurunuz.

Aldığınız hizmet içi eğitim/ler	Eğitimi nereden aldınız?	Eğitimin saati

9. Derslerinizde teknolojiyi ne sıklıkla kullanırsınız?

- Her ders kullanırım.
 Haftada bir kullanırım.
 Ayda bir kullanırım.
 Hiç kullanmam.

10. Derslerinizde kullandığınız teknolojiler nelerdir? (Elmas & Geban, 2012)

- İçerik yönetim sistemleri (Edmodo, Wikispaces vb.)
- Çevrimiçi toplantı (Voki, Todaysmeet vb.)
- Çevrimiçi depolama ve dosya paylaşımı (Dropbox, Screencast vb.)
- İnteraktif sunumlar (Prezi, SlideRocket vb.)
- Çevrimiçi anket (SurveyMonkey, Poll Everywhere vb.)
- Kavram haritası ve çizim araçları (Bubbl.us, Scribblar vb.)
- Animasyon ve video (Animoto, GoAnimate vb.)
- Kelime bulutları (Wordle, TagCrowd vb.)
- Diğer: (Lütfen belirtiniz.)

TEKNOPEDAGOGİK EĞİTİM (TPACK) YETERLİKLERİ ÖLÇEĞİ

Aşağıda verilen teknopedagojik eğitim yeterliklerini inceleyerek bu yeterlikleri karşılama düzeyinizi en uygun biçimde ifade eden yalnız bir seçeneği işaretleyiniz.

		KARŞILAMA DÜZEYİNİZ				
		Kesinlikle Yapamam	Yapamam	Kısmen Yapabilirim	Yapabilirim	Rahatlıkla Yapabilirim
1	Teknolojiden yararlanarak bir öğretim materyalini gereksinimlere (öğrenci, ortam, süre vb.) uygun olarak güncelleyebilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Öğretim süreci öncesinde öğrencilerin içeriğe dayalı gereksinimlerini belirlemek için teknolojiden yararlanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Öğretme-öğrenme sürecini zenginleştirmek için gereksinime uygun etkinlik geliştirmede teknolojiden yararlanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Öğretme-öğrenme sürecini teknolojik olanaklara uygun olarak planlayabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Konu alanı öğretiminin niteliğini artırmak amacıyla kullanılacak teknolojilere yönelik gereksinim analizi yapabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Bilgi ve İletişim Teknolojileri uygulamalarını kullanarak (eğitim yazılımı, sanal laboratuvar vb.) öğretim süresini optimum düzeye getirebilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	Gereksinime uygun ölçme aracı geliştirmede teknolojiden yararlanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	Konu içeriğinin etkili bir şekilde aktarılması için yöntem, teknik ve teknolojilerin özelliklerini değerlendirerek birbirleriyle uyumlu olanları seçebilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9	Etkili bir öğretim-öğrenme süreci için gereksinime uygun materyal tasarlamak amacıyla teknolojiden yararlanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10	Öğretme-öğrenme sürecinin gerçekleştirileceği ortamı teknoloji kullanımına uygun olarak düzenleyebilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11	Teknolojinin kullanıldığı öğretim-öğrenme süreçlerinde sınıf yönetimini sağlayabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12	Öğrencilerin öğretim sürecine ilişkin geçerli bilgiye sahip olma durumlarını uygun teknolojileri kullanarak ölçebilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13	Bireysel farklılıklara uygun öğretim yaklaşım ve yöntemlerini teknoloji yardımıyla uygulayabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14	Ödev, proje, staj gibi eğitsel etkinlikleri yürütmede teknolojiden yararlanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15	Öğretim sürecinde teknoloji destekli iletişim ortamlarından (blog, forum, sohbet, e-posta vb.) yararlanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16	Öğrencilerin konu alanına ilişkin başarı durumlarını değerlendirmede teknolojiyi kullanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17	Öğretim sürecinde etik kurallara uygun teknoloji kullanımında öğrenciye model olabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18	Öğrencilerin teknolojiye dayalı ürün (sunu, oyun, film vb.) veya etkinlik (ödev, proje vb.) oluşturma sürecine rehberlik yapabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19	Öğretme-öğrenme sürecine destek amaçlı güncel teknolojik yeniliklerden (facebook, blog, wiki, twitter, podcasting vb.) yararlanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20	Öğretimi gerçekleştirilecek konu alanı bilgi ve becerilerini güncellemede teknolojiden yararlanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21	Öğretim sürecinde kullanılan teknoloji bilgisini güncel tutabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22	Öğretim sürecine ilişkin bilginin güncel tutulmasında teknolojiden yararlanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23	Eğitim ortamlarında teknolojinin erişimi konusunda etik davranabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24	Konu alanı öğretiminde yararlanılacak özel/mahrem bilgileri teknoloji aracılığıyla edinmede (ses kaydı, video kayıt, doküman vb.) ve kullanmada etik kurallara uyma	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25	Öğretme-öğrenme sürecinin her aşamasında teknolojiden fikri mülkiyet	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		KARŞILAMA DÜZEYİNİZ				
		Kesinlikle Yapamam	Yapamam	Kısmen Yapabilirim	Yapabilirim	Rahatlıkla Yapabilirim
	(telif, lisans vb.) konularına uyararak yararlanabilme					
26	Teknoloji tabanlı öğretim ortamlarında (WebCT, Moodle vb.) sürecin her aşamasında öğretmenlik mesleği etik kurallarına uyma	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27	Öğretme-öğrenme sürecinde öğrencileri geçerli ve güvenilir dijital kaynaklara yönlendirerek doğru bilgiye ulaşmalarına rehberlik edebilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28	Eğitim ortamlarında teknolojinin sağlıklı kullanımı konusunda etik davranabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
29	Teknoloji tabanlı öğretim ortamlarında (WebCT, Moodle vb.) karşılaşılabilecek problemleri çözebilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30	Öğretme-öğrenme sürecinin her aşamasında teknolojiden yararlanırken ortaya çıkabilecek sorunları çözebilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
31	Konu alanıyla ilgili karşılaşılan problemlere (içeriğin yapılandırılması, güncellenmesi, gerçek yaşamla ilişkilendirilmesi vb.) yönelik çözüm üretmede teknolojiyi kullanabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
32	Alanıyla ilgili teknolojik yeniliklerin öğretim sürecinde kullanımının yayılmasına liderlik edebilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
33	İçeriğin aktarımı sürecinde karşılaşılan problemlerin çözümü için teknolojiden yararlanma konusunda disiplinler arası işbirliği yapabilme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

B. Pre-Interview

Sevgili öğretmenim,

Ben Mine Tanrısevdi. Orta Doğu Teknik Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü'nde yüksek lisans öğrencisi ve Aksaray Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü'nde araştırma görevlisiyim. Ben ve değerli danışmanlarım Prof. Dr. Jale Çakıroğlu ve Doç. Dr. Sedef Canbazoğlu Bilici, yüksek lisans tezim kapsamında “Fen Bilimleri Öğretmenlerinin Teknolojik Pedagojik Alan Bilgilerinin (TPAB) Farklı Değişkenler Açısından İncelenmesi” isimli çalışmayı yürütmekteyiz. Araştırmanın amacı, siz değerli öğretmenlerimizin teknolojiyi fen bilimleri dersine entegrasyon sürecini gözlemlemektir. Bu süreçte, sizinle dersini hakkında görüşmeler yapacağım. Bu görüşmelerin ortalama 45 dakika sürmesi planlanmaktadır. Çalışmaya katılımınız, fen öğretmenlerinin derslerine teknoloji entegrasyon süreçleri açısından alan yazına katkı sağlayacaktır.

Çalışmaya katılımınız tamamen gönüllülük esasına dayanmaktadır. Demografik bilgileriniz ve ses kayıtlarınız tamamen gizli tutulacaktır. Elde edilen veriler araştırmacı ve tez danışmanları dışında hiç kimseyle paylaşılmayacaktır. Katılımcılardan elde edilen veriler, sadece bilimsel amaçlarla kullanılacaktır. Katılım sırasında herhangi bir nedenden ötürü kendinizi rahatsız hissederseniz, çalışmayı yarıda bırakabilirsiniz.

Görüşme Yapılan Öğretmenin;

Görev Yaptığı Okul:

I. BÖLÜM

1. Kaç yıldır öğretmenlik yapıyorsunuz?
 - a. Devlet okulu dışında çalışmış olduğunuz kurumlar nelerdir?
2. Daha önce çalıştığınız okulların / kurumların teknolojik imkanları nasıldı?
3. Teknoloji ile ilgili olarak hangi eğitimleri aldınız?
 - a. Hizmet içi eğitimler neler?
 - b. Kurum dışında aldığınız eğitimler varsa neler? (TÜBİTAK, Öğretmen Ağı, ÖRAV gibi)

(1. , 2. ve 3. sorular, öğretmenlerin görüşmeye ısınması için sorulacaktır).
4. Öğrencilerinizin, mayoz bölünme kazanımlarını işlediğiniz ders için hazırbulunuşluk düzeyleri nedir?

Sonda: Ön bilgileri, kavram yanılgıları, anlamakta zorlandıkları kavramlar.
5.
 - a. Öğrencilerin gereksinimlerini nasıl belirlediniz?
 - b. Bu düzeyleri belirlemek için teknolojiden nasıl yararlandınız?
6. Dersinizde hangi öğretim yöntem ve tekniklerini kullandınız?
 - a. Bu yöntem ve teknikleri neye göre seçtiniz? (Alternatif soru: Yöntem ve teknikleri belirlerken dikkat ettiğiniz unsurlar nelerdir?)
7. Derste kullanılacağınız materyalleri seçerken nelere dikkat ettiniz?

Sonda: Var olan materyali aynen kullanma
Var olan materyal üzerinden değişiklikler yaparak kullanma
Sıfırdan materyal hazırlama
8. Derste kullanacağınız materyalleri hazırlarken nelere dikkat ettiniz?

Sonda: Öğrenme kuramı
Farklı gereksinimleri olan öğrenciler
Çoklu ortam araçları
Gerçek yaşamla ilişkilendirme
Alan bilgisinin / kavramların kazandırılması
Etkinlik – uygulama
Ölçme ve değerlendirme
Üst düzey düşünme becerilerinin geliştirilmesi

Güncel olması

Günlük hayatla ilişkilendirme

9. Teknolojik materyaller (resim, yazılım, e-kitap, video gibi) kullanırken dikkat ettiğiniz etik ilkeler nelerdir?

Sonda: Eşit erişim hakkı

Fikri mülkiyet hakkı

Güvenli internet kullanımı

Kişisel mahremiyet

10. Dersinizi planlarken nelere dikkat ettiniz? (**Alternatif Soru:** Bugünkü dersinizi planlarken dikkat ettiğiniz unsurlar nelerdir?)

Sonda: Öğretim programı kazanımları

Konu içeriği

Öğrenci bilgisi

Fiziki koşullar

11. Derste kullanacağınız teknolojiler ve teknolojik materyaller nelerdir?

Sonda: Geleneksel teknolojiler

Modern teknolojiler

Web 2.0 araçları

Simülasyon, animasyon

Bu teknolojik materyalleri neye göre belirlediniz?

12. Dersinizde öğrencilerinizin öğrenme durumlarını nasıl değerlendireceksiniz?

13. Dersinizde karşılaştığınız teknolojik engeller neler olabilir?

- a. Derse hazırlık
- b. Konu içeriğinin kazandırılması
- c. Ölçme-değerlendirme

14. Karşılaştığınız veya karşılaşıacağınız teknolojik engellerin üstesinden nasıl gelebilirsiniz?

C. Post-Interview

Görüşme Yapılan Öğretmenin;

Görev Yaptığı Okul:

1. Dersinizi planladığınız gibi işleyebildiniz mi? Neden?
2. Mayoz bölünme konusunu işlediğiniz dersinizi düşünürsek, hangi teknolojileri kullandınız?
 - a. Kullandığınız teknolojiler (akıllı tahtada video gösterimi vs) hangi amaçlara hizmet ediyordu?
3. Sizce, teknolojiyi dersinize nasıl daha fazla entegre edebilirsiniz?

Sonda: Öğretim, strateji, yöntem ve teknik

Öğrencilerin ön bilgilerini ölçme

Öğrencilerin olası kavram yanlışlarını belirleme

Öğrenciyi derse dahil etme

Ölçme ve değerlendirme
4. Teknolojiyi dersinize nasıl daha farklı şekillerde entegre edebilirsiniz?
5. Dersinizdeki teknoloji entegrasyonunu düşünürsek, bir kez daha aynı konuyu işleme şansınız olsa, dersinizde ne gibi değişiklikler yapardınız?
 - Derse giriş aşamasında
 - Dersi planlama aşamasında
 - Dersi uygulama aşamasında
 - Öğretim yöntem ve teknikleri
 - Ölçme ve değerlendirme
 - Alana özgü fen uygulamaları kullanımı (Biokids, WISE vb)
6. Dersinizde teknolojiyi entegre ederken ne gibi sorunlarla karşılaştınız? Bu sorunları nasıl çözdünüz?

D. Consent Form for Interviews

Sevgili öğretmenim,

Ben Mine Tanrısevdi. Orta Doğu Teknik Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü yüksek lisans öğrencisi ve Aksaray Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü araştırma görevlisiyim. Ben ve değerli danışmanlarım Prof. Dr. Jale Çakıroğlu ve Doç. Dr. Sedef Canbazoğlu Bilici, yüksek lisans tezim kapsamında “Fen Bilimleri Öğretmenlerinin Teknolojik Pedagojik Alan Bilgilerinin (TPAB) Farklı Değişkenler Açısından İncelenmesi” isimli çalışmayı yürütmekteyiz. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın amacı nedir?

Araştırmanın amacı, siz değerli öğretmenlerimizden teknolojik pedagojik alan bilgilerinize (TPAB) yönelik bilgi toplamaktır.

Bize nasıl yardımcı olmanızı isteyeceğiz?

Araştırmaya katılmayı kabul ederseniz, “Hücre ve Bölünmeler” ünitesinde gözlemlediğimiz dersiniz ile ilgili olarak sizinle görüşme yapacağız. Bu görüşmelerin amacı, teknopedagojik eğitim uygulamaları konusunda detaylı bilgi toplamaktır. Siz değerli öğretmenimiz hiçbir şekilde değerlendirilmeyeceksiniz. Çalışmaya katılımınız, alan yazındaki eksikleri giderme konusunda hem araştırmacıya yardımcı olacak hem de literatüre katkı sağlayacaktır.

Sizden topladığımız bilgileri nasıl kullanacağız?

Çalışmaya katılımınız tamamen gönüllülük esasına dayanmaktadır. Demografik bilgileriniz ve ses kayıtlarınız tamamen gizli tutulacaktır. Elde edilen veriler araştırmacı ve tez danışmanları dışında hiç kimseyle paylaşılmayacaktır. Katılımcılardan elde edilen veriler, sadece bilimsel amaçlarla kullanılacaktır.

Katılımla ilgili bilmeniz gerekenler:

Katılım sırasında herhangi bir nedenden ötürü kendinizi rahatsız hissederseniz, çalışmayı yarıda bırakabilirsiniz.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için ODTÜ Matematik ve Fen Bilimleri Eğitimi Bölümü öğretim üyelerinden Prof. Dr. Jale Çakıroğlu, Aksaray Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü öğretim üyelerinden Doç. Dr. Sedef Canbazoğlu Bilici ya da araştırma görevlisi Mine Tanrısevdi ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum. Verdiğim bilgilerin bilimsel amaçlı yayımlarda kullanılmasını kabul ediyorum.

E. Consent Form for Video Recordings

Sevgili öğretmenim,

Ben Mine Tanrısevdi. Orta Doğu Teknik Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü yüksek lisans öğrencisi ve Aksaray Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü araştırma görevlisiyim. Ben ve değerli danışmanlarım Prof. Dr. Jale Çakıroğlu ve Doç. Dr. Sedef Canbazoğlu Bilici, yüksek lisans tezim kapsamında “Fen Bilimleri Öğretmenlerinin Teknolojik Pedagojik Alan Bilgilerinin (TPAB) Farklı Değişkenler Açısından İncelenmesi” isimli çalışmayı yürütmekteyiz. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın amacı nedir?

Araştırmanın amacı, siz değerli öğretmenlerimizden teknolojik pedagojik alan bilgilerinize (TPAB) yönelik bilgi toplamaktır.

Bize nasıl yardımcı olmanızı isteyeceğiz?

Araştırmaya katılmayı kabul ederseniz, “Hücre ve Bölünmeler” ünitesinde bir ders saatinizi video ile kayıt altına alacağız. Kayıt altına almamızın nedeni, teknopedagojik eğitim uygulamaları konusunda bilgi toplamaktır. Siz değerli öğretmenimiz hiçbir şekilde değerlendirilmeyeceksiniz. Çalışmaya katılımınız, alan yazındaki eksikleri giderme konusunda hem araştırmacıya yardımcı olacak hem de literatüre katkı sağlayacaktır.

Sizden topladığımız bilgileri nasıl kullanacağız?

Çalışmaya katılımınız tamamen gönüllülük esasına dayanmaktadır. Demografik bilgileriniz ve video kayıtlarınız tamamen gizli tutulacaktır. Elde edilen veriler araştırmacı ve tez danışmanları dışında hiç kimseye paylaşılmayacaktır. Katılımcılardan elde edilen veriler, sadece bilimsel amaçlarla kullanılacaktır.

Katılımla ilgili bilmeniz gerekenler:

Katılım sırasında herhangi bir nedenden ötürü kendinizi rahatsız hissederseniz, çalışmayı yarıda bırakabilirsiniz.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için ODTÜ Matematik ve Fen Bilimleri Eğitimi Bölümü öğretim üyelerinden Prof. Dr. Jale Çakıroğlu, Aksaray Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü öğretim üyelerinden Doç. Dr. Sedef Canbazoğlu Bilici, ya da araştırma görevlisi Mine Tanrısevdi ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum. Verdiğim bilgilerin bilimsel amaçlı yayımlarda kullanılmasını kabul ediyorum.

Tarih

İmza

F. Parent Consent Form

Değerli Veli,

Ben Mine Tanrısevdi. Orta Doğu Teknik Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü yüksek lisans öğrencisi ve Aksaray Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü araştırma görevlisiyim. Ben ve değerli danışmanlarım Prof. Dr. Jale Çakıroğlu ve Doç. Dr. Sedef Canbazoğlu Bilici, yüksek lisans tezim kapsamında “Fen Bilimleri Öğretmenlerinin Teknolojik Pedagojik Alan Bilgilerinin (TPAB) Farklı Değişkenler Açısından İncelenmesi” çalışması yürütmekteyiz. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın amacı nedir?

Araştırmanın amacı, fen bilimleri öğretmenlerimizden teknolojik pedagojik alan bilgilerine (TPAB) yönelik bilgi toplamaktır.

Sizin ne yapmanızı istiyoruz?

Araştırma kapsamında fen bilgisi derslerinde video kayıtları alınacaktır. Videolar, öğrencilerin yüzleri gözükmeyecek biçimde, sınıfın en arka kısmından çekilecektir. Öğrencilerin kimlik bilgileri ve video kayıtları hiçbir şekilde araştırmacılar dışında kimseyle paylaşılmayacaktır. Çalışmaya katılım gönüllülük esasına dayalıdır. Çocuğunuzun katılımına izin vermeniz, alan yazındaki eksikleri giderme konusunda hem araştırmacıya yardımcı olacak hem de literatüre katkı sağlayacaktır.

Sizden topladığımız bilgileri nasıl kullanacağız?

Çalışmaya katılımınız tamamen gönüllülük esasına dayanmaktadır. Çocuğunuzun demografik bilgileri ve video kayıtları tamamen gizli tutulacaktır. Elde edilen veriler araştırmacı ve tez danışmanları dışında hiç kimseyle paylaşılmayacaktır. Katılımcılardan elde edilen veriler, sadece bilimsel amaçlarla kullanılacaktır.

Çocuğunuzun arařtırmaya katılımıyla ilgili bilmeniz gerekenler:

Çocuğunuzun arařtırmaya katılımı sırasında herhangi bir nedenden ötürü rahatsız hissederseniz, çalıřmayı yarıda bırakabilirsiniz. Ayrıca, istediğiniz zaman çalıřmaya katılmaktan vazgeçebilirsiniz.

Arařtırmayla ilgili daha fazla bilgi almak isterseniz:

Bu çalıřmaya katıldığımız için řimdiden teřekkür ederiz. Çalıřma hakkında daha fazla bilgi almak için ODTÜ Matematik ve Fen Bilimleri Eđitimi Bölümü öđretim üyelerinden Prof. Dr. Jale Çakırođlu, Aksaray Üniversitesi Matematik ve Fen Bilimleri Eđitimi Bölümü öđretim üyelerinden Doç. Dr. Sedef Canbazođlu Bilici ya da arařtırma görevlisi Mine Tanrısevdi ile iletiřim kurabilirsiniz.

Lütfen bu arařtırmaya katılmak konusundaki tercihinizi ařađıdaki seeneklerden size en uygun gelenin altına imzanızı atarak belirtiniz ve bu formu çocuğunuzla okula geri gönderiniz.

A) Bu arařtırmaya tamamen gönüllü olarak katılıyorum ve çocuđum'nın da katılımcı olmasına izin veriyorum. Çalıřmayı istediğim zaman yarıda kesip bırakabileceğimi biliyorum ve verdiđim bilgilerin bilimsel amaçlı olarak kullanılmasını kabul ediyorum.

İmza

B) Bu çalıřmaya katılmayı kabul etmiyorum ve çocuđum'nın da katılımcı olmasına izin vermiyorum.

İmza

G. Permission for the Instrument

Mine Tanrısevdi

TPACK Ölçek Ricası Hk.

Kime:

Bilgi: [Bilgi](#)

29 Temmuz 2019 22:06

[Ayrıntılar](#)

MT

Değerli Işıl Hocam,

Ben Mine Tanrısevdi. ODTÜ Fen Bilimleri Eğitimi alanında yüksek lisans öğrencisi, Aksaray Üniversitesi'nde araştırma görevlisiyim. Tez danışmanlarım Prof.Dr. Jale Çakıroğlu ve Doç.Dr. Sedef Canbazoğlu Bilici hocalarımdır. Yüksek lisans tezimi TPACK konusunda yapmak istiyorum.

İzniliniz olursa tezimde referans göstererek sizlerin geliştirmiş olduğu TPACK - Deep ölçeğini kullanmak isterim. İzni ve ölçeği paylaşmayı uygun görürseniz sizlere minnettar olurum.

Saygılarımla,
Mine Tanrısevdi

Işıl KABAKÇI YURDAKUL 

Ynt: TPACK Ölçek Ricası Hk.

Kime: Mine Tanrısevdi

Dün 14:59

IY

Merhaba Mine,
Yüksek Lisans tez çalışmada TPACK-deep ölçeğini kullanabilirsin. Ölçeğin Türkçe formatına ekli belgeden ulaşabilirsin. Çalışmada başarılar diliyorum. Jale hoca ve Sedef hocaya selamlar..

Doç.Dr. Işıl Kabakçı Yurdakul
Anadolu Üniversitesi
Eğitim Fakültesi, BÖTE Bölümü
Eskişehir, TÜRKİYE

Işıl Kabakçı Yurdakul, PhD
Department of Computer Education and
Instructional Technologies
College of Education
Anadolu University, TURKEY

Mine Tanrısevdi

4 Eylül 2019 15:16

MT

TPACK-Deep Hk.

Kime: Işıl Kabakçı Yurdakul



Değerli Işıl Hocam,

Öncelikle nasılsınız?

Daha önce TPACK-Deep ölçeği için izin vermişsiniz, çok teşekkür ederim.
Tekrar izninizi rica edeceğim bir konu olacak.

Tez çalışmamda, fen bilgisi öğretmenlerine TPACK-deep ölçeğini uygulayıp, seçeceğim öğretmenlerin dersini video ile kayıt altına alacağım. Daha sonra içerik analizi yaparak, hem data triangulation yapmayı hem de öğretmenlerin uygulamadaki durumlarını ortaya çıkarmayı hedefliyorum.

Değerli danışmanlarım Jale ve Sedef Hocamın bu konudaki önerisi, video research için pratik bir yöntem bulmamdı.
Ben de sizin de yürütücüsü olduğunuz TÜbitak projesinde Teknopedagojik Eğitim Yeterlikleri ve Göstergeleri tablosunu inceledim.

Eğer izniniz olursa, tezimin ikinci aşamasında göstergeleri checklist olarak kullanmayı rica ediyorum.

Desteyiniz ve kıymetli çalışmalarınız için çok teşekkür ediyorum.

Saygılarımla,
Mine

Işıl KABAĞÇI YURDAKUL

Evvvseli gün 14:35

IY

Ynt: TPACK-Deep Hk.

Kime: Mine Tanrısevdi

Tekrar merhaba Mine,

"Teknopedagojik Eğitim Yeterlikleri ve Göstergeleri" tablosunu tez çalışmada kullanabilirsin. Jale hoca ve Sedef hocaya kocaman selamlar. Tez çalışmada kolaylıklar..

Doç.Dr. Işıl Kabakçı Yurdakul
Anadolu Üniversitesi
Eğitim Fakültesi, BÖTE Bölümü
Eskişehir, TÜRKİYE

Işıl Kabakçı Yurdakul, PhD
Department of Computer Education and
Instructional Technologies
College of Education
Anadolu University, TURKEY

H. Approval of the Ethics Committee

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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Sayı: 28620816 / 374

 ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

04 EKİM 2019

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (IAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof.Dr. Jale ÇAKIROĞLU

Danışmanlığını yaptığınız Mine TANRISEVDİ'nin "Fen bilimleri Öğretmenlerinin Teknolojik Pedagojik Alan Bilgilerinin (TPAB) Farklı Değişkenler Açısından İncelenmesi" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve 354 ODTÜ 2019 protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof. Dr. Tülin GENÇÖZ
Başkan

Prof. Dr. Tolga CAN

Doç.Dr. Pınar KAYGAN

Dr. Öğr. Üyesi Ali Emre TURGUT
Üye

Dr. Öğr. Üyesi Şerife SEVINÇ
Üye

Dr. Öğr. Üyesi Müge GÜNDÜZ
Üye

Dr. Öğr. Üyesi Süreyya Özcan KABASAKAL
Üye

16 HAZİRAN 2020

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Jale ÇAKIROĞLU

Danışmanlığını yaptığınız Mine TANRISEVDİ'nin "Teknolojik Pedagojik Alan Bilgilerinin (TPAB) Farklı Değişkenler Açısından İncelenmesi" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve 193 ODTU 2020 protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof.Dr. Mine MISIRLISOY

Başkan

Prof. Dr. Tolga CAN

Üye

Doç.Dr. Pınar KAYGAN

Üye

Dr. Öğr. Üyesi Ali Emre TURGUT

Üye

Dr. Öğr. Üyesi Şehiye SEVİNÇ

Üye

Dr. Öğr. Üyesi Müge GÜNDÜZ

Üye

Dr. Öğr. Üyesi Süreyya Özcan KABASAKAL

Üye

I. Approval of Ministry of National Education



T.C.
MİLLÎ EĞİTİM BAKANLIĞI
Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü

Sayı : 81576613/605.01/305505

06.01.2020

Konu: Araştırma Uygulama İzin Talebi

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

- İlgi:a) Temel Eğitim Genel Müdürlüğünün 26/12/2019 tarihli ve 70297673-605.01-E.25879071 sayılı yazısı
b) Özel Öğretim Kurumları Genel Müdürlüğünün 31/12/2019 tarihli 360771160-405.01-E.201934 sayılı yazısı
c) Millî Eğitim Bakanlığının 22/08/2017 tarihli ve 35558626-10.06.01-E.12607291 (2017/25) sayılı genelgesi

İlgi (a) yazıyla Temel Eğitim Genel Müdürlüğü tarafından uygun görüşle Genel Müdürlüğümüze iletilen Orta Doğu Teknik Üniversitesi, Matematik ve Fen Bilimleri Eğitimi Bölümü Fen Bilimleri Eğitimi Anabilim Dalı Yüksek Lisans program öğrencisi Mine TANRISEVDİ'nin "Fen Bilimleri Öğretmenlerinin Teknolojik Pedagojik Alan Bilgilerinin (TPAK) Farklı Değişkenler Açısından İncelenmesi" konulu yüksek lisans tezi kapsamında hazırladığı veri toplama araçlarının 81 ilde bulunan Millî Eğitim Bakanlığına bağlı resmî ve özel okullarda görev yapmakta olan ortaokul fen bilgisi ve teknoloji öğretmenlerine uygulanmasına yönelik izin talebi Genel Müdürlüğümüz ve Özel Öğretim Kurumları Genel Müdürlüğü tarafından ilgi (b) yazısıyla incelenmiştir.

Denetimi okul/kurum idaresinde olmak üzere, kurum faaliyetlerini aksatmadan, gönüllülük esasına göre; onaylı bir örneği Bakanlığımızda muhafaza edilen ve uygulama sırasında da mühürlü ve imzalı örnekten çoğaltılan veri toplama araçlarının uygulanmasına ilgi (c) Genelge doğrultusunda izin verilmiştir.

Bilgilerinizi ve gereğini rica ederim.

Anıl YILMAZ
Bakan a.
Genel Müdür

Ek: Veri Toplama Aracı (4 Sayfa)

Emniyet Mahallesi Milas SokakNu:8 06560 Yenimahalle-ANKARA
Telefon No: (0 312)296 94 00 Fax: (0 312) 213 61 36
E-Posta: yegitek@meb.gov.tr İnternet Adresi: http://yegitek.meb.gov.tr

Bilgi için: Şeyda KARABULUT Dr.Atilla DEMİRBAŞ
Öğretmen Koordinatör
Telefon No: (0 312) 296 95 82.

Bu evrak güvenli elektronik imza ile imzalanmıştır. <https://evraksorgu.meb.gov.tr> adresinden e560-272c-3a39-8b99-614d kodu ile teyit edilebilir.

J. Approval of Aksaray Provincial Directorate of National Education



T.C.
AKSARAY VALİLİĞİ
İl Millî Eğitim Müdürlüğü

Sayı : 85705372-44-E.1996930
Konu : Uygulama İzni

28/01/2020

VALİLİK MAKAMINA

- İlgi: a) Millî Eğitim Bakanlığı Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 21.01.2020 tarih ve 2020/2 Nolu Genelgesi.
b) Aksaray Üniversitesi Araştırma Görevlisi Mine TANRISEVDİ'nin 22.01.2020 tarih ve bila sayılı dilekçesi.

İlgi (b) dilekçede belirtildiği üzere ; Aksaray Üniversitesi Matematik ve Fen Bilgisi Eğitimi Bölümü, Fen Eğitimi Anabilim Dalı Araştırma Görevlisi ve Ortadoğu Teknik Üniversitesi Yüksek Lisans Öğrencisi Mine TANRISEVDİ; "**Fen Bilimleri Öğretmenlerinin Teknolojik Pedagogik Alan Bilgilerinin (TPAB) Farklı Değişkenler Açısından İncelenmesi**" konulu tez çalışması kapsamında gözlemlerini Bağlıkaya İmam Hatip Ortaokulu, Doğantarla Ortaokulu ve Sezai Karakoç Ortaokulunda görev yapan öğretmenler üzerinde uygulamak istemektedir.

Konu ile ilgili belgelerin ve anket sorularının incelenmesi neticesinde; Başvurunun Araştırma, Yarışma ve Sosyal Etkinlik İzinleri konulu ilgi (a) da kayıtlı Genelgede belirtilen usul ve esaslara uygun olarak yapıldığı anlaşılmış olup;

Mine TANRISEVDİ; "**Fen Bilimleri Öğretmenlerinin Teknolojik Pedagogik Alan Bilgilerinin (TPAB) Farklı Değişkenler Açısından İncelenmesi**" konulu tez çalışması kapsamında gözlemlerini Bağlıkaya İmam Hatip Ortaokulu, Doğantarla Ortaokulu ve Sezai Karakoç Ortaokulunda görev yapan öğretmenler üzerinde uygulama isteği; çalışmanın gönüllülük esasına dayandığı gözönünde bulundurularak; sorumluluk okul/kurum idaresinde olmak, rapor sonuçlarının yazılı ve dijital ortamda birer örneğini İl Millî Eğitim Müdürlüğümüze vermek ve çalışmanın 2019-2020 eğitim-öğretim yılı içerisinde tamamlanması koşuluyla Müdürlüğümüzce uygun görülmemektedir.

Makamlarınızca da uygun görüldüğü takdirde, olurlarınıza arz ederim.

Muhittin ÖZTÜRK
İl Millî Eğitim Müdürü V.

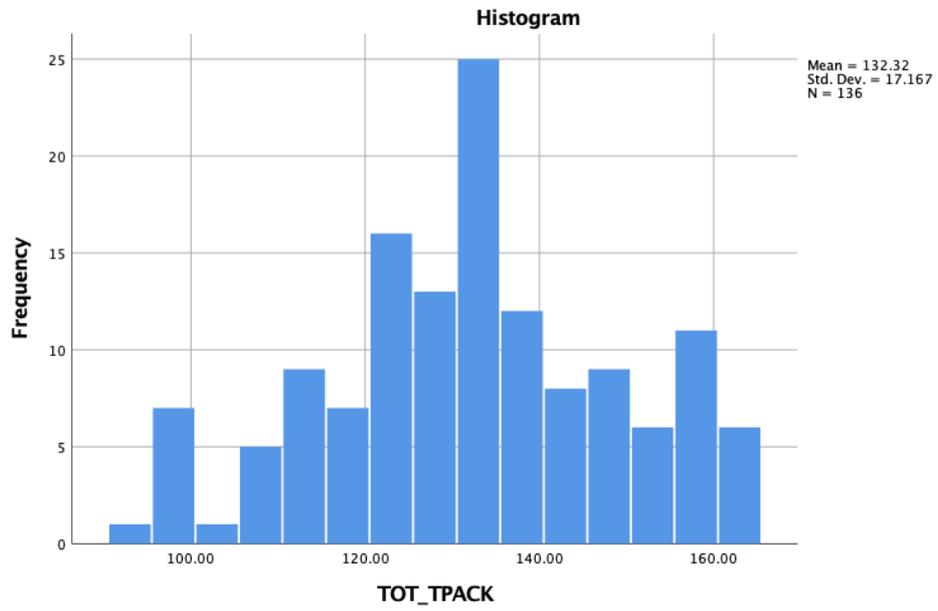
OLUR
28/01/2020
Hakkı LOĞOĞLU
Vali a.
Vali Yardımcısı

Yeni Sanayi Mah. 2/E 90 Bul No:47 Ek Valilik 3 Nolu Hizmet Binası 68100-AKSARAY
Elektronik Ağ: <http://aksaray.meb.gov.tr>
e-posta: aksaraymem@meb.gov.tr

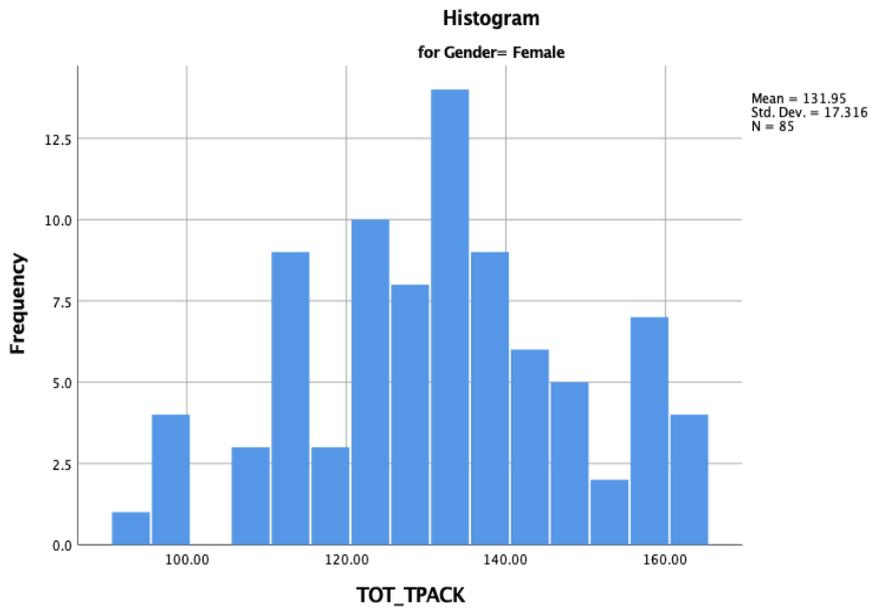
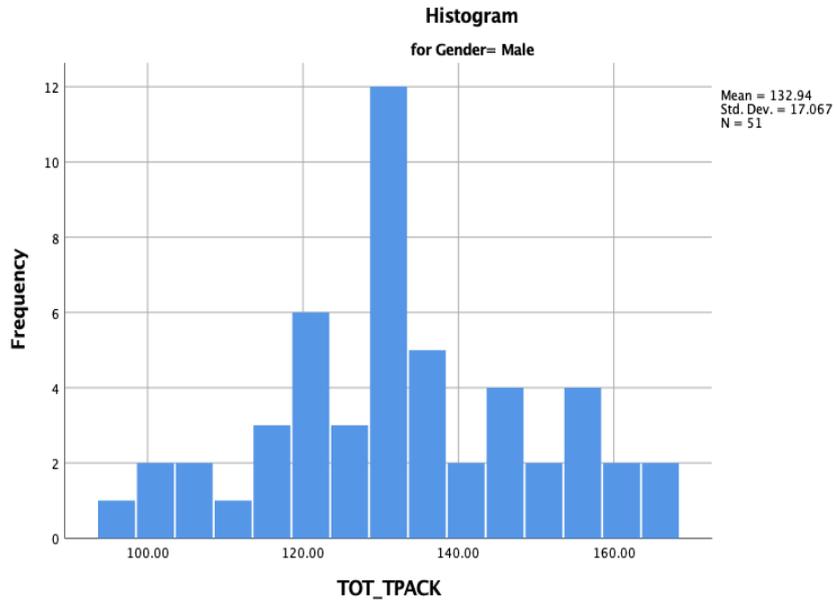
Ayrıntılı bilgi için: H.YALÇIN
Tel: 0 (382) 213 68 40/130
Faks: 0 382 213 68 14

Bu evrak güvenli elektronik imza ile imzalanmıştır. <https://evraksorgu.meb.gov.tr> adresinden 7e08-d781-349f-b02e-3c97 kodu ile teyit edilebilir.

K. Statistical Results and Histogram for TPACK



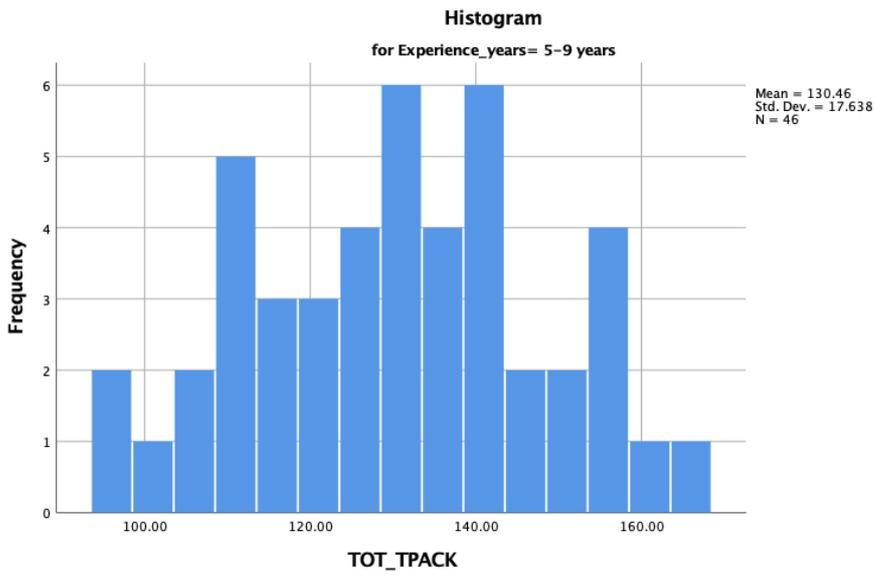
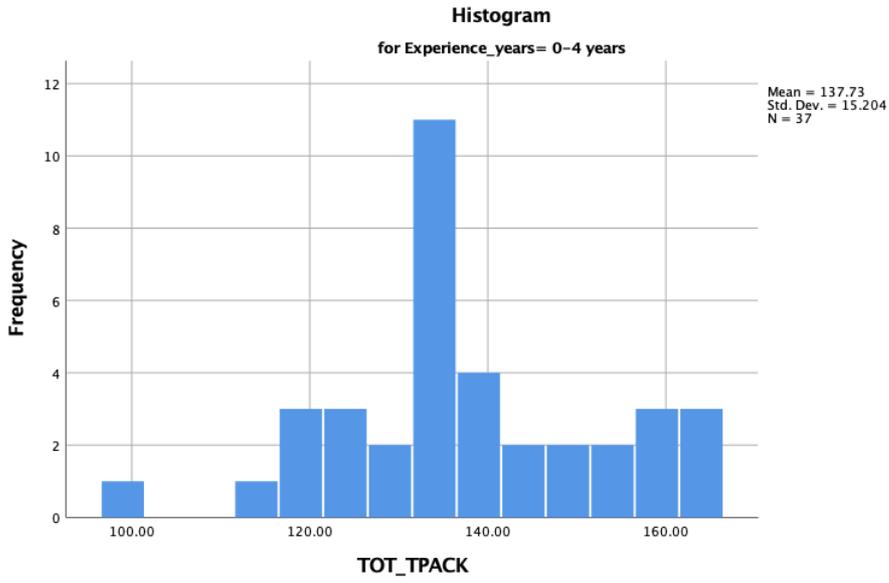
L. Statistical Results of TPACK for Male and Female Science Teachers

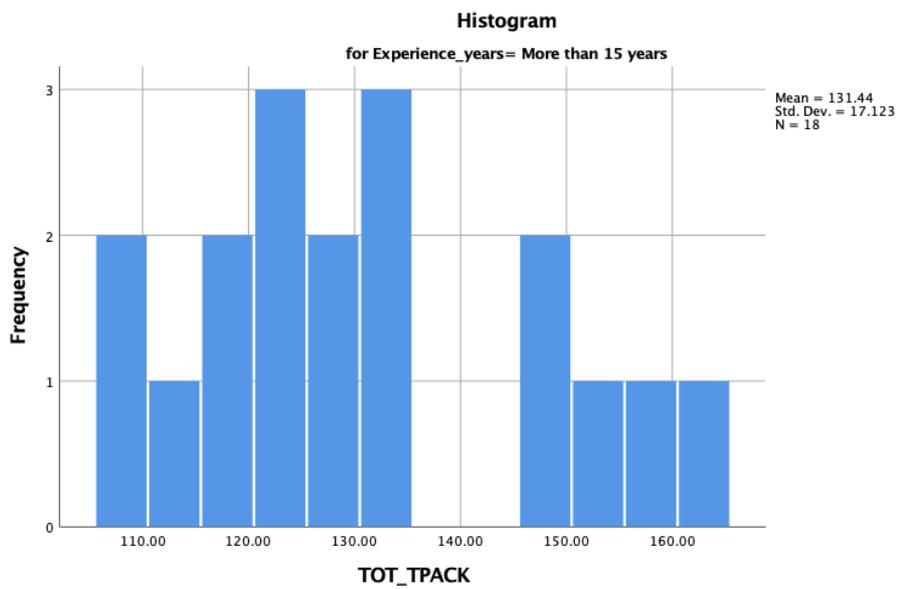
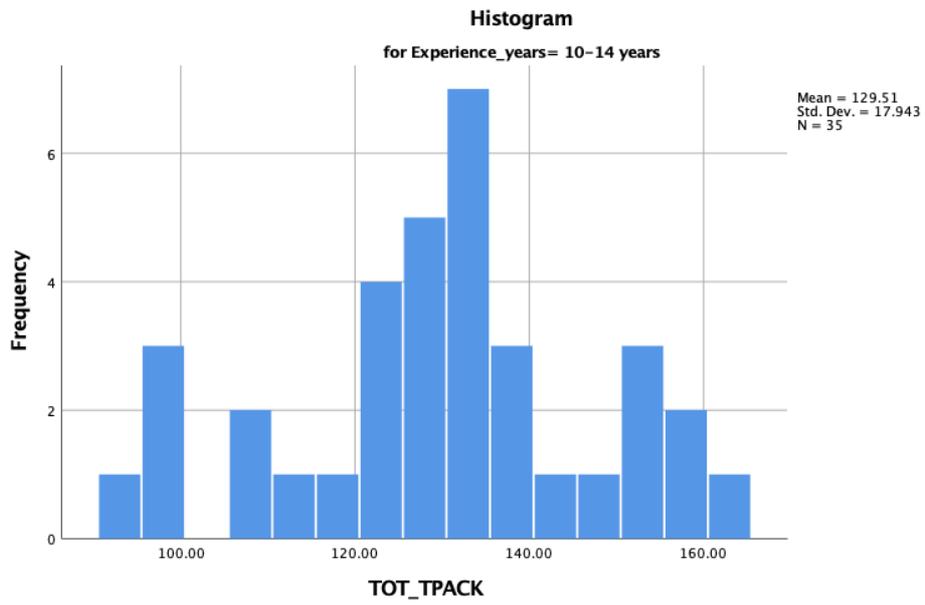


M. Statistical Results of TPACK for Different Experience Years

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
TOT TPACK	Based on Mean	.43	3	132	.73
	Based on Median	.51	3	132	.68
	Based on Median and with adjusted df	.51	3	129.89	.68
	Based on trimmed mean	.42	3	132	.74





N. Table of Indicators and Competencies of Technopedagogical Education

YETERLİ K ALANI	KAPSAM	YETERLİK	PERFORMANS GÖSTERGELERİ
A- ÖĞRETİM SÜRECİNİ TASARLAMA	Bu alan teknolojinin işe koşularak; içeriğe yönelik öğretimin tasarlanması	1- Öğretim süreci öncesi var olan durumu analiz etme	<ul style="list-style-type: none"> • Öğrencilerin hazır bulunuşluk düzeylerini belirlemek için teknolojiden yararlanabilme • Öğretim sürecinde kullanılacak teknolojilere yönelik gereksinim analizi yapabilme
	süreci öncesinde var olan durumun çözümlenmesini; öğretim sürecinde kullanılacak uygun yöntem, teknik ve teknolojilerin seçimini; öğretim sürecinde kullanılacak	2- Öğretimde kullanılacak uygun yöntem, teknik ve teknolojileri seçme	<ul style="list-style-type: none"> • Konu içeriğinin etkili bir biçimde aktarılması için var olan teknolojilerin özelliklerini değerlendirerek en uygun olanı seçebilme • Güncel bilgileri kazandırmaya yönelik bir öğretim ortamı (etkinlikler, öğretim materyalleri vb.) hazırlamak için en uygun teknolojiyi seçebilme • Öğretme-öğrenme sürecinde gerçek yaşamdan örneklerin sunumu için kullanılacak teknolojilerden uygun olanı seçebilme
	materyal, ortam ve etkinliklerin oluşturulmasını; var olan materyaller	3- Öğretim sürecinde kullanılacak ortam, etkinlik, materyal ve ölçme araçlarını hazırlama	<ul style="list-style-type: none"> • Bir öğrenme kuramına dayalı öğretim-öğrenme süreci oluşturmada teknolojiden yararlanabilme • Öğretim-öğrenme sürecinde farklı öğrenme gereksinimleri olan öğrencilere yönelik ortamların tasarlanmasında teknolojiyi kullanabilme

<p>üzerinde düzenlemelerin yapılmasını ve öğretim durumlarının planlanmasını kapsamaktadır.</p>	<ul style="list-style-type: none"> • İçeriğin gerçek yaşamla ilişkilendirilmesini sağlamak için çoklu ortam araçlarını kullanarak öğretim ortamı hazırlayabilme • Gerçek yaşamla ilişkili etkinlikler hazırlamada teknoloji bilgisini işe koşabilme • İçeriğin öğretimine yönelik problem çözmeye dayalı senaryolar oluşturmada teknolojiden yararlanabilme • İçerik sunumunun organizasyonunda bilgi ve iletişim teknolojilerinden yararlanabilme • Alanıyla ilgili farklı öğrenme kuramlarına uygun etkileşimli öğretim materyalleri oluşturabilme • Konu alanına uygun ölçme aracı hazırlarken teknolojiyi kullanabilme • Öğrencilerin başarısını gerçek yaşam uygulamaları ile ölçebilecek teknoloji tabanlı ölçme araçları hazırlayabilme • Öğrenme çıktılarını değerlendirmek için uygun ölçme araçlarının geliştirilmesinde teknolojiyi kullanabilme
<p>4- Öğretimde kullanılacak ortam ve materyaller üzerinde düzenleme yapma</p>	<ul style="list-style-type: none"> • Teknoloji kullanımına uygun öğrenme ortamı düzenleyebilme • Öğrencilerin, öğretim ortamındaki teknolojileri ergonomik kullanmalarına yönelik düzenlemeler yapabilme • Dijital bir öğretim materyalinin tasarımını ve içeriğini öğrencilerin öğrenme düzeylerine göre güncelleyebilme
<p>5- Öğretim durumlarının planlanması</p>	<ul style="list-style-type: none"> • Öğretme-öğrenme sürecinin planlanmasına katkı sağlayacak veli, meslektaş, öğrenci ve diğer paydaşlarla iletişim kurmada teknolojiyi kullanabilme

**B- ÖĞRETİM SÜRECİNİ
YÜRÜTME**

Bu alan; konu alanına yönelik öğretim sürecinin yürütülmesinde ve sürecin etkililiğinin ölçülmesinde ve değerlendirilmesinde teknolojinin işe koşulmasını kapsamaktadır.

**1-Öğretimi
gerçekleştirme**

- Öğretilecek içeriğin planlanmasında çevrimiçi ortamlardaki kaynaklara erişmek için arama stratejilerini kullanabilme
 - İçeriğe ilişkin bilgi ve becerileri kazandırmaya yönelik bir öğretim planı oluşturmada teknolojiden yararlanabilme
 - Teknolojiyi etkin kullanarak gerçek yaşam problemlerini çözebilme yetisinin kazandırılması için öğretim planı oluşturabilme
 - İçeriğin sunumuna yönelik öğretim durumlarının planlanmasında teknolojiyi kullanabilme
 - Gerçek yaşam problemlerine çözüm getirebilecek öğretimin planlanmasında teknolojiden yararlanabilme
 - Güncel bilgilerin aktarımı sürecinde teknolojinin etkili şekilde kullanıldığı öğretim durumlarını planlayabilme
 - Gerçek yaşamla ilişkili ders dışı etkinlikler (ödev, gözlem, söyleşi vb.) planlamada teknolojiyi kullanabilme
-
- Yeni öğrenmelere yönelik anlamsal ilişkileri teknoloji yardımıyla yansıtabilme
 - Öğretim sürecinde kavramsal bilgiler arasındaki ilişkiyi teknolojiyi kullanarak yapılandırabilme
 - Çevrimiçi ortamlarda yürütülen öğretim sürecinde sınıf yönetimini sağlayabilme
 - Bilgisayar laboratuvarlarında öğretimi gerçekleştirirken sınıf yönetimini teknoloji aracılığı ile sağlayabilme
 - İçeriği çevrimiçi ortamlarda belirli bir öğretme-öğrenme yaklaşımına dayalı sunabilme

-
- İeriđin ğretiminde uygun ğretim yntem ve tekniđi teknoloji aracılıđı ile uygulayabilme
 - ğretim srecinde teknoloji destekli iletiřim olanaklarından yararlanabilme
 - ğretim srecinin bireysel farklılıklara dayalı olarak aktarılması iin teknolojiden yararlanabilme
 - ğrencilerin teknolojiyi, arařtırma ve sorgulama amacıyla etkili bir Őekilde kullanmalarına rehberlik edebilme
 - İeriđin aktarımında teknolojik sunum ortamlarından (WebCT, Moodle, BDE, WDE vb.) yararlanabilme
 - Farklı ğretme-ğrenme yntemlerini (grup alıřması, iřbirliđine dayalı yntem, problem özme vb.) uygulamada teknolojiyi kullanabilme
 - ğrencilerin eski ve yeni ğrenmeleri arasında iliřki kurmalarını sađlamak iin teknolojiden yararlanabilme
 - ğrencilerin belirli bir konuya iliřkin teknolojiyi kullanarak rün oluřturmalarında (oyun, web sitesi, film vb.) rehberlik yapabilme
 - ğretme-ğrenme srecinde ğrencilerin gdlenmelerini sađlamada teknolojiyi kullanabilme
 - Sınıf ii ve sınıf dıřı eđitsel etkinlikler (dev, proje, staj vb.) yrtmede teknolojiden yararlanabilme
 - ğretim srecinde ğrencilerin st dzey becerilerini (eleřtirel dřnme, problem özme, karar verme vb.) geliřtirmek amacıyla teknolojiden yararlanabilme
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-
- Öğretim sürecinde konu alanına ilişkin gerçek yaşam örneklerini teknoloji aracılığı ile sunabilme
 - Gerçek yaşamdaki problem çözme becerilerinin öğretme-öğrenme sürecine aktarılmasında teknolojiyi kullanabilme
 - Öğretme-öğrenme sürecinde öğrenciyi gerçek yaşam örneklerine yönlendirecek teknoloji kaynaklarını kullanabilme
 - Güncel içerik bilgisinin öğretme-öğrenme sürecine aktarımında teknolojik kaynakları kullanabilme
 - Güncel içerik bilgisinin öğrenme kuramlarına dayalı olarak sunumunda uygun teknolojileri kullanabilme
 - Teknolojiyi kullanırken karşılaştığı problemlere ilişkin çözümlmelerini öğretme-öğrenme sürecine aktarabilme
 - Öğretim sürecinde etik kurallara uygun teknoloji kullanımına model olabilme

2- Öğretim sürecinin etkililiğini ölçme ve değerlendirme

- Öğrencilerin başarısını gerçek yaşam uygulamaları ile ölçmede teknolojiden yararlanabilme
 - Öğrencilerin problem çözme becerilerini ölçmede teknolojiyi kullanırken karşılaşılan problemlere ilişkin üretilen çözümlmelerden yararlanabilme
 - Alanındaki teknolojilerin kullanımında karşılaşılan problemlerin çözümüne yönelik güncel bilgilere öğrencilerin sahip olma durumlarını ölçebilme
 - Öğrenci performanslarını ölçme ve değerlendirme sürecinde teknolojiyi etkili kullanabilme
-

C- YENİLİKLERE AÇIK OLMA	Bu alan; içerik, teknoloji ve öğretim süreci ile ilgili güncel bilgilerin takip edilmesinde ve gerçek yaşama ait yeniliklerin öğretim süreciyle bütünleştirilmesin		<ul style="list-style-type: none"> • Gerçek yaşamla ilişkili bir konuda yapılan ölçme sonucuna göre öğrenci başarısına karar vermede teknolojiden yararlanabilme • Öğrencilerin uygun teknolojileri etkili kullanımlarına ilişkin değerlendirme yapabilme • Öğrenci başarısını değerlendirmede teknoloji tabanlı bir değerlendirme süreci yürütebilme • Güncel alan bilgisini kazandırmaya yönelik ders dışı etkinlikleri (ödev, gözlem, söyleşi vb.) değerlendirmede teknolojiyi (rubrik, e-portfolyo vb.) kullanabilme • Öğrencilerin, alandaki teknolojilerin etik kurallara uygun kullanılma durumunu değerlendirebilme • Öğretme-öğrenme sürecinde alanındaki teknolojilerin kullanımına ilişkin özdeğerlendirme yapabilme
		1- İçerikle ilgili güncel bilgileri takip etme	<ul style="list-style-type: none"> • İçeriğe ilişkin bilgi ve becerileri güncelleme sürecinde teknolojiden yararlanabilme • Öğretme-öğrenme sürecine ilişkin içerik bilgisinin güncel tutulmasında teknolojiyi kullanabilme
		2- Teknolojiyle ilgili güncel bilgileri takip etme	<ul style="list-style-type: none"> • İçeriğin öğretimi sürecinde kullanılan teknoloji bilgisini güncel tutabilme • Öğretme-öğrenme sürecinde kullanılan teknolojilere yönelik ortaya çıkabilecek olası teknolojik problemlerin çözümüne ilişkin bilgileri güncel tutabilme

D- ETİK KONULARA UYMA

de teknolojinin işe koşulmasını kapsamaktadır.	3- Öğretim süreciyle ilgili güncel bilgileri takip etme	<ul style="list-style-type: none">• İçeriğin öğretime ilişkin güncel alan bilgi ve becerilerini geliştirmede teknolojiden yararlanabilme• Öğretimin gerçekleştirilmesine ilişkin pedagojik bilginin güncel tutulmasında teknolojiyi etkin kullanabilme• Ölçme ve değerlendirme sürecine ilişkin bilgi ve becerilerin güncel tutulmasında teknolojiden yararlanabilme• Öğretim sürecinin yürütülmesine ilişkin bilginin güncel tutulmasında teknolojiyi etik olarak kullanabilme
	4- Gerçek yaşama ait yenilikleri öğretim süreciyle bütünleştirme	<ul style="list-style-type: none">• Öğretme-öğrenme sürecine destek amacıyla çevrimiçi yeni ortamlardan (facebook, blog, wiki, twitter, podcasting vb.) yararlanabilme• Öğretme-öğrenme sürecinde içeriğin gerçek yaşam örnekleri ile somutlaştırılmasında sanal ortamlardan (laboratuvar, müze, dünya vb.) yararlanabilme
	1- Teknoloji kullanımında erişim hakkına uyma	<ul style="list-style-type: none">• Güncel bilgilerin öğretme-öğrenme sürecine aktarımında kullanılacak teknolojik kaynaklara (yazılım, e-kitap, video vb.) öğrencilerin erişiminde etik davranabilme• Öğretme-öğrenme sürecinde öğrencilerin teknolojik kaynaklardan eşit erişim hakkına uygun yararlanmalarını sağlayabilme• Güncel bilgileri kazandırmaya yönelik hazırlanan bir öğretim ortamını (simülasyon, oyun, CD vb.) öğrencilerin eşit düzeyde kullanmalarını sağlayabilme• Ders içi ve ders dışı etkinliklerde öğrencilerin alana özgü teknoloji kullanımında eşit erişim hakkı sunabilecek şekilde planlama yapabileme

yönelik konuları kapsamaktadır.	2- Teknoloji tabanlı fikri mülkiyet konularına uyma	<ul style="list-style-type: none">• Öğretim materyali tasarlarken kullanılan dijital kaynaklara ilişkin telif haklarını dikkate alma• İçeriğin aktarımında sunum/gösterim yazılımlarından etik kurallara uyarak yararlanabilme• Ölçme ve değerlendirmeye ilişkin lisanslı yazılım kullanımında etik kurallara uyabilme• Öğrenci başarısının ölçülmesinde dijital ortamlardaki ölçme araçlarından (ölçek, anket, test vb.) etik kurallara uygun yararlanabilme• İçeriğin yapılandırılmasında teknoloji aracılığıyla edinilen dijital kaynaklardan etik kurallara uyarak yararlanabilme• İçeriğe ilişkin ölçme aracı hazırlamada teknolojiden fikri mülkiyet konularına uyarak yararlanabilme• Dijital ortamlardan edinilen ve içeriğin sunumunda yararlanılan örneklerin (resim, video, müzik vb.) kullanımında etik kuralların farkında olabilme• Öğretimin planlanması aşamasında gerçek yaşamla ilişkili örnekler hazırlarken kullanılan dijital kaynaklarda fikri mülkiyet konularına uyabilme• Öğretme-öğrenme sürecine ilişkin pedagoji ve içerik bilgisinin güncel tutulmasında teknoloji aracılığıyla erişilen dijital kaynakları referans göstererek kullanabilme
	3- Teknoloji tabanlı bilginin	<ul style="list-style-type: none">• Gerçek yaşamla ilişkili ölçme aracı hazırlama sürecinde yararlanılan dijital kaynaklardaki bilginin doğruluğunu etik açıdan değerlendirebilme

doğruluđu konularına uyma	<ul style="list-style-type: none">• Öğretme-öğrenme sürecinde gerçek yaşamla ilişkilendirilmiş teknoloji destekli etkinlikler hazırlarken doğru bilgilerin aktarılmasının farkında olabılme• Öğretim sürecinde içeriđe ilişkin bilgi ve becerileri gerçek yaşamla ilişkilendirirken etik açıdan bilginin doğruluđunun farkında olarak teknolojiden yararlanabilme• Öğretme-öğrenme sürecinde öğrencileri güvenilir İnternet kaynaklarına yönlendirebilme• Öğretim sürecinde öğrencilerin dijital kaynaklardaki (İnternet, CD vb.) doğru bilgiye ulaşmalarına rehberlik edebilme
4- Teknoloji tabanlı bilginin gizliliđi ve güvenliđi konularına uyma	<ul style="list-style-type: none">• Teknoloji destekli gerçek yaşam örneklerini kullanırken kişinin tanınmasına neden olacak kişisel veya kurumsal bilgilerin (görüntü, doküman, isim vb.) kullanımını konusunda etik kurallara uyabilme• Öğretim sürecinde içeriđe ilişkin gerçek yaşamda karşılaşılan örnekleri teknoloji aracılıđı ile sunarken özel bilginin güvenliđinin farkında olabılme• Güncel alan bilgisini kazandırmaya yönelik ders dışı etkinliklerin (gözlem, söyleşi, röportaj vb.) teknoloji aracılıđıyla gerçekleştirilmesinde özel bilginin gizliliđi ve güvenliđi konularında öğrencilere rehberlik edebilme• Gerçek yaşam durumlarına yönelik bir etkinlik hazırlarken yararlanılacak özel bilgileri teknoloji aracılıđıyla elde etmede etik kurallara uyabilme

E- PROBLEM ÇÖZME

Bu alan; konu alanı, öğretim süreci ve teknoloji ile ilgili problemlerin çözümüne yönelik öneriler üretme, uygun olanı seçme ve problemlerin

5- Öğretmenlik meslek etiğine dikkat etme

- Güncel bilgilerin yapılandırılmasında öğrencilerin bireysel farklılıklarını dikkate alan teknolojik ortamların etik bir şekilde kullanılmasına rehberlik edebilme
- Gerçek yaşam örnekleri ile zenginleştirilmiş teknoloji destekli ölçme sürecinde etik kurallara uyabilme
- Öğrenci başarısını değerlendirmek için yapılan teknoloji destekli değerlendirme sürecinde etik davranabilme
- Teknoloji tabanlı öğretim sürecinde öğrenci başarısını etik kurallara uygun ölçme ve değerlendirebilme
- Öğrencilerin, öğretim ortamındaki teknolojileri ergonomik kullanmalarını sağlayabilme
- Teknoloji tabanlı öğretim sürecine ilişkin mesleki gelişime açık olabilme

1- Teknolojiye yönelik problemleri çözme

- Öğretim planı hazırlarken güncel alan bilgisini edinme sürecinde karşılaşılan teknolojik problemlere çözüm üretebilme
- Teknoloji tabanlı ortamlarda (WebCT, Moodle vb.) öğretim planı oluşturma sürecinde karşılaşılan teknolojik problemleri çözebilme
- Güncel bilgileri kazandırmaya yönelik bir öğretim ortamı (etkinlikler, öğretim materyalleri vb.) hazırlamak için kullanılan teknolojilerde karşılaşılan problemlere alternatif çözümler üretebilme
- Gerçek yaşamla ilişkili etkinlikler hazırlarken karşılaşılan teknolojik problemlere çözüm üretebilme

çözümünü kapsamaktadır.	<ul style="list-style-type: none">• Öğretim materyali tasarlarken kullanılan dijital kaynakların gereksinime uygun olarak düzenlenmesinde karşılaşılan problemleri çözebilme• Gerçek yaşamla ilişkili ölçme aracı hazırlamada karşılaşılan teknolojik problemlere çözüm üretebilme• Öğrencilerin alan bilgisini güncel tutmada kullanılan teknolojilerde karşılaşılan problemleri çözebilme• Öğretimin gerçekleştirilmesi sürecinde kullanılan teknolojik araçlarda ortaya çıkabilecek olası sorunları çözebilme• Güncel alan bilgisini kazandırmaya yönelik ders dışı etkinlikler (ödev, gözlem, söyleşi vb.) gerçekleştirmede teknolojiden yararlanırken karşılaşılan problemlere alternatif çözümler getirebilme• Teknoloji tabanlı ortamlarda (WebCT, Moodle vb.) gerçekleştirilen öğretim sürecinde karşılaşılan teknolojik problemlere çözüm üretebilme• Öğretimin ölçülmesi ve değerlendirilmesine ilişkin teknolojilerin kullanımında karşılaşılan problemleri çözebilme
2- Öğretim sürecine yönelik problemleri çözme	<ul style="list-style-type: none">• Öğretim sürecinde gerçek yaşam örnekleri sunarken karşılaşılan problemlere teknoloji aracılığı ile alternatif çözümler getirebilme• Öğrencilerin ölçme değerlendirme sürecinde karşılaştıkları problemleri açıklamada teknolojiden yararlanabilme• Öğretme-öğrenme sürecinde ortaya çıkabilecek problemleri çözmede teknolojiden yararlanabilme

Bu alan;
öğretmenlik
mesleği alanında
uzmanlaşarak
teknolojinin
içerik ve pedagoji
ile
bütünleştirilmesi
konusunda
çevresine liderlik
yapabilmeyi
kapsamaktadır.

3- İçerik bilgisine
yönelik
problemleri
çözme

- İçeriğin yapılandırılmasında karşılaşılan problemlere çözüm üretebilmede teknolojiyi kullanabilme
- Kavram haritalarının geliştirilmesinde karşılaşılan problemlere teknoloji aracılığı ile çözüm üretebilme
- Kavram yanlılığı problemlerinin çözümünde teknolojik araçlardan yararlanabilme
- Eski ve yeni öğrenmeler arasında ilişki kurmada karşılaşılan problemlerin üstesinden gelmede teknolojiden yararlanabilme
- Yeni öğrenmeleri farklı alanlara transfer etmede karşılaşılan problemleri teknoloji aracılığı ile çözebilme

1- Konu alanı
uzmanlığını
kullanarak liderlik
yapabilme

- İçeriğin aktarımı sürecinde karşılaşılan problemlerin çözümü için teknolojiden yararlanma konusunda meslektaşlarına rehberlik yapabilme
- Kurumunda alanıyla ilgili yürütülen teknoloji entegrasyonu sürecine yönelik stratejileri değerlendirebilme
- Disiplinler arası işbirliği yaparak teknoloji entegrasyonu politikaları geliştirme sürecinde yer alabilme
- Alanıyla ilgili teknolojik yenilikleri takip ederek, bu yeniliklerin öğretim sürecinde kullanımının yayılmasına liderlik yapabilme

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