PRE-SERVICE SCIENCE TEACHERS' TPACK EFFICACY LEVELS AND TECHNOLOGY INTEGRATION QUALITY: APPLICATION OF TPACK-IDDIRR MODEL

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ABSTRACT

PRE-SERVICE SCIENCE TEACHERS' TPACK EFFICACY LEVELS AND TECHNOLOGY INTEGRATION QUALITY:
APPLICATION OF TPACK-IDDIRR MODEL

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Nowadays, teachers have a great responsibility in developing and updating their technology knowledge and competences, because in an environment where technology affects education so much, the way to achieve the desired objectives in lessons is to integrate technology into the classroom environment effectively. The purpose of the current study was to investigate the technological pedagogical content knowledge (TPACK) development in terms of TPACK efficacy levels and technology integration qualities of pre-service science teachers enrolled science methods course enhanced by the application of the TPACK-IDDIRR Model. The participants of the study were 57 undergraduate students from Elementary Science Education department. Data sources included the TPACK-Deep survey in order to evaluate the TPACK efficacy levels, lesson plans and micro-teaching observations in order to evaluate the technology integration qualities of pre-service science teachers. In the study, it was observed that the TPACK efficacy levels and technology integration of pre-service science teachers was raised considerably after the science methods course and in order to determine such increase was significant or not statistical analysis were applied. The statistical analysis revealed that the science methods course enhanced by the application of TPACK-IDDIRR model had positive effect on pre-service science teachers in terms of both TPACK efficacy levels and technology integration quality.

Keywords: TPACK, TPACK-IDDIRR Model, Pre-Service Science Teachers, Information and Communication Technology (ICT), Development Study

ÖZ

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ TPİB YETERLİK DÜZEYLERİ
VE
TEKNOLOJİ ENTEGRASYON NİTELİKLERİ:
TPACK-IDDIRR MODELİNİN UYGULANMASI

Atakan, İskender
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Günümüzde öğretmen adayları teknoloji bilgi ve yeterliliklerini geliştirme ve güncelleme konusunda büyük bir sorumluluğa sahiptirler, çünkü teknolojinin eğitimi bu denli etkilediği ortamda, derslerde istenilen sonuçlara ulaşmanın yolu teknolojiyi etkili biçimde sınıf ortamına entegre etmekten geçmektedir. Bu çalışmanın amacı TPACK-IDDIRR modeli ile zenginleştirilmiş fen bilimleri metot dersine kayıt yaptırmış öğretmen adaylarının TPİB gelişimlerini, TPİB yeterlik düzeyleri ve teknoloji entegrasyon nitelikleri açısından incelemektir. Araştırmanın katılımcıları İlköğretim Fen Bilgisi öğretmenliği bölümünden 57 lisans öğrencisinden oluşmaktadır. Veri kaynakları ise öğretmen adaylarının TPİB yeterliklerini değerlendirmek amacıyla kullanılan TPACK-Deep ölçeğini ve teknoloji entegrasyon niteliklerini değerlendirmek amacıyla kullanılan ders planlarını ve mikro-öğretimleri içermektedir. Araştırmada fen bilimleri metot dersinden sonra öğretmen adaylarının TPACK yeterliklerinin ve teknoloji entegrasyon niteliklerinin önemli ölçüde yükseldiği gözlemlenmiştir ve bu artışın istatiksel olarak anlamlı olup olmadığına karar vermek amacıyla istatiksel analizler uygulanmıştır. Uygulanan istatiksel analizler, TPACK-IDDIRR modelinin uygulanmasıyla zenginleştirilmiş fen bilimleri metot dersinin, öğretmen adaylarının hem TPİB yeterlik düzeylerinde hem de teknoloji entegrasyon niteliklerinde olumlu etkisi olduğunu ortaya koymuştur.

Anahtar Kelimeler: TPAB, TPACK-IDDIRR Model, Fen Bilgisi Öğretmen Adayları, Bilgi ve İletişim Teknolojileri (BİT) Gelişim Çalışması,

To Us

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LIST OF ABBREVIATIONS

ICT	Information and Communication Technology
TPACK	Technological Pedagogical Content Knowledge
LBD	Learning by Design
TPACK-IDDIRR	TPACK-Introduce, Demonstrate, Develop, Implement and Reflect
TIAR	Technology Integration Assessment Rubric
TIOI	Technology Integration Observation Instrument

CHAPTER 1

INTRODUCTION

In this chapter, it is given a brief information to introduce the present study. As a beginning, with the background of the study, the problem statement is presented. Secondly, the current study's objectives with the research questions and the significance are explained. Lastly, the definitions of the key terms and the acronyms of these terms are presented.

1.1. Background of the Study

Technology always had an influential place in human life throughout history. When we looked at industrial revolutions that changed the direction of humanity in history, technological developments lie at the heart of all of them. For instance, the "first industrial revolution" occurred when steam powered machines entered human life. This was followed by the "second industrial revolution" with the discovery of electricity and the use of electric based technologies. In the "third industrial revolution", in other words, in the digital revolution, with the introduction of computers into our lives, the place of technology has advanced a whole new dimension in human life. With the developing computer and information technology, the human being who increased the speed of communication and information has started to give place to it in every field of his life. Eventually, it has become an unavoidable evolving area and started to be integrated in all parts of our lives. Today, people agree that the use of modern technologies is a necessity in every part of life as it improves the quality of life and strengthens communication (Younes & Al-Zoubi, 2015). People handle everything through technology, from the book that they read to banking transactions, the food that they eat to workplace meetings.

Technology has become a necessity rather than a choice. As technology has penetrated so much into human life, and because of the dramatic progress it has made in the last two decades, the concept of third industrial revolution has been inadequate to describe it. Nowadays, it has begun to talk about the fourth industrial revolution.

"The concept of Industry 4.0" or fourth industrial revolution become first publicly introduced in 2011 via a set of representatives from different fields which includes academia, politics and business (Nicoletti, 2018). It is the "concept of smart factories" where machines are enriched by web connectivity and can visualize the entire production chain and decide the process by their own (Marr, 2016). In other words, computers and machines can communicate with each other and direct the production process themselves. The concept based on artificial intelligence, augmented reality, simulation, virtualization and autonomous robots makes people almost out of the process. Eventually, computers and machines could take the workers place. These developments which combine the physical, computerized and natural worlds will change a large portion of our professions (Marr, 2016). In the face of this progress it would be unthinkable that education is not affected by this situation.

Studies have shown that rapid changes in technology also affect the schools and in the learning environment it leads to introduce many multimedia technologies (Pedretti, Smith & Woodrow, 1998). Smart boards, touch computers and tablets which are becoming increasingly popular on schools day by day, are already in almost every class. Besides, in Ally and Perito-Blazquez study (as cited in Krull & Duart, 2017) it is predicted that next generation mobile learning will be everywhere and learners that have capability to learn utilizing more than one device, themselves will become more mobile. This transformation of education cannot be ignored. In order for students to adapt to a world surrounded by intelligent technologies, they need to be educated in a way different from traditional education (Marr, 2019). Yet it needs to be remembered that integration of technology into education can be regarded as double sided sword. It can be a very effective tool when used properly. For instance, it helps to stimulate topics which are difficult-to-understand in learners' minds and it also makes possible to observe the outcomes of phenomena where it is impossible to observe results in real life by accelerating time and creating virtual environments (McCrory, 2008). Moreover, it can lift the borders of a room by making possible to travel among countries or even planets which are difficult to reach. Similarly, Angeli (2005) states that computer demonstrating devices provide investigating the meaning of abstract and theoretical scientific concepts. On the other hand, technology carries some risks if it is not used for its intended purposes. An incredible breadth of knowledge is being reached with technology, which creates information pollution. If the course content is not well planned, it can lead to failure and bring time and economic losses with it. Therefore, it is very important to use technology effectively and appropriately within the classroom.

The way to bring technology and classroom environment together effectively is to train teachers with technology integration competencies. Similarly, Hofer and Grandgenett (2012) indicate that teacher education courses are often considered as the key solution in terms of preparation of pre-service teachers to integrate technology into their educational practices. In this context, universities offer some courses in order to improve the technological competence of pre-service teachers. However, these courses are intended to improve the technological skills of teachers rather than focusing on how teachers effectively integrate technology into the classroom environment. Even though these courses improve the technological efficiency of teachers, they are inadequate to educate teachers to integrate technology effectively into the classroom environment. Similarly, Jang and Chen (2010) emphasize that having advanced technological abilities are not enough for pre-service science teachers to construct effective technologically enriched science lessons. In addition, giving one such course is not enough to prepare teachers to integrate technology effectively (Mishra, Koehler, & Kereluik, 2009). Thus, universities need to offer technology courses which aim to train teachers constructing technology-mediated science lessons in addition to courses aiming to construct technological skills. These courses should combine all components of teachers' knowledge which are subject matter knowledge, pedagogy skills and technology skills (Angeli & Valanides, 2009).

The problem with the training of teachers who can use the technology successfully in their lessons is not only the lack of the adequate courses but also the inadequacy of theoretical domains in this subject. "A few of those problematic issues were ascribed to the absence of a hypothetical base about the place that the technology remains in teaching" (Archambault & Barnett, 2010). For all these reasons, interest in this area has increased among the academic environments and researchers with the 2000s. As new technologies joined to the classrooms, there is an expanded enthusiasm for the fundamental parts and characteristics of instructor knowledge bases essential for integration technology fruitfully (Kurt, 2012). In a similar way, Agyei and Voogt (2012) stated that aggregation of technology into education has progressively turned into a vital worry among scholars. Thus, knowledge of technology became another important knowledge base and it created a need for development of new theoretical framework (Angeli & Valanides, 2008).

In order to describe the interplay and intersections among "pedagogical knowledge", "content knowledge of teachers" and how to integrate technology into teaching, "Technological Pedagogical Content Knowledge (TPACK)" was developed from Shulman's (1987) "pedagogical content knowledge (PCK)" model (Koehler & Mishra, 2008). TPACK framework provides a guideline for understanding how teachers might use their technological knowledge and mediate effective technology integration into classrooms (Harris, Mishra & Koehler, 2009). Additionally, the framework promises a solid base for researchers making studies in the area of technology integration. Nevertheless, TPACK has some deficiencies in spite of the fact that it guides how the programs' content for teacher education would be and how to approach pre-service teachers. Even though technological knowledge is regarded as distinct knowledge domain, technology definition is not clear in the framework. Similarly, Graham (2011) stated that due to the absence of a clear definition, more than one researcher have endeavored to clarify the definition and extent of the technological knowledge under scrutiny certain in their study by recognizing TPACK. For instance, Angeli and Valanides (2009) came up with ICT-TPACK as a knowledge frame in order to narrow down the technology description with "information and communication technologies (ICT)" and eliminate the confusion about what meant with technology.

ICT-TPCK addresses the TPACK framework as a conceptual basis and in addition to TPACK framework knowledge domains which are "pedagogical, content and technological knowledge", it has context and learners knowledge. It is presented as a strand of TPACK and it is portrayed as the methods knowledge about instruments and their affordances, subject matter, learners, pedagogy and context and it synthesized these knowledge domains into a comprehension of how specific topics which are hard to comprehend by learners (Angeli & Valenides, 2009). ICT-TPCK is regarded as a unique knowledge base for teacher education to develop learning environments enriched by technology.

When we looked at the literature about the technology integration and teacher development studies, design-based activities based on TPACK and ICT-TPCK generally were used. Many studies include activities which were developed in the light of "learning by design (LBD)" approach. Koehler and Mishra defined the LBD (as cited in Uygun, 2013) as an TPACK development approach for instructors and learners study as groups to discover ideal answers for poorly organized technology problems such as developing an online course. One of the most suitable environments for all these activities is the method courses integrated with appropriate TPACK development model. Similarly, Nies (2008) supports the idea that methods courses create the best learning environment for engaging pre-service teachers by connecting them with TPACK perception. Since these courses give them an opportunity to be aware of the approaches and strategies by focusing the background and prior knowledge of the students.

In the current study an instructional design model based on TPACK which is called as “TPACK-IDDIRR (Introduce, Demonstrate, Develop, Implement, Reflect, and Revise)” is embedded into science methods course in pre-service teacher education program, because teachers are the most important agent that will place educational technologies into the classroom environment. This means that graduating pre-service teachers with high TPACK qualifications from universities will make it easier to reach the desired achievements. The way to train teachers with the required competencies is through the development of well-planned courses and appropriate development models. TPACK-IDDIRR Model serves as an applicable framework and represents applicable strategies that can be utilized as a part of technology integration lesson with a purpose to develop pre-service teachers TPACK (Lee & Kim, 2014).

1.2. Purpose of the Study

It has become a necessity to closely follow up technological developments in order to make progress in many areas. Given the fact that children are using technology from early age, it is very important to include them in the educational process through technology and to enable them to access technology-enriched teaching environments. Especially in the science classes, the use of technology has a very critical precaution. Science classes are the natural environments in order to use technology due to the majority of science depending technology today (McCrory, 2008). Teachers, who have a great responsibility in the development of technology related skills and in achieving the desired results, are also required to educate themselves according to the conditions of the age and to update their existing technological competences with appropriate courses in the university.

The current study specifically aiming to investigate the TPACK development of pre-service science teachers who are enrolled in a course called science methods course enhanced by the integration of the TPACK-IDDIRR (Lee & Kim, 2014) model. In addition, the study proposes a TPACK development program designed according to the selected model for pre-service teachers with the aim of enriching the classroom environment with technology effectively and provide them with the opportunity to experience how technology is used in science lessons. In this regard the research questions of the present study are:

1. What are the effects of Science Methods Course enhanced by the application of the TPACK-IDDIRR model on pre-service teachers' TPACK efficacy levels?

2. What is the effect of Science Methods Course enhanced by the application of TPACK-IDDIRR Model on pre-service science teachers' quality of technology integration in their lesson plans?

    a. What is the quality of technology integration of unrevised lesson plans prepared by per-service science teachers with respect to different teaching methods of science?

    b. What is the quality of technology integration of revised lesson plans prepared by per-service science teachers with respect to different teaching methods of science?

    c. Are there any significant differences between the technology integration qualities of lesson plans prepared by pre-service science teachers with respect to different teaching methods of science?

3. What are the pre-service science teachers' technology integration qualities in practice in the Science Methods Course enhanced by the application of TPACK-IDDIRR Model in practice?

1.3. Significance of the Study

The world undergoes a significant change with the effects of technological transformation occurring at the global level since the last quarter of the twentieth century. This technological transformation affects not only macro level structures like economy, military and society but also micro level structures such as schools, classrooms or student and teachers. The technological tools in the classrooms are increasing day by day. Similarly, Brenner (October, 2015) stated that technology is turning into an undeniably vital piece of the classroom, with 93 percent of educators now utilizing some kind of technological tools to lead instruction. However, increasing the technological tools in classrooms do not guarantee that the effectiveness of teaching and learning will increase. In other words, technological tools in the classroom are not enough by itself to effective learning environment. Effectiveness of teaching with technology still depends on teachers (Koehler & Mishra, 2008). Thus, Angeli and Valanides (2008) suggest that teachers demand to gain new skills and techniques to integrate technology into lessons and change their traditional teaching. In this context, technological competence has begun to be seen as one of the qualifications teachers must have. For instance, "National Science Teachers Association (NSTA)" published the standards for pre-service science teacher preparation in 2012 as:

- Understand the supporting part of particular technology in science
- Include applications of particular technologies in science into lessons when suitable
- Select and outline learning exercises, instructional resources including particular technologies in science to accomplish the objectives

All these reasons reveal that there is a necessity of research and course about how to train pre-service teachers with required skills of integrating technology effectively into teaching. However, these courses should be well planned and structured in order to provide expected competencies to the pre-service teachers. As skill based courses are usually planned in segregation from a pedagogical context, they are insufficient for getting ready teachers to instruct with technology effectively (Angeli & Veletsianos, 2010). On the other hand, teacher training programs are assumed a basic part to get ready future instructors to turned proficient in the integrative of technology under those educational module (Kurt, 2012). Therefore, many TPACK development studies have done by pre-service teachers in the last decade. However, majority of the development studies do not focus on different science methods course (inquiry, demonstration, etc.). Similarly, Abbit (2011) emphasized that few studies have analyzed TPACK via an upgraded method course that uses different ways to deal with measure the apparent learning and ability (as cited in Price, 2013). Unlike other studies, present study focuses on the major science teaching methods or strategies as well as technology integration. In this regard, current study has a significant potential for pre-service teachers to acquire the qualifications required in the TPACK development and well-planned science lesson.

One of the important needs in TPACK studies is the search for the right model, which provides researchers building their studies and the teachers increasing their TPACK. For information and communication technologies to be effectively integrated into the education and training environment, teachers with these competencies need to be trained. For instance, Bilici, Guzey and Yamak (2016) stated that their work emphasized the requirement of continued researches in order to investigate the development of TPACK. This is only possible through trained teachers using the right methods and models. In addition, researchers have often remarked these points in their studies. Abitt (2011) emphasized that there is a general requirement to develop and evaluate TPACK development programs in order to give extra information to the field. Considering all this, the importance of present study is increasing, because the qualification of the TPACK-IDDIRR Model (Lee & Kim, 2014) is also investigated in this study. Moreover, the model in the current study implemented to the pre-service science teachers, unlike the other studies with TPACK-IDDIRR Model administered to pre-service teachers from multiple disciplines.

Contrary to majority of other TPACK development studies, current study limits technology as “Information and Communication Technology (ICT)”. There are several reasons why ICT tools are considered as technology in the current study. First of all, the definition of technology is a very broad definition, which makes the measurement of technology integration very difficult. Another reason is that each unit in education has been interacting with ICT tools as never before. In this respect, the importance of raising teachers with ICT qualifications has increased considerably in the last decade. As supported by the Ghavifekr and Rosdy (2015), ICT skills are needed by teachers in order to implement ICT tools into education and gain confidence levels to operate effectively such tools in instruction. This study promises an important place in the field because of carrying same purpose.

The reports published in recent years also support the need for studies aimed to develop ICT skills in this field. In the OECD TALIS data (2009), educators were approached to rate their improvement requirements for different parts of their work, and numerous instructors report needs in particular areas. ICT teaching skills are reported as a high level of need by teachers. As seen in the Figure 1 which represents areas of greatest development need, ICT teaching skills is in the second step after teaching special learning needs students. This data provides us with very important findings and conclusions in terms of the studies in the field. All findings emphasize that teachers need a great deal of ICT skills in their professional lives. In this case, as in this study, the importance of the studies aiming to develop ICT skills is once again emerging.

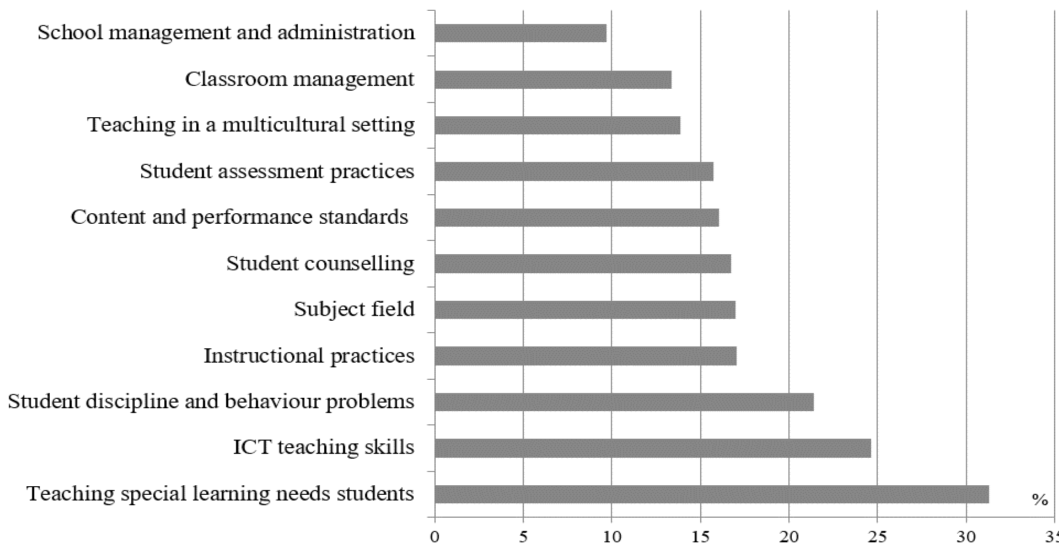

Figure 1. Areas of greatest development need from OECD, TALIS 2009 Database, p. 60

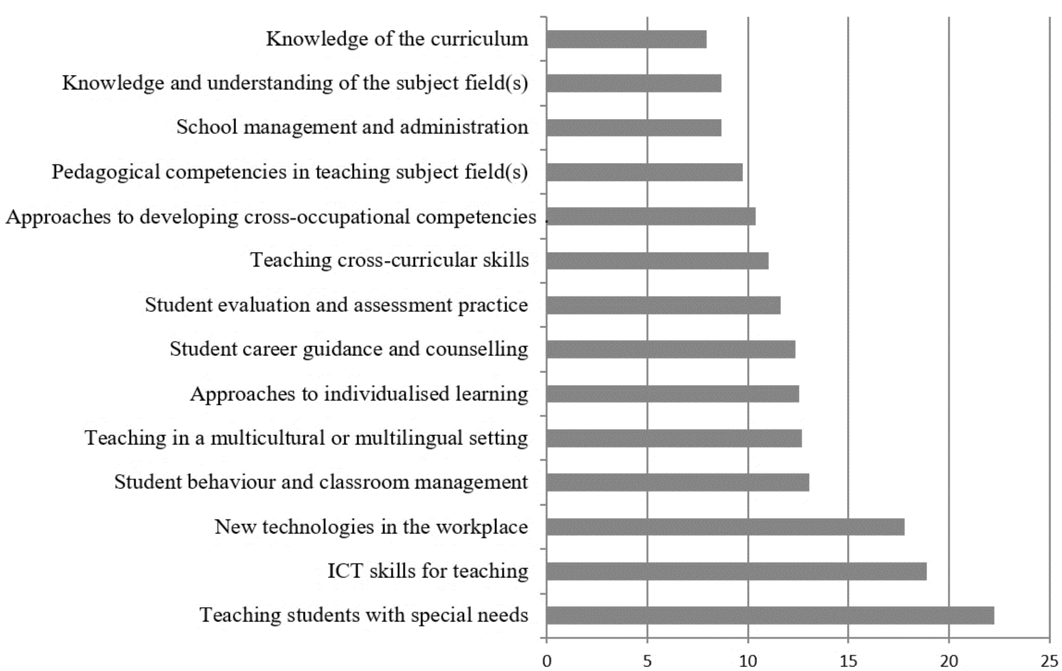

Figure 2. Teachers' needs for professional development from OECD, TALIS 2013 Database, p. 109

Moreover, the data obtained from the 2013 and 2018 results emphasize that such studies should be continued even though significant number of studies have been carried out in the field between 2009 and 2018, because it seems that the needs of teachers to acquire ICT skills were not met. According to the Figures 2 - 3 which obtained from 2013 and 2019 results, ICT skills are still the areas most needed by teachers. Based on these data, the current study has an important potential to meet this obvious need which is gaining ICT skills, as it aims both to increase ICT integration qualities of pre-service teachers and to raise their efficacy levels.

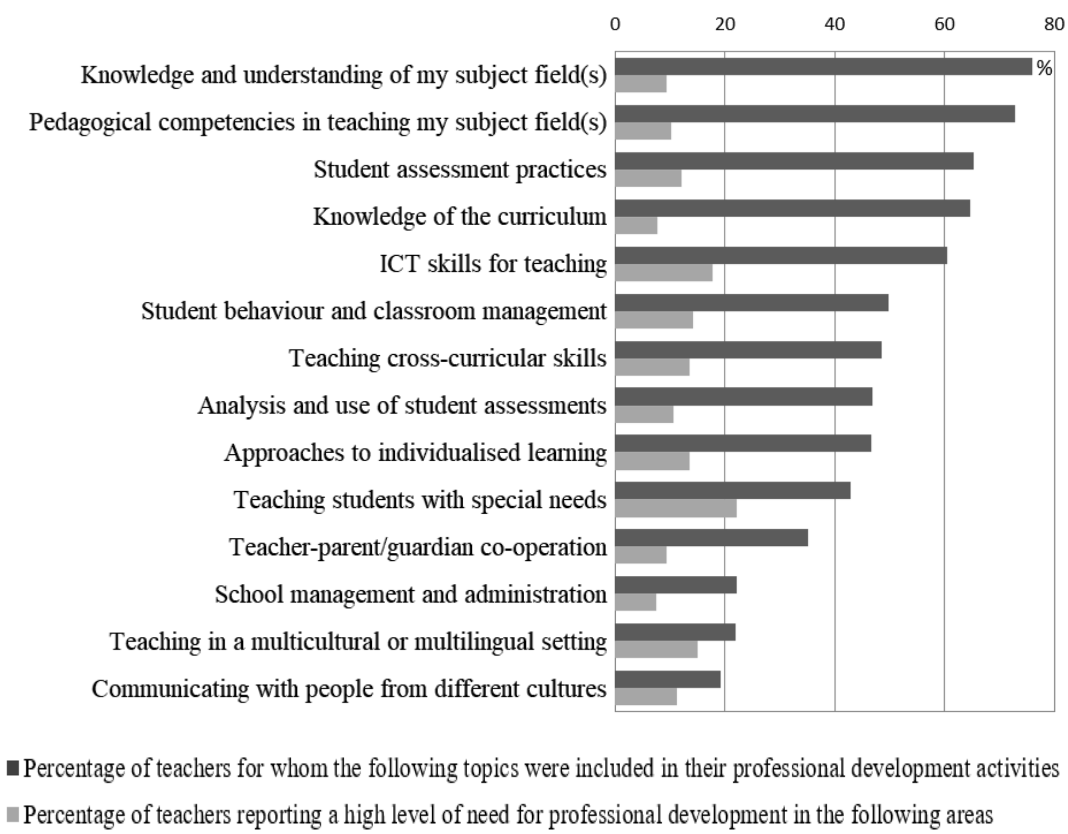

Figure 3. “Participation and need in professional development for teachers” from OECD, TALIS 2018 Database, p. 165

1.4. Definitions and Acronyms

Information and Communication Technology (ICT): It is a collection of visual, auditory and written instruments that are formed by the combined use of computer and communication technologies including cell phones, internet and wireless networks, which provide information access and information production.

Pedagogical Content Knowledge (PCK): According to Shulman (1986), it is the methods for presenting and formulating the topic that make it conceivable to others by the comprehension of what makes the learning of particular subjects simple or troublesome.

Technological Pedagogical Content Knowledge (TPACK): It is a new type of knowledge that is the premise of successful teaching using technology and behoves a comprehension of the portrayal of the concepts via technology and pedagogical strategies that utilize technologies to teach content (Koehler & Mishra, 2008).

ICT-TPCK: The creators, Angeli and Valanines (2009), characterize ICT-TPACK as knowing how ICT and their academic affordances, pedagogy, subject, learners, and setting are synthesized into a comprehension of how specific subjects which are hard to comprehend by students.

TPACK Introduce, Demonstrate, Develop, Implement, Reflect, and Revise (TPACK-IDDIRR) Model: It is an instructional design model that serves as an applicable framework for technology integration lesson constructed with the aforementioned steps of the model and with a purpose to develop pre-service teachers TPACK (Lee & Kim, 2014).

Pre-Service Science Teachers: The students to be trained to join teaching profession in the elementary science education programs of education faculty.

Science Methods Course: The undergraduate program course aims to develop pre-service science teachers' perspectives on different teaching methods of science for effective teaching.

CHAPTER 2

LITERATURE REVIEW

The aim of the current literature review is providing an overall structure for origins of TPACK and literature on TPACK development studies. Firstly, origins of TPACK are presented and then the approaches on TPACK framework are discussed. Later, TPACK development models aiming to improve levels of pre-service teachers in terms of TPACK were introduced. After that the TPACK development studies are summarized to introduce the trends and findings about previous studies. Finally, the results of the other studies in the field using preferred data collection tools in the study were presented.

2.1. Conceptual Framework of TPACK

Throughout history, one of the biggest questions in researcher's' mind was that "what qualifications teachers need to have for a better learning environment?" In this regard Shulman (1986) described the idea of teachers' knowledge for better teaching. He proposed two distinct domains as "content knowledge and pedagogical knowledge". "Content knowledge (CK)" is the subject matter knowledge that includes theories, concepts, ideas, evidences and proofs, and approaches to develop these knowledge (Shulman, 1986). Unlike content knowledge, "pedagogical knowledge (PK)" is a different kind of knowledge that can be defined as knowledge about how to represent or transmit the subject to others comprehensively. Yet, the content knowledge and pedagogical knowledge is not enough for effective teaching.

Shulman (1986) defined "Pedagogical Content Knowledge (PCK)". It arises from the mutual effect of content knowledge and pedagogical knowledge. PCK represents basically what teachers need to know, what they need to do and why they need to do so. According to Shulman "it includes an understanding of what makes the learning of specific topics" (1986, p.9). Moreover, PCK expresses the subject in terms of most useful forms of representation, the strongest analogies, explanations, examples and demonstrations and to express it clearly in order to make the subject understandable to others (Shulman, 1986).

With the years 2000, the rapid changes in technology have also begun to affect the education and it has started to be shown among the competences that teachers need to have. In this context, the "International Society for Technology in Education" (ISTE, 2000) offered new standards of technology for teachers and considered technology as an integral part of learning or academic subject areas. Shulman did not take into account technology knowledge and its relation with other knowledge domains (content & pedagogy), because the technologies used in the classroom such as head projectors, charts, tables from 1980s' conditions up to 2000s could be regarded as ordinary. In other words, the technologies used in the classrooms up to 2000s were stated as "transparent" or commonplace (Mishra & Koehler, 2006).

Researchers have begun to look for a conceptual framework for educational technology, because new technologies have begun to recreate classroom environments and technology has begun to be perceived as one of the competencies of teachers in order to be effective in such environments. Moreover, researches in the educational technology field has been criticized frequently that they are not based on theoretical bases (Mishra & Koehler, 2006). The conceptual grounding was initiated by Pierson's study (2001). In the study technology knowledge was represented as additional domain to the PCK. The study includes both technology competencies and understanding of particular technologies with unique characteristics in teaching and learning processes. Teachers need to benefit from combination of technology knowledge and extensive content and pedagogical knowledge for integrating technology effectively (Pierson, 2001).

The technological pedagogical content knowledge was illustrated as Figure 4 represents the interaction of three types of teacher knowledge. Part A which presents the interaction of technological knowledge and content knowledge could be considered as knowledge of technological resources about content areas. Part B presents the interaction of pedagogical and technological knowledge and it could be considered as knowledge of technology use of the methods of managing and organizing learning. "Part C represents the intersection, or technological-pedagogical-content knowledge, which is true technology integration" according to Pierson's (2001, p. 247) study.

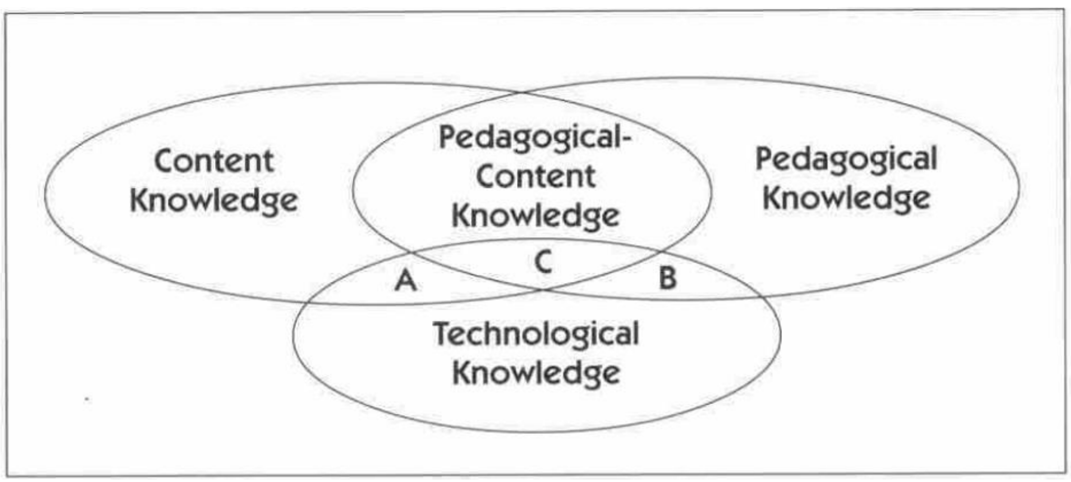

Figure 4. "Relationships among content, pedagogical and technological knowledge" (Pierson, 2001, p. 427).

Angeli & Valanides (2005); Koehler & Mishra (2005); Lee (2005); Margerum-Leys & Marx (2003, 2004); Niess (2005) and Wallace (2004) followed the idea in their researches that suggest similar concepts about technology integration (as cited in Graham, 2011). However, the idea of "Technological Pedagogical Content Knowledge (TPCK)" took its reputation after Mishra and Koehler's study in 2006. "Technological Pedagogical Content Knowledge framework" called TPCK until 2008 in the literature. However, the abbreviation of the TPCK was problematic and it was difficult to say the letters in correct order. Thus, the new abbreviation has become TPACK due to use and remember easily (Thompson & Mishra, 2008).

TPACK framework was constructed on Shulman's (1986,1987) "Pedagogical Content Knowledge (PCK)" model in order to describe the interactions between pedagogical knowledge, content knowledge and technological knowledge of teachers and how to integrate technology into teaching (Koehler & Mishra, 2008). The integrative TPACK model which is put forward by Koehler and Mishra (2008) is generally represented with three overlapping circles as Figure 5 (Herring, Koehler & Mishra, 2009).

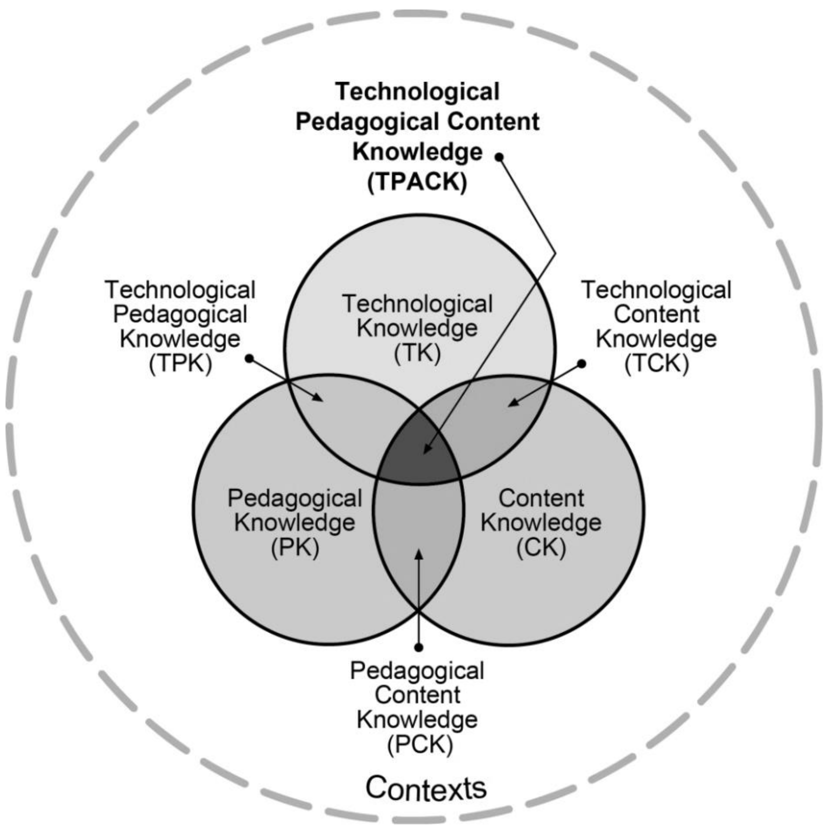

Figure 5. Integrative TPACK Model (from www.tpack.org)

In the model in the Figure 5, TPACK consist of triple combination of main knowledge domains which are CK, PK and TK. Furthermore, three different information fields arise from the binary combination of CK, PK and TK. According to this model pedagogical content knowledge (PCK) is formed from the binary combination of CK and PK; technological content knowledge (TCK) is formed from the combination of CK and TK and technological pedagogical knowledge (TPK) is formed from the combination of TK and PK.

"Content knowledge (CK)" is the knowledge that teachers need to know and understand the subjects to be learned or taught. According to Shulman (1986) concepts, ideas, organizational frameworks, theories, evidences and proofs are included by CK (as cited in Koehler, Mishra & Cain, 2013). Content knowledge has a critical importance for teachers, because the content to be covered for each level is different. In other words, the content to be processed in middle school and content to be processed in high school are different for the same course.

"Pedagogical knowledge (PK)" is knowledge about teaching methods and practices that incorporate all educational values, objectives related to both teaching and learning (Mishra & Koehler, 2006). This knowledge comprises how students learn, development of lesson plans, methods and practices used in class, nature of audience the learning environment and student assessment strategies (Koehler & Mishra, 2008).

"Pedagogical content knowledge (PCK)" emerges from the effective interaction of CK and TK and it is parallel with the definition of Shulman's (1986, 1987) idea of PCK. According to Shulman (1987), PCK can be considered as combination of content and pedagogy in order to understand how particular topics or issues are represented, organized and adapted to learners' different abilities and interests. PCK includes essential of teaching and learning process such as conditions promoting learning and combining curriculum, assessment and pedagogy (Koehler & Mishra, 2008).

It is very difficult to give definite definition to the technological knowledge (TK), because the rapid change in technology is putting the lifetime of the definition at risk. In the integrative model TK defined as knowledge about both transparent or commonplace technologies like blackboards and charts and more developed technologies like internet or digital video (Mishra & Koehler, 2006). This knowledge comprises the required abilities to operate specific technologies like operating computer hardware, using standard software programs (e-mail, spreadsheets, and office programs) (Mishra & Koehler, 2006).

“Technological content knowledge (TCK)” arises from the interplay of technology and content knowledge and can be defined as knowledge on how to convey the content to be expressed to technological tools. Teachers should be aware of which technologies are suitable to the content to be transmitted and how the educational technologies used shape the content or how content shape educational technologies used (Harris, Mishra & Koehler, 2009).

“Technological knowledge (TK)” and pedagogical knowledge (PK) constitute “technological pedagogical knowledge (TPK)” and it can be defined as knowing how the learning and teaching process is affected by the use of various technologies. This knowledge is about knowing the benefits and limitations of technological tools in relation to developmentally appropriate pedagogical designs and strategies. For TPK, it is important to know the constraints of technology, its abilities, and its relation to the course content to which it relates (Harris et al, 2009). Since, most of the software programs are not designed for educational purposes (Koehler & Mishra, 2008), and teachers demand to embed such technological tools to their pedagogical technological purposes for effective teaching environments.

“Technological Pedagogical Content Knowledge (TPACK)”, which consists of the combination of three main knowledge domain and the interactions of pedagogy, content and technology knowledge, is the knowledge of using the related technologies in the classroom environment in terms of meaningful learning of the students. It is seen as an important aspect in the realization of effective learning through the help of technology. TPACK is the base of teaching effectively requires an understanding of presentation of subjects via technology; pedagogical procedures to use technology in order to instruct the concepts; how to use technology to overcome the problems faced by students and the factors that make them difficult or facilitate the concepts; pre-knowledge of students and how technologies can be used to strengthen students' existing knowledge and build new concepts on this knowledge (Koehler & Mishra, 2009).

The TPACK framework has some weaknesses and among the researchers, there is not an agreement about the framework due to several reasons. First of all the framework lacks a theoretical transparency. Even though the TPACK framework has had an influential impact and inspired the researchers in the field, the definitions, and descriptions regarding TPACK are not explicit so far (Cox & Graham, 2009). Another reason is that what is meant by technology is confusing and the concept of technology is not measurable because Koehler and Mishra (2008) do not differentiate the technologies as older (pencil, boards etc.) and new (blogs, multimedia etc.). In other words, since there is no distinction between old and new technologies, everything in the classroom can be counted as technology, which in turn makes the measurability of technology integration very weak. Similarly, Graham (2011) stated that current literature in the field confirm that TPACK definitions lack clarity and what is implied by technological knowledge is a case of absence of clearness in the TPACK framework.

It is very important to note that technology knowledge does not have a single correct definition. In some resources it is defined as the knowledge of any technology and in some resources it is limited to the knowledge of digital technologies (Voogt, Fisser, Robin, Tondeur & van Braak, 2013). Some models have been proposed by researchers in order to limit and clarify the concept of "technology", because the description of technology in the TPACK framework is not clear. For instance, Lee and Tsai (2010) proposed the term Technological Pedagogical Content Knowledge-Web (TPCK-W) with the purpose of examining knowledge of educators in Web-based instruction. It is claimed that in order to integrate Web-based teaching into educational environments effectively, educators and teachers need to gain TPCK-W competencies which is the essential knowledge domain to combine educational purposes and pedagogies about Web technologies (Lee & Tsai, 2010).

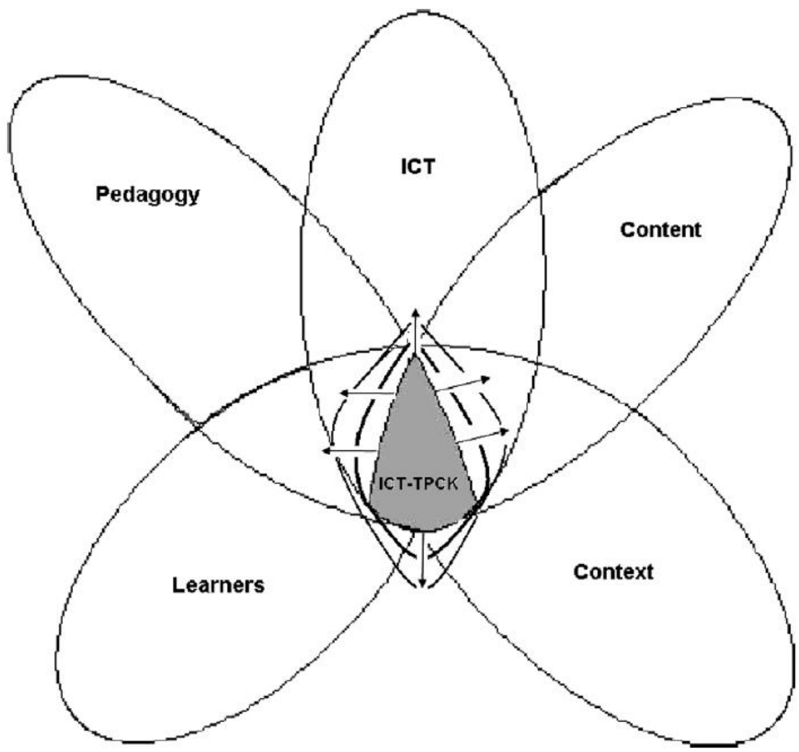

Figure 6. “ICT-TPCK” (Angeli & Valanides, 2009, p. 159)

In the other study aimed to limit the scope of technology Angeli and Valanides (2009) proposed a model named ICT-TPCK that focusing the information and communication technologies (ICT). It can be considered as a body of knowledge that makes the teacher competent in the preparation of technologically mediated learning environments. ICT-TPCK can be described as the ways in which knowledge is taken into account in different areas such as learners, content, context, ICT tools used and their pedagogical competences (Angeli & Valanides, 2009). In other saying, ICT-TPACK can be regarded as a unique body of knowledge which come into existence from the synthesis of knowledge bases which are pedagogy, ICT, content, context and learners as shown in Figure 6.

To sum up, researchers have always aimed to answer the question of what kind of competences teachers need to have for a better educational environment. In this respect, they have formed more than one conceptual framework. Shulman proposed the PCK framework in 1986 in order to define the teachers' required knowledge to create effective learning environments. Thereby, the ideas about the qualifications that teachers should have in the field were put on the theoretical basis and have been studied by the educational researchers for many years. By the 2000s, rapid changes in technology and new developments began to affect education. Therefore, it became clear that teachers should be component in technology. In 2005, Mishra and Koehler added technology knowledge domain to PCK definition and TPCK concept emerged. After that although the concept of TPACK was popular in the field in a short time, there were also highly discussed aspects. The most important of these was that it could not clearly explain the technology. Therefore, more than one researcher has introduced technology restrictive models like TPACK-W (Lee & Tsai, 2010) and ICT-TPCK (Angeli & Valanides, 2009) to clearly emphasize technology. In the present study, technology also restricted as ICT.

2.2. TPACK Development Models

Due to the complicated nature of TPACK, it was observed that multiple developments models have been developed in the literature. When the studies were grouped, it could be said that in most of the studies "Learning by Design (LBD)" approach was used. The LBD approach has been described by Koehler and Mishra (2005) where teachers learn about technology integration into educational environment via participating in authentic design tasks with small collaboration groups. Moreover, Koehler, Mishra, Hershey and Peruski (2004) and Koehler and Mishra (2005) stated that the activities used in LBD approach help teachers deeply understanding the connections among content, pedagogy and technology (as cited Uygun, 2013, pp.19). Therefore, this approach contributes to TPACK development as it enables teachers to discover both the beneficial and problematic aspects of educational technologies and helps them develop alternative ways of thinking about learning, technology and design (Koehler & Mishra, 2005).

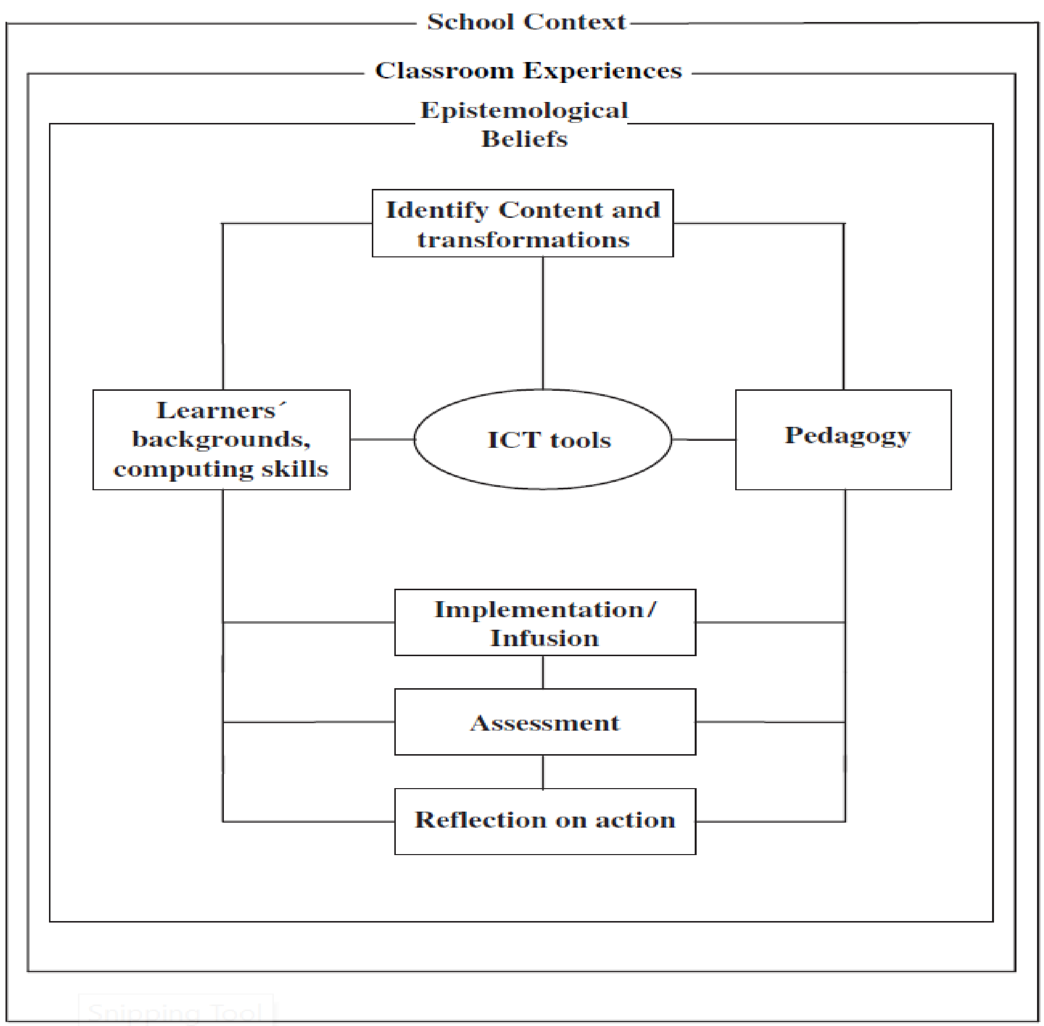

Figure 7. ISD Model (Angeli & Valanides, 2005, p.298)

In addition to the studies using LBD approach, specialized models based on the same approach have been developed in the literature. The Instructional Design (ID) models used to redesign the educational courses by enriching with technology for teacher education (Angeli, 2005). One of the models created for similar purposes is the instructional system design (ISD) model (Angeli & Valanides, 2005). The ICT-based PCK competences of the pre-service teachers were aimed to be developed with the ISD model which can be adapted to various courses such as methods courses or educational technology courses (Angeli & Valanides, 2005). The Figure 7 representing the model is given.

According to the model, firstly the subject to be taught should be determined. Afterwards, ICT tools are selected considering the characteristics of the learners and instructional strategies and the lesson plans should be implemented. Lastly the reflections are given in order to revise the lesson plans. The model following the above steps was reported by Angeli and Valanides (2005) to be effective in ICT-based PCK improvement of pre-service teachers.

Another model that focuses on the TPACK improvement of pre-service teachers is "TPACK Comprehension, Observation, Practice and Reflection (TPACK-COPR) model" (Jang & Chen, 2010). The representation of TPACK-COPR model which is a transformative model is shown in Figure 8.

As seen in Figure 8, the TPACK-COPR model is a cyclical model and in the first step, pre-service teachers become familiar with the TPACK framework and related concepts. Then, the example teachings demonstrated by experienced teachers are observed by the pre-service teachers and important points are noted. In the next step, technology-enriched lesson plans are prepared by pre-service teachers, prepared lesson plans are presented, and peer evaluations are performed respectively. In the last step, the performances of the pre-service teachers are evaluated, and suggestions are given (Jang & Chen, 2010).

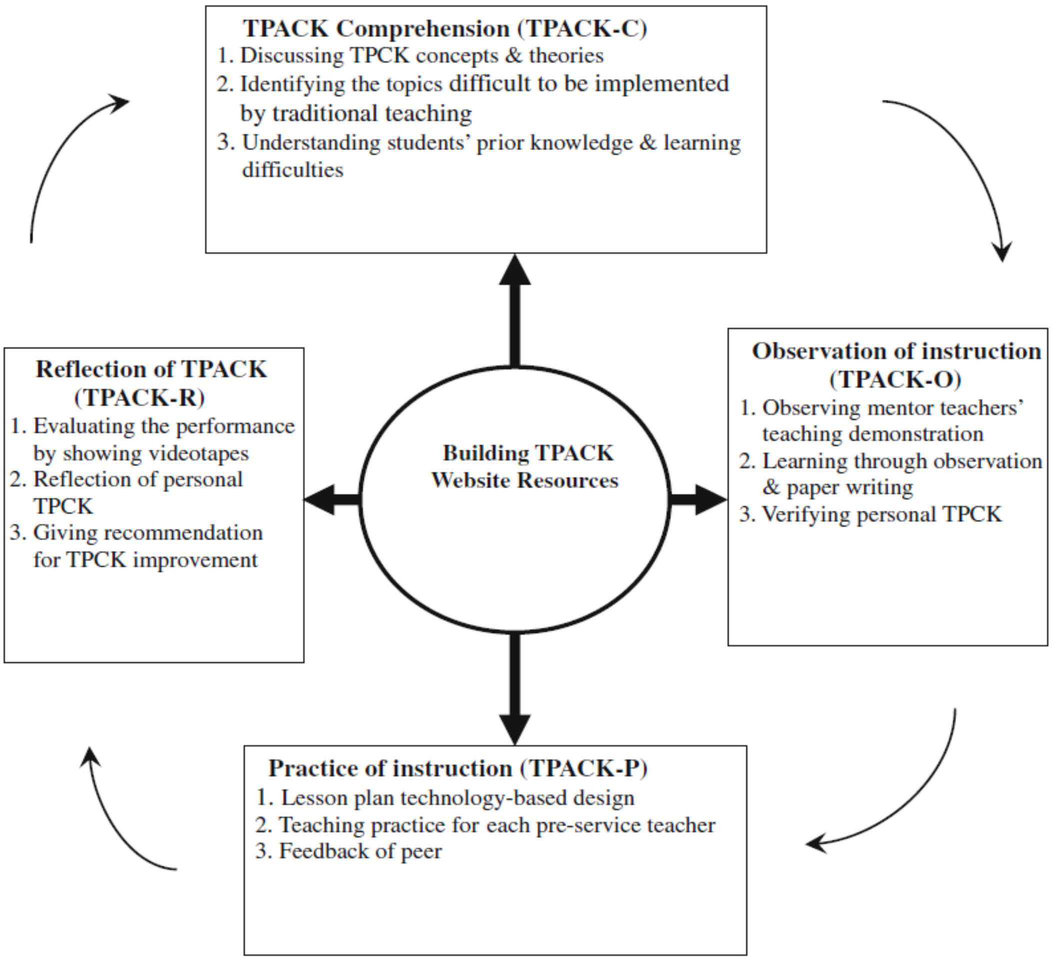

Figure 8. “TPACK-COPR model” (Jang & Chen,2010, p.556).

“TPACK-IDDIRR (Introduce, Demonstrate, Develop, Implement, Reflect, and Revise) model,” which is an ID model used in the current study, was created as a result of reviewing, comparing and synthesizing the obtained information from the “Angeli and Valanides’ ISD model (2005)” and “Jang and Chen’s TPACK-COPR model (2010)” as presented above. The representation of the functional structure of the model and the relationship between the steps to be followed is given in Figure 9.

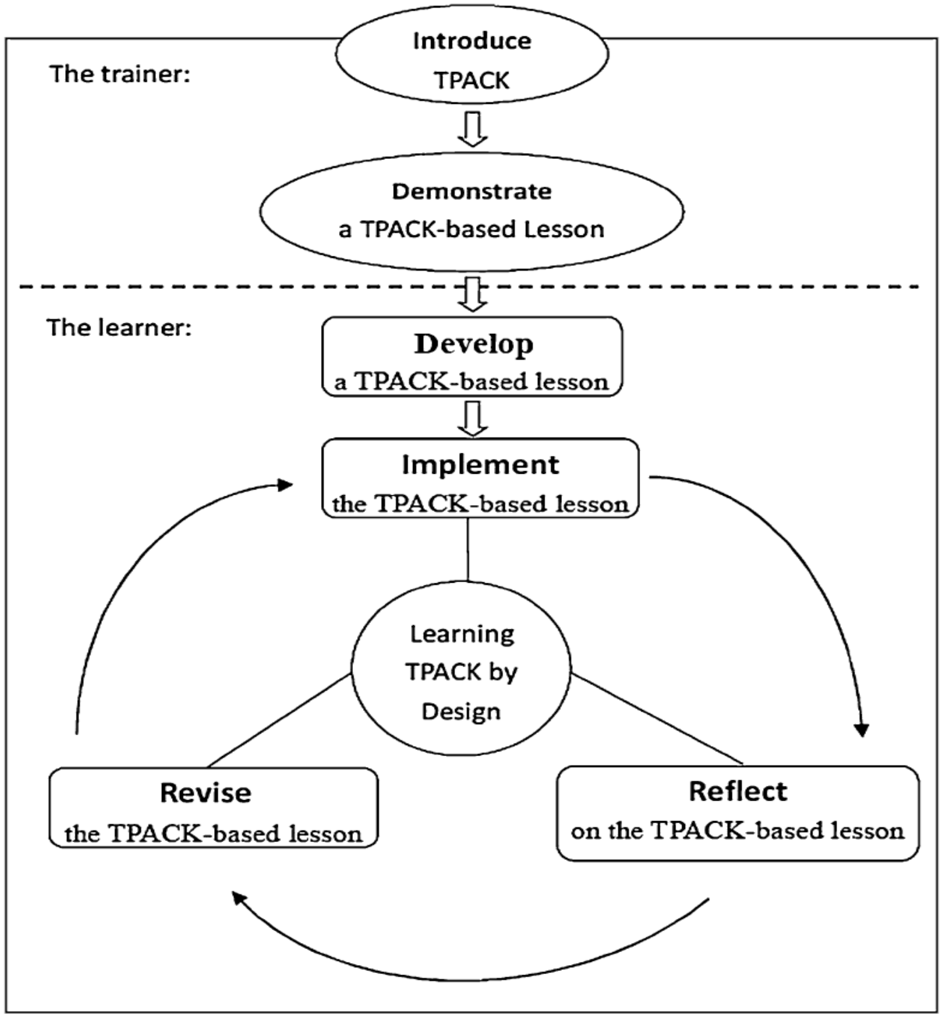

Figure 9. The TPACK-IDDIRR Model (Lee & Kim, 2014, p.444)

In the first stage (*Introduce*) of the model, the TPACK framework is described to the pre-service teachers and the conceptions related to the framework was presented them primarily. After the first stage is completed by the trainer, a sample lesson prepared within the framework of TPACK is presented to the pre-service teachers in order to develop their TPACK comprehension (*Demonstrate*). In the stages after the first and second stages, the pre-service teachers take an active role as a requirement of the model. The pre-service teachers first form small collaborative groups and prepare a lesson plan in accordance with the TPACK framework considering acquisitions in the first two stages (*Develop*). In the *Implement* stage, a pre-service teacher from each group make a micro-teaching based upon prepared lesson plan and other group's members take student role. Afterwards, the effective and ineffective parts of the demonstrated lessons are discussed, and the reflections of the groups are shared *(Reflect)*. In the last stage of the model (Revise), pre-service teachers review the ineffective parts of the lesson plans and revise them in accordance to the reflections. The cycle of the model continues until each pre-service teacher completes the process.

When the outcomes of the studies in which the mentioned models were revealed, were examined, similar results were reported. Based on the outcomes of the study in which ISD model was established, Angeli and Valanides (2005) reported that the model was effective and contributed to the development of ICT-related PCK of pre-service teachers. Likewise, Jang and Chen (2010) stated that TPACK-COPR model they developed was promising model in the development of TPACK of the pre-service teachers. Finally, in the study conducted by Lee and Kim (2014) for the development of TPACK-IDDIRR model, it was emphasized that the model contributed to determining practical difficulties and identifying the necessary steps to overcome the difficulties.

2.3. Relevant TPACK Studies

To begin with, the TPACK development studies were reviewed and settings, general purposes, data collection and statistical analysis processes and results of the reviewed studies were presented. Later, the studies, which were conducted to measure efficacy levels using various questionnaires, reviewed and the information obtained was presented. Afterwards, the studies examine the technology integration quality via both lesson plans and micro-teaching observations were grouped and the information obtained them were included.

2.3.1 TPACK Development Studies

Due to the compliceted character of TPACK framework, it was observed that multiple development studies with various development models have been conducted in the literature. The first study conducted to develop technology integration levels was Angeli and Valanides' (2005) study. In this study, using "Instructional System (ISD)" model, it was aimed to develop ICT-based PCK of pre-service teachers. In the study which was conducted with 116 participants, an experimental design with three iterative stages was used. As a necessity of the model, pre-service teachers were asked to select a topic and appropriate ICT tools and design an ICT based lesson respectively. The lessons need to be designed student centered. Then, ICT based lessons are evaluated with respect to four aspects (Identification of topic, Identification of instructional strategies, Selection of appropriate ICT tool, Infusing ICT activities in classroom) and reflections were given. The lessons assessed as they get "1" point, if topic selected by pre-service teachers, if not they get "0" from the evaluation. Two independent raters evaluated all the lessons and descriptive statistics were used to determine effectiveness of the model. When the data obtained from evaluations in three stages were analyzed, it was observed that while pre-service teachers showed poor performances for integrating ICT tools into student centered instructional strategies in the first stage of the experimental design, they showed statistically significant higher performance for using ICT in order to support student centered teaching strategies in the third stage. As a result, it was concluded that, ISD-model was effective in the development of ICT-related PCK of pre-service teachers (Angeli & Valanides, 2005).

Another study was carried out to develop TPACK of pre-service teachers by Jang and Chen (2010) using TPACK-COPR model. Qualitative approaches were used in the study which was carried out with 12 pre-service secondary science teachers for 18 weeks. In the study where the steps of the TPACK-COPR model were followed, firstly the TPACK training was given to the pre-service teachers for the first 4 weeks (Comprehension). TPACK framework, useful resources and tools were presented to the pre-service teachers in the TPACK training. Then in the 5th and 6th weeks, the pre-service teachers were presented sample lessons by experienced mentor science teachers (Observation). From the 7th week to the 16th week, pre-service teachers took active roles. Pre-service teachers developed lesson plans enriched with technology integration and made micro teachings according to the lesson plans (Practice). Lastly, the videotaped micro-teachings were watched in the week 16th and 18th by the pre-service teachers in order to evaluate the teaching performance. The feedbacks and reflections were shared according to evaluations (Reflection). According to the findings obtained during the whole process, it was stated that observation of the mentor teachers was effective. In addition, the TPACK-COPR model provided opportunities to pre-service teachers to experience technology integration with different tools and instructional strategies or pedagogies. Moreover, it was reported that pre-service teachers agreed on that they developed their TPACK and technology integration abilities. As a results, it was concluded that the study provide empirical evidences that TPACK-COPR model have positive effect on pre-service teachers TPACK levels (Jang & Chen, 2010).

In different study, Graham, Burgoyne, Cantrell, Smith, Clair and Harris, (2009) investigated the in-service teachers' TPACK development in terms of TPACK confidence levels. For this purpose, they constructed a questionnaire which measures the confidence levels of in-service science teachers regarding four construct (TK, TPK, TCK and TPACK) of TPACK framework. 15 in-service teachers attended a development program in the study called SciencePlus. Firstly, interactive instruction was given to the in-service teachers and then in-depth study was conducted with them on selected science topic. The final stage was the development program was giving teachers opportunity to develop, present and reflect on science topics selected. In the study, the constructed questionnaire was implemented to the in-service teachers before and after the development program. According to the results obtained from pre-test post-test design, there was a significant improvement between pre-test confidence levels and post-test confidence levels in all of the constructs which are TK, TPK, TCK and TPACK (Graham et. al., 2009).

Chai, Koh and Tsai (2010) conducted a TPACK development study with 889 pre-service teachers. They examined the TPACK development with experimental design before and after ICT course. In order to collect data, they re-designed the questionnaire developed by Schmidt, Baran, Thompson, Koehler, Mishra and Shin (2009). The re-designed questionnaire was composed of 18 items with 7 points likert scale ranging from strongly disagree (1) to strongly agree (7). After they took the pre-test and post-test scores, they applied t-test to evaluate the effectiveness of ICT course and TPACK development of pre-service teachers. According to the results, there was a significant increase with effect size in good level, which means that the ICT course had significant effect on TPACK development of pre-service teachers and on technology integration abilities.

A case study with the aim of investigating pre-service science teachers' TPACK development after constructing digital storytelling was carried out with 21 pre-service teachers by Sancar Tokmak, Surmeli and Ozgelen (2013). The digital storytelling process was composed of 4 stages that firstly pre-service teachers wrote stories based on science topics. Then, they select related pictures and matched the stories with selected pictures. Lastly, they developed digital files. During the stages feedback was given to the pre-service science teachers. The data collected via demographic questionnaire (gender, age, GPA etc.), open-ended questionnaire, interviews and observations. After the data were analyzed, it was suumarized that while pre-service science teachers had trouble in writing science-based stories at first, they showed significant improvement in terms of perceived TPACK. In other words, the digital storytelling process was effective on pre-service science teachers' perceived TPACK (Sancar Tokmak, Surmeli & Ozgelen, 2013).

In a different study, Canbazoglu Bilici, Guzey and Yamak (2016) examined the TPACK development of pre-service teachers in the TPACK-based science methods course via lesson plans and micro-teaching observations. In the study, which 27 pre-service teachers attended, case study methodology was used. Throughout the semester the changes in the lesson plans and micro-teachings of the pre-service teachers were evaluated. According to the results, it has been observed that TPACK-based science methods course had a positive effect on the TPACK levels of pre-service teachers and the course provide pre-service teachers gain technology integration skills in order to effective educational usage (Canbazoglu Bilici et. al., 2016).

2.3.2. The Studies Examine the TPACK Efficacy Levels

The TPACK Deep Scale, which is used to measure the TPACK of pre-service teachers, has identified in multiple studies in the field. When the identified studies were reviewed, it has seen that the scale was administrated to determine the TPACK efficacy of both teachers and pre-service teachers and even academic staff in the university. Even though time to time there were differences in the results obtained from the scale, it could be said that similar results were obtained in general in the reviewed studies.

First of all, if we chronologically list the studies with teachers, Albayrak Sari, Canbazoglu Bilici, Baran and Ozbay (2016) applied the TPACK-Deep Scale to the 483 teachers from multiple disciplines in their study. Regarding the results of the study, the relationship between TPACK competency of teachers in different disciplines and their attitudes towards ICT was examined; teachers considered themselves sufficient in the ethics, exertion, design and proficiency factors of TPACK-Deep Scale respectively. In addition, while there was no significant difference in TPACK competency of teachers with respect to discipline, a positive relationship was found between TPACK competencies and attitudes towards ICT.

In another study conducted with teachers, Coklar and Ozbek (2017) worked with 421 teachers from different disciplines in order to investigate the relation between TPACK competencies of teachers and innovativeness levels of teachers. The results of the study indicated that the relationship between TPACK competency levels and innovativeness levels found to be significant and teachers considered themselves as the most competent in ethics factor and least competent in proficiency factors.

Secondly, “TPACK-Deep Scale” was used to investigate the TPACK competencies of 132 academic staff with respect to several variables in the study of Simsek, Demir, Bagceci and Kinay (2013). According to the results obtained from the study, it was determined that TPACK competency levels of the academic staff were high. In addition, it was reported that TPACK competency levels did not change with respect to gender or title (prof., assoc. prof., etc.), but it showed a significant change in age (under 30, 31-41, 41-50, upper 50) variable.

Finally, TPACK-Deep Scale was found to be used more frequently in the studies conducted with pre-service teachers. Keser, Karaoglan Yılmaz and Yılmaz (2015) conducted a study to compare the TPACK competency levels and self-efficacy of pre-service teachers in technology integration in terms of several variables. TPACK competency levels were found to be high in the study in which students from different disciplines in the 1st and 4th grade of the university participated. However, TPACK competencies of pre-service teachers did not change according to gender, while grade level was reported to be a variable affecting the TPACK competency. Moreover, it was stated that there was a correlation between the TPACK competency level and self-efficacy about technology integration.

Ersoy, Kabakci Yurdakul and Ceylan (2016), another study carried out with pre-service teachers, used the TPACK-Deep scale in an experimental design. In the study, 61 pre-service classroom teachers were applied techno pedagogical training activities and then the results obtained from the pre-test and post-test were evaluated in terms of gender. When the results were examined, there was a significant difference between pre-test and post-test result or training was found to be effective, while there was no difference according to gender.

In the study conducted by Kabakci Yurdakul (2018), TPACK-Deep Scale was applied to 1493 pre-service teachers from multiple disciplines in order to investigate the relationship between "digital nativity" and "TPACK competency levels". According to the results of this comprehensive study, there was a significant relationship between digital nativity and TPACK competency levels. In other words, possible increase in digital nativity will directly influence TPACK competency of pre-service teachers.

Gokdas and Torun (2017) studied with 186 pre-service teachers' TPACK efficacy by using TPACK-Deep Scale. A comparative method was operated in the study which aiming evaluating the effectiveness of "Instructional Technology Material Design (ITMD) courses". When the results of the study were contrasted, it was seen that ITDM course was effective in the development of proficiency, exertion and design factor but not in the development of ethics factor.

In order to decide the efficacy levels of pre-service teachers or in-service teachers not only TPACK-Deep Scale was used, but also some other questionnaires were used in the literature. For instance, Aquino (2015) investigated the self-efficacies of 37 pre-service biology teachers with respect to gender, owning electronic device and accessing internet. In order to determine the self-efficacy levels 37 item was used from the "Technological, Pedagogical Content Knowledge questionnaire" (Schmidt, Baran, Thompson, Koehler, Mishra & Shin, 2009). According to the descriptive survey method results, it was reported that the self-efficacy levels of pre-service teachers affected weakly from gender, owning electronic device and accessing internet variables.

In another study, Wright and Akgunduz (2018) examined the self-efficacy levels of 344 pre-service teachers and relationship between the self-efficacy levels and Web 2.0 (More interactive and collaborative web pages such as Wiki) usage. In order to determine the self-efficacy levels of pre-service teachers TPACK self-efficacy belief scale (TPACK-SBS) developed by Canbazoglu Bilici (2012) was used. According to the results of the study, it was found that there was a significant relationship between self-efficacy levels of pre-service teachers and Web 2.0 applications usage. In other words, self-efficacy levels of pre-service teachers were affected positively from usage of Web 2.0 applications (Wright & Akgunduz, 2018).

2.3.3. The Studies Examine the Technology Integration Quality via Lesson Plans

"Technology Integration Assessment Rubric (TIAR) (Harris, Grandgenett & Hofer, 2010)" has been used to evaluate technology integration quality in lesson plans in multiple studies designed for different purposes in the field (e.g., Lee, Smith & Bos, 2014; Anyasari, 2015; Matty, 2015; Mustafa, 2016; McCusker, 2017). If the reviewed studies presented chronologically, Price (2013) conducted a study investigating the impact of "Integrated Triadic Model (ITM)" with 42 pre-service teachers. For this purpose, the researcher randomly selected %10 of the first and final lesson plans prepared by pre-service teachers and compared the results with respect to 4 criteria of the rubric which were "Curriculum Goals & Technologies, Instructional Strategies & Technologies, Technology Selections and Fit". The results of the study showed that there was no significant raise on the mean scores of all criteria of the rubric. In another saying; the pre-service teachers did not show any observable development in the integration of technology from the first to the last lesson plans.

In another study, the appropriateness of chosen student-centered technological tools was researched by Lee, Smith and Bos (2014). For this purpose, only the first criterion of the rubric ("Instructional Strategies and Technologies") was used. When the results were analyzed, it was observed that the teachers selected the most applicable tools for "Direct Instruction" and "Inductive Thinking" strategies.

However, in selecting applicable tools for "Inquiry" method pre-service teachers showed least performance.

Anyasari (2015) analyzed the effects of a professional development program on teachers' ability to construct lesson plans in the context of TPACK components. There were 12 attendants whose lesson plans were gathered before and after treatment and evaluated with TIAR. According to the study results, it was seen that teachers showed a development in all components of TPACK framework. That's why it can be concluded that the development program which was designed for basic technology integration had a positive effect on teachers to construct TPACK based lesson plans.

In the doctoral thesis conducted by Matty (2015), high-stakes tested subjects and non-tested subject based lesson plans from the perspective of TPACK were compared. When the results were taken into consideration it was stated that there was no difference between teachers in terms of technology integration into high-stakes tested English subjects. Similarly, statistically no difference was found between teachers in terms of technology integration into non-tested tested English subjects. On the other hand, there was a significant difference between both of the teachers who prepared lesson plans according to high-stakes tested science and non-tested science. In addition, according to the results of the t-test that performed to compare the high-stakes tested subjects and non-tested subjects, there was no difference between subjects of high-stakes English and non-tested English, but a statistically significant difference was found between high-stakes tested Science and non-tested Science.

In the study of Mustafa (2016), the effects of experiencing the method of learning cycle (5E Model) on science teachers' TPACK was investigated. In this context, the lesson plans prepared by science teachers evaluated by TIAR and the results were presented via descriptive statistics. According to the results, science teachers showed good performance in two criteria which are Instructional Strategies

& Technology and Fit (Harmony of Technology, Pedagogy and Content), while they showed low performance in Curriculum Goals & Technology criterion.

Finally, the study conducted by McCusker (2017) was a different study compared to other studies reviewed in terms of setting of the study. In the study conducted with K-12 teachers, the lesson plans prepared by the teachers were evaluated with TIAR, and then the teachers were asked to evaluate the lesson plans again with same rubric. According to the results, teachers perceived themselves as performed better than the results of the survey in all criteria. In addition, the criteria that the teachers scored themselves as highest and lowest showed alignment with highest and lowest scores of the survey. As both the survey results and teachers agree, teachers showed the best performance in supporting their instructional strategies with technology, while the lowest performance was in the fit criteria.

2.3.4. The Studies Examine the Technology Integration Quality via Observations

"Technology Integration Observation Instrument (TIOI) (Hofer, Grandgenett, Harris, & Swan, 2011)" has been used to evaluate technology integration quality in practice in several studies in different years (e.g., Kurt, 2014; Clark, Zhang & Strudler, 2015; Heintzelman, 2017; Korucu, Kis & Ozmen, 2019). The scale consists of 6 criteria which are "Curriculum Goals & Technology, Instructional Strategies & Technology, Technology Selections, Fit, Instructional Use and Technology Logistics" respectively. The first of the reviewed studies using TIOI was Price's (2013) thesis. In this study, the effect of "Integrated Triadic Model (ITM)" on TPACK levels of pre-service teachers in method course which was a content specific course was investigated. The researcher evaluated the pre-service teachers' practices and compared the results obtained separately for each criterion of the instrument. Regarding the result of the comparison, pre-service teachers did not show any improvement in all criteria of the instrument. In other words, it was concluded that pre-service teachers did not show a development in the quality of technology integration into their practice.

In another study conducted by Kurt (2014) using TIOI, presented “TPACK levels of pre-service teachers” during their internship were investigated. In the research, it was observed that all the pre-service teachers operate the chosen technologies quite well. In addition, it was discoveed that the internship experience had an effect positively on the pre-service teachers and they developed a good of the complex relationship between the three basic knowledge domain of TPACK framework, PK, CK and TK.

Clark, Zhang and Strudler’ (2015) study, which was also one of the researches on the quality of technology integration in pre-service teachers’ internship environment, was carried out with pre-service secondary teachers. The aim of the observations carried out in the study was to gather findings about the technology integration of pre-service science teachers. The findings were evaluated by TIOI and the data obtained from the evaluation were interpreted. According to this, it has been determined that few of the pre-service teachers used technology for learning of the students, while most of them used technology for teacher-centered purposes. As a result of the evidence obtained from the results, it was seen that pre-service teachers could not fully transfer the technology integration education they experienced in the education programs to the student-centered teaching environments.

In another study using TIOI, Heintzelman (2017) investigated how “special education teachers” integrate technology into their classrooms to involve emotionally and behaviorally disordered (EBD) students. Then, the written and observed data were evaluated using TIAR and TIOI and the results were compared. According to the results, it was found that the written and observation results aligned in “Curriculum Goals & Technology, Instructional Strategies & Technologies, Technology Selections and Fit” criteria and there was no statistical difference between them. In addition, it was seen that the quality of effective use of technology by teachers during the course (Instructional Use) was lower than other skills.

Finally, Korucu Kis and Ozmen (2019) designed a study with experimental design. In the study, the traditional training program and the developmental training program were defined as independent variable and the effect of it on pre-service teachers' TPACK-based skills was investigated. For this purpose, pre-service teachers' performances were evaluated with TIOI. As a result of the evaluations, it was observed that the experimental group had higher scores in all criteria of the instrument than the control group. Therefore, it was concluded that the developmental training program had a positive effect on TPACK-based skills of pre-service teachers.

2.4. Summary

When the literature was reviewed, it was revealed that developing TPACK levels of both pre-service and in-service teachers was a complex process and there was no agreement upon the models or programs to be used to develop their TPACK levels. As evidence, in the literature it was observed that several development models or development programs were used in different studies with the aim of developing TPACK levels. For instance, Instructional Design model (ISD) was used by Angeli and Valanides (2005), TPACK-COPR model was used by Jang and Chen (2010) and in the studies (Graham et al., 2009; Sancar et al., 2013) SciencePlus and Digital Story telling programs were used in order to develop TPACK levels. Similar results have been obtained in the studies using different development models and programs and it was emphasized that such models and programs were effective in the development of TPACK levels.

Moreover, it was also observed after literature review that studies who examining the efficacy levels were in majority and the scores were used with different purposes. For instance, Albayrak et al. (2016) examined the relationship between the

TPACK efficacy levels and attitudes towards ICT and found positive relationship. In addition, the efficacy scores were used to determine the effectiveness of treatments in the experimental design studies (e.g., Gokdas & Torun, 2017) Besides, lesson plans and observations were also important data sources in TPACK studies. It has been observed that development programs or models have a positive effect in studies (e.g., Kurt, 2014; Mustafa, 2016; Anyasari, 2015) investigating the quality of technology integration in lesson plans and observations. It was also observed that pre-service teachers could not fully transfer the technology into education (Clark et al., 2015). Besides, it was realized that the studies focused on TPACK development were conducted without considering different teaching methods. Considering the difficulty of examining TPACK development with respect to different teaching science methods, none of the studies conducted to examine TPACK development with different teaching science methods. In the current study, pre-service science teachers' TPACK development and effectiveness of science methods course enhanced by TPACK development model were investigated. Moreover, technology integration qualities in lesson plans and micro-teachings were explored considering different science teaching methods. Hence, current study could be sparkle for future research and filled the gap in the literature.

CHAPTER 3

METHODOLOGY

Purpose of this chapter is providing an overview of the methodology of the study. In this context, firstly the study's design was introduced. Afterwards, detailed explanations and descriptions about research questions, research process and "TPACK development model used in the research process", characteristics of the participants, role of researcher, course instructor and assistants, data collection tools and instrumentation process and data analysis were given. Lastly, trustworthiness, ethical considerations, assumptions and limitations of the study was provided in the chapter.

3.1. Design of the Study

In the present study which was created to investigate TPACK changes of pre-service teachers in "science methods course", quantitative research approach was used. As it was suitable for the purpose of the research, the study was carried out according to one group pretest - posttest design which generally used to investigate the impact of an independent variable (intervention or treatment) on a specific group (Allan, 2017). In this design, the theory is tested by determining how to collect data to confirm or refute a hypothesis. Before and after the experimental process, the design is used to evaluate the attitudes and products of the participants. In this context, a randomly selected group is tested before the treatment, then the planned process in the light of the purposes of the study is applied and final tests are performed at the end of the process. After analyzing the obtained data, the differences or changes in the measurements made before and after the treatment is assumed to be due to the treatment performed (Creswell, 2003).

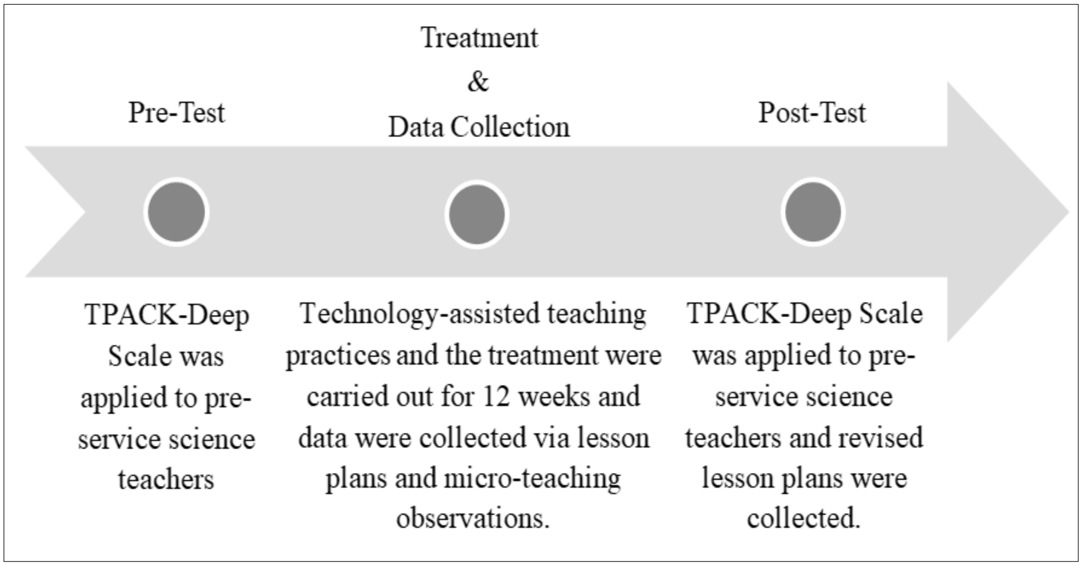

Figure 10. Schematic representation of the study

In accordance with the design, the pre-test was applied first in the research process. Then, TPACK training based upon "TPACK-IDDIRR (Introduce, Demonstrate, Develop, Implement, Reflect, Revise) model (Lee & Kim, 2014) was administered to pre-service teachers in the science methods course". Each week participants were taught about different science teaching methods and how to integrate ICT tools effectively into different teaching methods through the semester. Along the process, pre-service teachers were asked to prepare lesson plans with respect to different science teaching methods and make a micro-teaching once in accordance with the lesson plan. The lesson plans and micro-teachings were evaluated by the researcher and the course assistants and feedback was given to the participants. Finally, the post-test was applied, and the final drafts of the lesson plans that were given feedback were collected. The schematic representation of one group pretest - posttest design conducted in this study is presented in Figure 10.

3.2. Research Context

3.2.1. The Instructional Design Model

In this research, TPACK-IDDIRR model (Lee & Kim, 2014), which was developed for pre-service teacher from synthesis of characteristics and guidelines of Angeli's Instructional Design (ID) model (2005), Angeli and Valanides' ID model (2005), Jang and Chen's ID model (2010), was used. The diagram of the design model used in the current study is shown in Figure 11. The overlap of the procedures and nature of the science methods course with the instructional procedures of the model was effective in the selection of the model although it was suitable for a multi-disciplinary course. The model consists of six stages. According to the model, firstly, it is aimed to help pre-service teachers understand the TPACK framework. Therefore, TPACK knowledge base is developed in Introduce stage which is the first stage of the model. The instructor describes the fields that make up the TPACK framework and provides examples for each subdomain (Lee & Kim, 2014).

In the second stage of the model (Demonstrate), a model lesson prepared within the scope of TPACK is presented to the pre-service teachers by course assistants. It is aimed to advance the TPACK understanding of pre-service teachers who observe this lesson presentation (Jang & Chen, 2010). After the demonstrate stage, pre-service teachers are expected to take an active role. In this context, small groups are formed from pre-service teachers. First, the groups are asked to prepare lesson plans in the scope of the learned teaching method considering what they learnt about TPACK in previous stages (Develop). Each group developed 9 lesson plans in total for different science teaching methods throughout the semester. Once the lesson plans have been prepared, one of the pre-service teachers from each group make a micro-teaching according to their lesson plan and other pre-service teachers act as students (Implement). Then, the strengths and weaknesses of the lessons offered by the students are discussed in the class and micro-teachings are evaluated (Reflect). Lastly, lesson plans are revised by groups in line with the feedback (Revise) and the whole process continues until each group member completes the cycle. In the model, there is no criterion which determines which group member will be the first practitioner. The aim is to ensure that the pre-service teachers make their own plans while performing their required tasks and provide them autonomy in working environment (Lee & Kim, 2014).

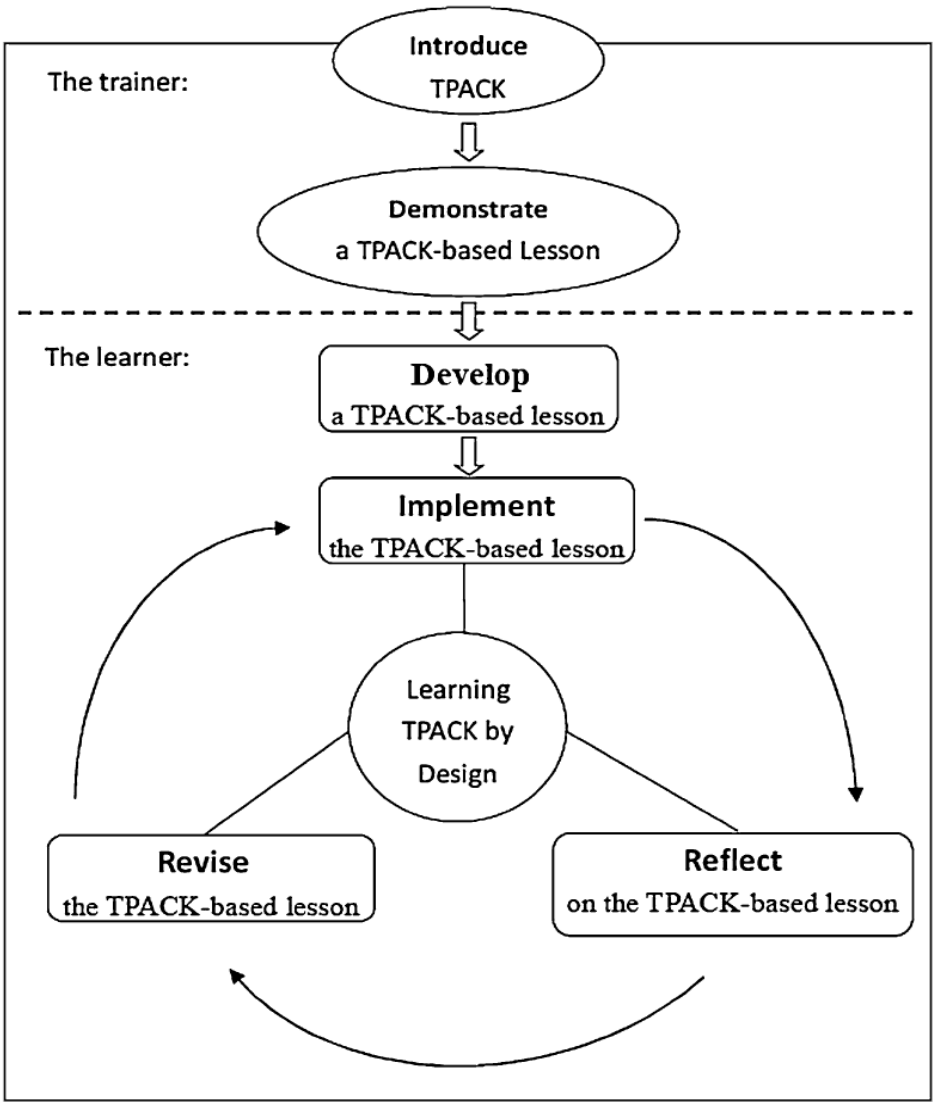

Figure 11. The TPACK-IDDIRR Model (Lee & Kim, 2014, p. 444)

3.2.2. The Setting

Science methods course was used in the present study. It is a 3- credit must course with four hours a week (two theoretical and two practice hours) and offered third year students in “Elementary Science Education Department” in Educational Faculty. The purpose of the course is to demonstrate and critically discuss methods of teaching science with appropriate teaching strategies, materials, and relevant science content. In the course the pre-service teachers were expected to make their readings assigned them weekly, attend the discussions actively about different science methods course and work effectively and compatibly with their group members.

Table 1. *Science Methods Course assignments*

Assignments	Activities
Lesson Plans	Through the semester pre-service teachers were asked to prepare lesson plan for all of the teaching methods taught in the science methods course every week. Every week before the practice hour the groups should submit their lesson plans.
Micro – Teachings	Each week one participant in each group was expected to present their lesson plan in the practice session of the course.
Reflections & Feedbacks	Every week, after micro-teachings, the presenters should write a self-reflection about their micro-teaching experience. Other participants in the class were expected to give feedback for their friends related to their micro-teaching.
Portfolios	At the end of the semester, groups were asked to submit their semester portfolio as a group. This portfolio included: first drafts of their lesson plans (with the given feedback), revised version of each lesson plan and individual reflections.

In addition, through the semester, pre-service teachers were expected to complete several assignments. Firstly, the groups of pre-service teachers were asked to prepare lesson plans enriched with ICT tools appropriate to the science teaching method that taught each week. Then, a pre-service teacher from each group was expected to make a presentation according to the prepared lesson plan. They should also participate in class discussions and give feedback to the pre-service teachers who made micro-teaching in the online forum prepared for each pre-service teacher's micro-teaching. At the end of the semester, the groups should revise all their lesson plans according to the feedback given by other pre-service teachers and course assistants and create a portfolio. Detailed course assignments table was given in the Table 1.

Science methods course helps pre-service teachers gain different perspectives in different teaching science methods. The course mainly focuses on pedagogical and subject matter skills of pre-service teachers. In this study, TPACK-IDDIRR model has been integrated to enrich the content of science methods course in terms of developing TPACK and classroom applications of pre-service science teachers and tried to create technologically rich learning environments. After the integration of TPACK-IDDIRR model and the research process was planned, the overall program of the science methods course was presented in Table 2.

Table 2. *Overall program of the study*

Week	Method	Activity
Week 1	-	- First Meeting - Course introduction
Week 2	-	- Application of TPACK-Deep Scale (Pre-Test) - TPACK framework presentation by the researcher. (Introduce Stage of TPACK-IDDIRR model)

Table 2 (Continued)

Week	Method	Activity
Week 3	Demonstration/ Predict-Observe-Explain	- Presentation of Demonstration method by course instructor - Demonstrating sample lesson by course assistants (Demonstrate Stage of TPACK-IDDIRR model)
Week 4	Inquiry and Teaching Science: Learning Cycle	- Lesson plan submission of the groups regarding Demonstration method (Develop Stage of TPACK-IDDIRR model) - Micro-teachings of the groups regarding demonstration method (Implement Stage of TPACK-IDDIRR model) - Feedback and discussions about lesson plans and micro-teachings (Reflect Stage of TPACK-IDDIRR model) - Presentation of Inquiry and teaching science method by course instructor - Demonstrating sample lesson by course assistants
Week 5	Concept Cartoons and Argumentation	- Lesson plan submission of the groups regarding inquiry and teaching science method - Micro-teachings of the groups regarding inquiry method - Feedback and discussions about lesson plans and micro-teachings - Presentation of Argumentation method by course instructor - Demonstrating sample lesson by course assistants
Week 6	Field Trip	- Lesson plan submission of the groups regarding argumentation method - Micro-teachings of the groups regarding argumentation method - Feedback and discussions about lesson plans and micro-teachings - Presentation of Field trip method by course instructor - Demonstrating sample lesson by course assistants

Table 2 (Continued)

Week	Method	Activity
Week 7	Laboratory Approaches	- Lesson plan submission of the groups regarding field trip method - Micro-teachings of the groups regarding field trip method - Feedback and discussions about lesson plans and micro-teachings - Presentation of Laboratory approaches method by course instructor - Demonstrating sample lesson by course assistants
Week 8	Project-based Learning	- Lesson plan submission of the groups regarding laboratory approaches method - Micro-teachings of the groups regarding laboratory approaches method - Feedback and discussions about lesson plans and micro-teachings - Presentation of Project-based learning method by course instructor - Demonstrating sample lesson by course assistants
Week 9	Problem-based Learning	- Lesson plan submission of the groups regarding project-based learning method - Micro-teachings of the groups regarding project-based learning method - Feedback and discussions about lesson plans and micro-teachings - Presentation of Problem-based learning method by course instructor - Demonstrating sample lesson by course assistants
Week 10	Teaching with Analogy	- Lesson plan submission of the groups regarding problem-based learning method - Micro-teachings of the groups regarding problem-based learning method - Feedback and discussions about lesson plans and micro-teachings - Presentation of Teaching with analogy method by course instructor - Demonstrating sample lesson by course assistants

Table 2 (Continued)

Week	Method	Activity
Week 11	Role Playing / Drama	- Lesson plan submission of the groups about teaching with analogy method - Micro-teachings of the groups about teaching with analogy method - Feedback and discussions about lesson plans and micro-teachings - Presentation of Role playing/drama method by course instructor - Demonstrating sample lesson by course assistants
Week 12	-	- Lesson plan submission of the groups about role playing/drama method - Micro-teachings of the groups about role playing/drama method - Feedback and discussions about lesson plans and micro-teachings
Week 13	-	- Portfolio submission included revised lesson plans (Revise Stage of TPACK-IDDIRR model) - Application of TPACK-Deep Scale (Post-Test)

In the first week of the science methods course the instructor introduced the requirements of course and what are expected from the pre-service teachers throughout the semester. The lesson plan templates (see Appendix A) and course schedule was shared with them. In the second week of the course the researcher applied the pre-test and as a requirement of the Introduction stage of the model, researcher made a presentation to the pre-service teachers to introduce TPACK framework. In the presentation the subdomains of TPACK, the definition of technology from the point of view of present research and limitations of technology integration and advantages of technology integration into science lessons were included. After this week the first science teaching method was taught by course instructor who is Professor of science education and both domain specific and domain free ICT tool suggestions that are suitable to use in first science teaching method were given to the pre-service teachers by the instructor. At the end of the theoretical part of the course, a micro-teaching example enriched with ICT tools was made by the course assistant in accordance with science teaching method covered in the first lesson (Demonstrate stage of the model). Then, pre-service teachers shared their ideas about the science teaching method and micro-teaching and discussion environment were created.

After this week, the process proceeded as a cycle in which pre-service teachers' participation increased. They divided into 15 groups (at least two, max five members) and each group was responsible to develop their own lesson plan enriched ICT tools based on science teaching method they learnt before (Develop stage of the model). Before the next lesson the groups were expected to upload their lesson plans to the online platform of the course and one pre-service teacher made micro-teaching according to lesson plan while other participants acted as students (Implement stage of the model). At the end of the micro-teachings, course assistants shared their feedback related to pedagogical, content and technological perspectives and other pre-service teachers shared their feedback in online forum of the course considering strong and weak points of the micro-teaching. In addition, the lesson plans prepared by the groups were evaluated by the course assistants and feedback was shared with the groups (Reflect stage of the model). The process moved iteratively as instructor presented the next science teaching method based on the program of the study, the course assistants made example micro-teaching, the groups prepared lesson plan, one candidate made micro-teaching, feedbacks were given, and groups revised 9 lesson plans in total until the all science teaching methods completed (Revise stage of the model). At the end of the semester the groups uploaded their portfolios which was included the unrevised lesson plans with feedback and revised lesson plans to the online platform of the course and post-test was applied them.

3.2.3. Course Instructor and Assistants

The instructor who has been offering the course for ten years and was Professor of science education, of the science methods course guided the overall process in the study as an expert in this subject area. Instructor presented different science teaching methods and strategies every week to the pre-service science teachers. After that instructor attended the micro-teaching examples about the relevant teaching method as an observer and specified the requirements and important points of relevant teaching method during the micro-teaching.

The 4 course assistants, which were completed the master degree and were students in doctoral programs, have been taking part for at least two years in the course and at that time one of them was studying doctoral study focusing on TPACK and technology integration into science teaching. The course assistants took an active role in the present study. First of all, they presented micro-teaching examples according to science teaching method or strategy presented by the instructor of the course. After that, they attended the observation of micro-teaching of the pre-service teachers every week and gave feedback on them. Lastly, they reviewed the lesson plans with the researcher and feedback was given to the lesson plans which are enriched by technology and prepared by pre-service teachers according to relevant teaching method.

3.2.4. The Researcher

Researcher generally took observer and designer role throughout the study. At the beginning of the semester, the researcher made a presentation on the strengths and weaknesses of the integration of technology into the science course and the theories about technology integration. After that, the researcher designed different micro-teaching examples about relevant teaching method enriched by technology by making meetings with course assistants under the guidance of the course instructor. The researcher also attended as an observer to the practice hours of the course for the micro-teaching of pre-service science teachers and evaluated the both lesson plans and micro-teachings of them. Moreover, the researcher organized and directed the online course platform for discussions and feedbacks, technology suggestions for pre-service science teachers.

3.2.5. Research Questions

The research questions of the study, which aimed to investigate the TPACK development of pre-service science teachers enrolled science methods course enhanced by the integration of the TPACK-IDDIRR (Lee and Kim, 2014) model was:

1. What are the effects of Science Methods Course enhanced by the application of the TPACK-IDDIRR model on pre-service teachers' TPACK efficacy levels?

2. What is the effect of Science Methods Course enhanced by the application of TPACK-IDDIRR Model on pre-service science teachers' quality of technology integration in their lesson plans?

   a. What is the quality of technology integration of unrevised lesson plans prepared by per-service science teachers with respect to different teaching methods of science?

   b. What is the quality of technology integration of revised lesson plans prepared by per-service science teachers with respect to different teaching methods of science?

   c. Are there any significant differences between the technology integration qualities of lesson plans prepared by pre-service science teachers with respect to different teaching methods of science?

3. What are the pre-service science teachers' technology integration qualities in practice in the Science Methods Course enhanced by the application of TPACK-IDDIRR Model in practice?

3.3. Participants

To the present study, 3rd-grade pre-service science teachers in the Department of Elementary Science Education (ESE) in Faculty of Education within the big university in Ankara was participated. The sample of the study was composed of 3 male and 54 female (N=57) pre-service teachers. Participants were selected considering the research questions.

The pre-service science teachers who took the science methods course participated in the study. The reason why they were studied with them was that they had already completed two courses aiming to improve their technological competence. The courses were "Computer Applications in Education" and "Instructional Technology and Material Development" focusing on gaining basic computer skills to pre-service teachers, teaching office programs and different material developments strategies via office programs and Web 2.0 tools. Another reason why they were studied with them was that they have already gained lesson plan preparing skills in "instructional principles and methods course" taken in previous years.

The sample of the study was selected according to "convenience sampling method" which means that all available individuals who willing to participate in the study were selected (Fraenkel, Wallen & Hyun, 2012). This sampling method is most common used sampling method in all sampling methods and is more useful than other nonprobability methods if the population size is large and impossible to reach each individual even though it is weak to represent entire population (Maheshwari, 2017). Participants were given brief information about thesis study at the beginning of the semester and permission documents were signed by participants for volunteering. It was also stated that they will be observed throughout the semester and all data obtained will only be used for the study.

3.4. Data Collection Tools

Table 3. *Data collection tools*

Data Collection Tool	Activities
TPACK-Deep Scale	Used in order to evaluate the TPACK efficacy levels of pre-service science teachers before and after the study as pre-test and post-test
Technology Integration Assessment Rubric (TIAR)	Used to evaluate technology integration qualities of pre-service science teachers in both unrevised and revised lesson plans.
Technology Integration Observation Instrument (TIOI)	Used to evaluate technology integration qualities of pre-service teachers during micro-teachings.

Data were collected using three different instruments in the current study (see in table 3). “Techno-pedagogical Efficacy (TPACK-Deep) Scale (Kabakci Yurdakul, Odabasi, Kilicer, Coklar, Birinci & Kurt, 2012)” was used as a pre-test and post-test in order to find out the efficacy of the pre-service science teachers about TPACK in the current study. In addition, the data obtained from lesson plans and observations made in micro-teachings constituted the data of the study. “Technology Integration Assessment Rubric (Harris, Grandgenett & Hofer, 2010)” was used in order to evaluate the lesson plans and “Technology Integration Observation Instrument (Hofer, Grandgenett, Harris & Swan, 2011)” was used in order to evaluate the micro-teachings of pre-service science teachers.

3.4.1. TPACK-Deep Scale

"The TPACK-Deep Scale (Appendix B), which was developed by Kabakci Yurdakul et al. (2012") to measure the TPACK efficacy levels of the pre-service teachers, was applied as pre-test and post-test in the present study. All of the items of scale consisted of positive expressions and there was no reverse coded item. The scale items were 5-likert type, such as "strongly disagree, disagree, neither agree or disagree, agree, strongly agree".

The scale was composed of thirty-three items with four factors which are design, exertion, ethics and proficiency (see Table 4). The design factor is first important factors of the instrument that expresses pre-service teachers' capability in designing instruction by enriching with technology to teaching process. The exertion which is the second most important factor of the scale expresses the efficacy of pre-service teachers in using technology to conduct the teaching process and assess the effectiveness of the process (Kabakci Yurdakul et al., 2012). Ethics, which is another factor of the scale includes both pre-service teachers' efficacies related to their profession and ethical issues related to technology such as accessibility, accuracy and privacy. Lastly, proficiency factor indicates that the efficacy of pre-service teachers specializes their profession to integrate technology into content and pedagogy, make suggestions for the solution of problems related to the subject area, teaching process and technology and choose the most appropriate one (Kabakci Yurdakul et al., 2012).

Cronbach's alpha values were calculated by the researchers with the aim of measuring the consistency or reliability of the items. It was reported by the researchers that the Cronbach's alpha value of the whole instrument was calculated as .95. The Cronabach's alpha values for the factors of the scale were respectively .92 for Design, .91 for Exertion, .86 for Ethics, and for .85 Proficiency. In addition, the test-retest reliability coefficient for the instrument was calculated as .80 (Kabakci Yurdakul et al., 2012). It was emphasized that because of its high validity and reliability levels, the scale could be used to measure pre-service teachers' TPACK efficacy levels and was very powerful in providing reliable measurements (Kabakci Yurdakul et al., 2012).

Table 4. *TPACK-Deep Scale factors, items and explanations*

Factors	Items	Explanation
Design	1-10	expresses teachers' capability in designing instruction by enriching with technology to teaching process
Exertion	11-22	expresses the efficacy of prospective teachers in using technology to conduct the teaching process and evaluate the effectiveness of the process
Ethics	23-28	includes both pre-service teachers' efficacy related to their profession and ethical issues related to technology such as accessibility, accuracy and privacy
Proficiency	29-32	indicates the ability of prospective teachers specialize their profession to integrate technology into content and pedagogy

3.4.2. Technology Integration Assessment Rubric

In the present study, "Technology Integration Assessment Rubric (Harris, Grandgenett, & Hofer, 2010)" were used to evaluate pre-service teachers' levels of TPACK in the lesson plans that reflect their instructional decisions. In this study it was utilized to evaluate the lesson plans which were developed by the pre-service science teachers. The scale consists of a total of four criteria: "Curriculum Goals & Technologies, Instructional Strategies & Technologies, Technology Selections and Fit." Each criterion in the rubric is categorized to rate from 1 to 4 and the descriptions of each criterion were given in the categories (Appendix C).

In the Curriculum Goals and Technologies criteria are used to measure the technology choices to be used in the course plans for the curriculum goals. In the second criterion (Instructional Strategies & Technologies) the effectiveness of the use of technology in instructional strategies is evaluated. Another criterion of the rubric which is Technology Selections measures the compatibility of technologies with instructional strategies and curriculum goals. Fit, which is the last criterion of the scale evaluates whether technology, content and pedagogy are suitable for each other in the lesson plans (Harris et al., 2010).

Construct validity and face validity were used in order to examine the validity of TIAR. In order to test the validity of scale in reflecting TPACK levels, evaluation and comments of TPACK experts were used. Five out of six researchers stated that the criteria of the scale represented TPACK constructs, while only one researcher stated that additional questions were needed (Harris et al., 2010). In addition, face validity strategy was approved with the analysis and comments of classroom teachers considering the instrumentality of the rubric (Harris et al., 2010).

The procedures in order to examine the reliability of the rubric were completed by two trials. While the scores of southern trial were .646 for Interclass Correlation Coefficient, 83.6 % for percent agreement and .902 for internal consistency, the scores of mid-western trial were .857 for Interclass Correlation Coefficient, 84.1 % for percent agreement and .911 for internal consistency (Harris et al., 2010). According to the result obtained Technology Integrations Assessment Rubric could be considered valid and reliable instrument which assess TPACK levels of pre-service science teachers and technology integration qualities in their lesson plans (Harris et al., 2010).

3.4.3. Technology Integration Observation Instrument

In the present study, “Technology Integration Observation Instrument (Hofer, Grandgenett, Harris, & Swan, 2011)” was used to evaluate pre-service teachers’ quality of technology integration in practice. In this study it was utilized to evaluate the micro teachings of pre-service science teachers. The scale includes same criterion with the Technology Integration Assessment Rubric (Appendix D) and additionally two other criteria which are Instructional Use and Technology Logistics. Each criterion in the rubric is categorized to rate from 1 to 4 and the descriptions of each criterion were given in the categories. The first of the additional criteria of the scale which is Instructional Use evaluates effectiveness of instructional use of technology in practice and Technology Logistics which is other additional criteria evaluates how well technology is operated in observed lesson.

Construct validity and face validity were used in order to examine the validity of TIOI. Broad range of comments and suggestions were provided for review by the seven TPACK experts and they evaluated the instrument quite positively (Hofer et al. 2011). Additionally, scorers' feedback reviewed for determining rubric's face validity and all written comments from scorers were positive for using the rubric in determining the quality of technology integration in practice (Hofer et al., 2011). The procedures in order to examine the reliability of the rubric were completed by two trials. Average scores of the trials were 90.8 % for percent agreement, .802 for Interclass Correlation Coefficient, .914 for Cronbach's Alpha and 93.9 % for the test-retest reliability. Hofer et al. (2011) concluded the TIOI is quite promising instrument to assess teachers' TPACK in practice.

3.5. Analysis of Data

In the current study, quantitative data were obtained from the participants through scale, assessment tool and observation rubric. “SPSS (Statistical Package for Social Sciences) 20.0” program was used in the analysis of the obtained data. Descriptive statistics were calculated, and various non-parametric and parametric tests were applied through SPSS. In this section, it was explained how the data obtained from TPACK Deep Scale were analyzed, then the steps followed for the analysis of the results obtained from the evaluation of the lesson plans were presented and finally the explanations about the statistical analysis of the results of the observations were given.

3.5.1. Analysis of the Data from TPACK-Deep Scale

TPACK Deep Scale was administrated to the pre-service science teachers initially in order to measure their TPACK efficacy. Then, pre-service science teachers were involved in the science methods course enhanced by the application of TPACK-IDDIRR model. At the end of the whole process, TPACK-Deep scale was applied to participants as a post-test and the results were analyzed. To begin with, the internal consistency of the scores obtained from the scale checked by calculating the Cronbach's alpha value via SPSS for pre-test and post-test. Then, in order to determine the method to be used in the analysis of the data collected through TPACK-Deep Scale, it was checked whether the data provided the assumption of normality. In this context, Kolmogorov-Smirnov and Shapiro-Wilk values were used for normality test. As the data showed normal distribution according to the results of the tests, one of the parametric tests, dependent or paired sample t-test, was conducted to determine whether the pretest and posttest scores obtained from TPACK-Deep Scale differed. This analysis method is used to investigate whether there is a significant difference between two means obtained from the same group in different times and if there is a change, it is assumed that this change is caused by an independent variable (Gravetter & Wallnau, 2013). In addition, descriptive statistics were used by using TPACK-Deep Scale data and the results obtained from pretest and posttest was compared.

3.5.2. Analysis of the Data from Lesson Plans

One of the data sources used to determine the TPACK levels of pre-service science teachers in the current study was lesson plans prepared according to different teaching methods each week. After the lesson plans prepared, they were scored through “Technology Integration Assessment Rubric”. Before the lesson plans were evaluated, the researcher and course assistants had a meeting and the rubric, how to use it and the points to be considered were presented to the assistants by the researcher. Then, the lesson plans were evaluated separately by the researcher and the course assistants. After the lesson plans evaluated according to the rubric, the researcher and the assistants compared the results and exchanged ideas related to the scores. Afterwards, feedback was given to the pre-service science teachers and asked to revise their lesson plans. Revised lesson plans were re-evaluated by the researcher and assistants using the same rubric.

In order to test the reliability of the scores obtained from both the first lesson plans and the revised lesson plans, the "Interrater Correlation Coefficient (ICC)" value was calculated with SPSS for each criterion and overall scores. ICC is generally used for evaluating "Interrater Reliability" which indicates the consistency, variation and agreement among the at least two raters that measure the same data from the same group (Koo & Li, 2016). After the reliability of the results were tested, statistical analyzes were performed to interpret the obtained data. Firstly, descriptive statistics were determined for each criterion of the rubric and the scores of different teaching methods were compared. Mean, standard deviation, minimum and maximum values were used for this purpose.

After descriptive statistics were used to evaluate the quality of technology integration into both unrevised and revised lesson plans and TPACK levels of pre-service science teachers, the scores obtained from the unrevised and revised lesson plans were compared in order to evaluate the effectiveness of the training and feedback. For this purpose, Wilcoxon Sign Rank Test, which is a non-parametric test, was applied because the sample size was not sufficient to meet the assumptions of the parametric test. Finally, Friedman Test, that is another non-parametric test, was applied to evaluate whether pre-service teachers' technology integration qualities into lesson plans change with respect to different teaching methods and the results were interpreted.

3.5.3. Analysis of the Data from Observations

The results obtained from the scale and lesson plans used in the present study, the results of the micro-teachings performed by the pre-service science teachers were evaluated. Technology Integration Observation Instrument was used to evaluate their micro-teaching performances. Descriptive statistics were calculated for the six criteria of the instrument and compared with each other. Then, in order to evaluate the pre-service science teachers' ability to use technology in different teaching methods, the means of the total scores obtained from the instrument were evaluated and compared with each other.

3.6. Trustworthiness of the Study

In the studies, the precautions need to be taken for the threats to the trustworthiness of the study in order to ensure the validity and reliability. The first precaution taken for this purpose was to eliminate the bias in data collection. In order to eliminate data collection bias the data was triangulated in the current study, because the triangulation could be defined as collecting data via different types of data collection tools to enrich the strength and validity of the study (Patton, 2002). Besides, the necessity of data triangulation to ensuring validity was supported by Merriam (2002). In the current study, the data were collected via different type of data collection sources such as survey, lesson plans and micro-teaching observation in order to determine pre-service teachers' TPACK levels more deeply.

In the current study Cronbach's alpha values were calculated in order to ensuring the reliability of the data obtained from TPACK-Deep Scale, because reliability or internal consistency of test items or scale is evaluated via Cronbach's alpha measure (Goforth, 2015). The obtained Cronbach's alpha values were presented in Table 5 below.

Table 5. *Items of scale and reliability results by factors*

		Kabakcı Yurdakul et al., 2012	Current Study	
Factors	Items	Cronbach's Alpha (α)	Pre-test (α)	Post-test (α)
Design	1-10	.92	.92	.92
Exertion	11-22	.91	.91	.91
Ethics	23-28	.86	.88	.88
Proficiency	29-33	.85	.91	.87
Overall	1-33	.95	.96	.96

As seen in the table 5, the "Cronbach's alpha" values of factors and overall scale for pre-test and post-test was ranged between 0.88 and 0.96. Considering all the results, it can be concluded that the scale is reliable, because the Cronbach's alpha value is considered to be quite good as it approaches 1.00 (Fraenkel, Wallen & Hyun, 2012).

In order to ensure the validity and reliability of the data obtained from lesson plans the course assistants and researcher compared the scores of the lesson plans and discussed about and they agreed upon them before giving feedback to the lesson plans. In addition, Interrater Reliability was tested using SPSS for each criteria of the rubric to evaluate reliability. "Interrater Correlation Coefficient (ICC)" results were used for this purpose. ICC is generally used for evaluating "Interrater Reliability" which indicates the consistency, variation and agreement among the at least two raters that measure the same data from the same group (Koo & Li, 2016). Moreover, Koo and Li (2016) stated that ICC values in the 95% confident interval should be used considering the ranges in the Table 6 to evaluate reliability level.

ICC values for unrevised lesson plans are found to be 0.91 for fist criteria which is Curriculum Goals & Technologies, 0.91 for second criteria which is

Instructional Strategies & Technologies, 0.90 for third criteria named Technology Selections and 0.89 for last criteria which is Fit. When all ICC values were evaluated, it indicated excellent reliability, or it indicated excellent agreement between the measurements.

Table 6. *General guideline for level of reliability*

ICC Value	Reliability Level
ICC < 0.5	Poor
0.5 < ICC <0.75	Moderate
0.75 < ICC < 0.9	Good
0.9 < ICC	Excellent

The reliability of the scores obtained from revised lesson plans were also examined by calculating “Interrater Correlation Coefficient (ICC)” in SPSS. The ICC value was calculated as 0.90 at the 95% confidence interval and the lower bound was 0.80 and upper bound was 0.94. Thus, the conclusion that we would draw looking these outputs would be quite good reliability or between scores of raters (assistants and researcher) have high reliability.

3.7. Ethical Considerations

At the beginning of the semester, before conduct to study the permission was taken from “Applied Ethics Research Center of METU” (Appendix E). In addition, all the participants were informed about the process of the study without explaining purposes explicitly and they are asked to sign the permission form (Appendix F) which they agree to be volunteer to attend the study. The form included the context and duration of the study and permissions for being videotaped. Moreover, it was emphasized that the records and identities of the participants were kept confidentially and in the study the results and data obtained from them presented without revealing identities of the pre-service science teachers.

3.8. Assumptions

1. It is assumed that pre-service teachers in the study have sincerely responded to the data collection instruments.

2. During the study, it is assumed that the researcher does not act with prejudice and does not interact positively or negatively with the pre-service teachers during the application.

3. It is assumed that there is no positive or negative interaction among pre-service science teachers during the data collection process and they who are participating voluntarily in the study are equally affected by adverse factors.

4. It is presumed that the course assistants reflect their views objectively and sincerely respond to the instruments.

5. It is accepted that data collection tools are capable of measuring TPACK efficacy and technology integration quality of pre-service science teachers at a reasonable level.

3.9. Limitations

1. The study is limited to the 57 pre-service teachers who are in the third grade, in “Elementary Science Teacher Education Program in the Educational Faculty”.

2. The technology perception in the research is limited to Information and Communication Technologies (ICT).

3. Data collection instruments used to determine the integration quality of technology and TPACK efficacy of pre-service science teachers are limited to instruments identified by the researcher.

4. Since teaching the different science subjects has been stated in the science methods course, the research has not been realized within the context of a specific science topic.

CHAPTER 4

FINDINGS AND RESULTS

In this chapter, findings related to TPACK and classroom applications of pre-service science teachers were given. First of all, the findings of the data obtained from TPACK-Deep Scale were introduced and interpreted. Then, the findings obtained from in-class practices of pre-service science teachers were included. For this purpose, lesson plans of pre-service science teachers in accordance with different teaching methods were used as data sources. Lastly, the findings obtained from the analysis of the micro-teaching data were presented. According to the research questions of the study, the results obtained from the data were combined and interpreted in this section in a way to support each other.

4.1. Research Question 1

RQ1: What are the effects of Science Methods Course enhanced by the application of the TPACK-IDDIRR model on pre-service teachers' TPACK efficacy levels?

TPACK efficacy levels of 57 pre-service science teachers that attended to the current study were analyzed primarily. For this purpose, it was investigated whether TPACK efficacy levels showed a change in the scope of pre-test and post-test in line with the research questions of the study. For deciding on the research design used in the study, firstly the data obtained from TPACK-Deep Scale were tested for normal distribution. Using SPSS 20.0 it was analyzed whether the difference of the scores obtained from pre-test and post-test was normally distributed and "Kolmogorov-Smirnov and Shapiro-Wilk" values were taken for this purpose. As Kolmogorov-Smirnov and Shapiro-Wilk normality test results were $p= 0.20$ and $p=0.40$ respectively, it was accepted that the distribution was normal. Sig. 2-tailed values which are obtained from Kolmogorov-Smirnov and Shapiro-Wilk tests are greater than 0.05 indicates that the distribution is normal (Kilmen, 2015). Since the results were normally distributed parametric statistical analyzes were used. Therefore, Paired Sample T-test, which is one of the parametric tests and used to compare the data obtained from the same group at different times, was used. The results of the test indicate not only the difference between the scores but also the effect size of the differences with the calculations (Gravetter & Wallnau, 2013).

In order to examine the effect of science methods course enhanced by the application of TPACK-IDDIRR model on TPACK efficacies of pre-service science teachers, firstly, pre-test and post-test mean scores were compared. The results were given in the Table 7.

Table 7. *TPACK efficacy scores of pre-service science teachers*

	N	Mean Scores	TPACK Level
Pre-Test	57	123.46	Average Level
Post-Test	57	146.70	High Level

As shown in table 7, the scores obtained from the TPACK-Deep Scale increased by 23 points from the pre-test to the post-test. The lowest score that can be obtained from the scale is 33 and the highest score is 165. In addition, if the total score of the scale is less than 95, TPACK efficacy level is considered as low, if the total score of the scale is between 95 and 130, TPACK efficacy level is considered as average and if the total score of the scale is greater than 130, TPACK efficacy level is considered as high (Kabakci Yurdakul et al., 2012). When the table 6 was examined, it was seen that pre-service teachers' TPACK efficacy levels were average before the science methods course, but levels increased to high after the course. In order to determine whether the increase in the pre-test and post-test results were significant, the analysis outcomes obtained from Paired Sample T-test were evaluated. The hypothesis identified in this context was given below:

Null Hypothesis (H_0): Science methods course enhanced by the application of TPACK-IDDIRR model has no effect on TPACK efficacy levels of pre-service science teachers.

According to the results in the table 8, the null hypothesis was rejected and a significant difference was found between the TPACK efficacy levels of pre-service science teachers attended to the study ($t(56)= -9.499$; $p< .05$). "The p value (.000) has actually been rounded down to three decimal places and it means that the actual probability value was less than .005" (Pallant, 2011, p. 246). In order to comment on effect size, eta square (η^2) was calculated and it was found as 0.62 according to calculations. As a result, it was concluded that the effect size was large. Since, Cohen (1988) gave guidelines to interpret the value as .01 small effect, .06=moderate effect and .14=large effect. In the light of all these results, it can be said that science methods course enhanced by the application of TPACK-IDDIRR model provided significant improvement on the TPACK efficacy levels of pre-service science teachers attended to the study.

Table 8. *T-test results for pre-test and post-test*

	Mean	SD	t	df	p
TPACK General	-23.24361	18.47612	-9.499	56	.000

It was also found out that TPACK efficacy levels of the pre-service science teachers showed similarity for the factors of TPACK-Deep Scale. The results of the factors of the scale obtained from pre-service teachers were given in Table 9.

Table 9. *Descriptive of the factors of TPACK-Deep scale for pre-test and post-test*

Factors	Pre-Test Mean Score	Pre-Test SD	Post -Test Mean Scores	Post- Test SD
Design	3.68	.601	4.45	.478
Exertion	3.85	.529	4.52	.429
Ethics	3.96	.611	4.47	.496
Proficiency	3.34	.750	4.24	.582
General	3.71	.527	4.42	.426

When the table 9 is examined, before the science methods course enhanced by the application of TPACK-IDDIRR model it was seen that pre-service science teachers perceive themselves as most efficient in Ethics factor and Proficiency factor was lowest factor. According to avarage scores of pre-service teachers' TPACK efficacy levels were listed as Ethics, Exertion, Design and Proficiency. When the average scores of pre-service teachers at the end of the course were examined, they saw themselves as the most efficient in Exertion factor. The factor which was thought to be least efficient by the pre-service teachers was Proficiency again. When the pre-test and post-test results were compared, significant increases were observed in all factors as seen in Table 9. It was also noteworthy that pre-service teachers considered themselves to be the most efficient in Exertion factor, after enrolling of science methods course enhanced by the application of TPACK-IDDIRR model. In the light of all these findings, it could be said that the course made positive effects on pre-service teachers' TPACK efficacy levels. In order to evaluate whether this effect was significant, the results analyzed with Paired Sample T-test for each factor again. The analysis results for each factor were given in the Table 10 below.

In order to interpret data obtained from the T-test firstly the Bonferroni adjustment was made. Bonferroni correction was used to assign new significance level when multiple comparisons was made to decrease the Type I error and calculated by dividing the alpha level to number of tests applied in the study (Napierala, 2012). Thus, in this analysis the new significance level was calculated as 0.05/4= 0.0125 after Bonferroni correction.

Table 10. *T-test results for pre-test & post-test with respect to factors*

Factors	Mean	SD	t	df	p	Effect Size (η^2)
Design	-7.70175	6.74263	-8.624	56	.000	.57
Exertion	-8.03509	6.69212	-9.065	56	.000	.59
Ethics	-3.01754	3.91650	-5.817	56	.000	.38
Proficiency	-4.49123	4.33475	-7.822	56	.000	.52

According to the results in the table 10, all of the p values of the factors were smaller than 0.0125. This indicated that a significant difference was found among the means of the factors. In other words, science methods course had a significant effect on each of the factors which are Design, Exertion, Ethics and Proficiency. In order to comment on effect size eta square (η^2) was calculated for each factor. The eta square values found to be 0.57 for Design factor, 0.59 for Exertion factor, 0.38 and 0.52 for Proficiency factor and it indicated large effect size for all factors. When the results were considered, it could be concluded that science methods course enhanced by the application of TPACK-IDDIRR model had a positive effect on the TPACK efficacy levels in terms of “Design, Exertion, Ethics and Proficiency”. In addition, it was found that this positive effect was seen mostly in Exertion factor while Ethics factor was the least affected.

4.2. Research Question 2

RQ2: What is the effect of Science Methods Course enhanced by the application of TPACK-IDDIRR Model on pre-service science teachers' quality of technology integration in their lesson plans?

In order to determine the impact of the Science Methods Course enhanced by the application of TPACK-IDDIRR model on technology integration quality of pre-service science teachers, the scores of the unrevised lesson plans and the scores of the revised lesson plans after the treatment were compared. The compared results were given in the Figure 12 below.

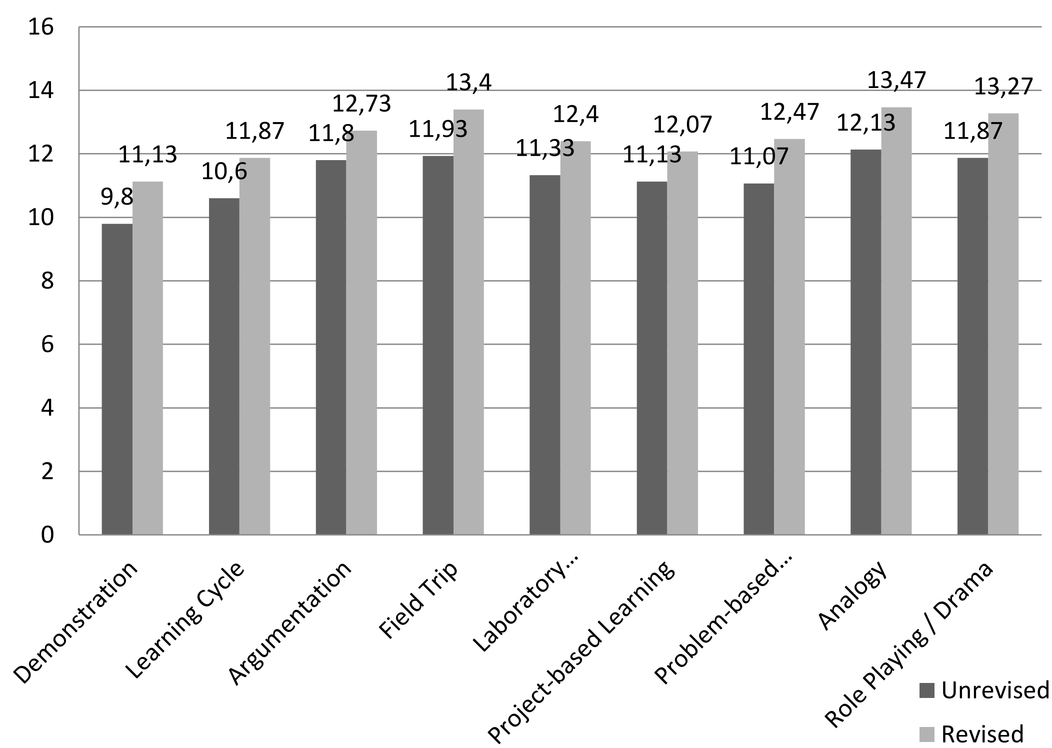

Figure 12. Overall scores obtained from unrevised lesson plans and revised lesson plans.

When the results were examined, it has seen that pre-service science teachers' score from the lesson plans prepared with respect to different teaching methods have increased considerably. This reveals that the science methods course and the feedback given the pre-service science teachers have a positive effect on their technology integration quality. Wilcoxon Sign Rank Test, which is one of the "non-parametric" tests, was applied to evaluate whether this effect is significant or not, because the non-parametric tests were suggested to be used and they were more valid, when the sample size was smaller than 30. Similarly, Altman, Gore, Gardner and Pocock (1983) and Dwivedi, Mallawaarachchi and Alvarado (2017) stated that if the required assumptions for parametric tests were not be provided or the sample size was small, non-parametric tests should be used.

The results obtained from the Wilcoxon Sign Rank Test and calculated effect size for each teaching method were given in the Table 11 below and the null hypothesis constructed for the test was:

Table 11. *Wilcoxon Sign Rank Test results*

Teaching Methods	Z	p	N	r
Demonstration	-3.134	.002	15	-0.81
Learning Cycle	-3.126	.002	15	-0.81
Argumentation	-2.263	.024	15	-
Field Trip	-2.989	.003	15	-0.77
Laboratory Approaches	-2.889	.004	15	-0.75
Project-based Learning	-3.276	.001	15	-0.85
Problem-based Learning	-3.270	.001	15	-0.84
Analogy	-3.166	.002	15	-0.82
Role Playing/Drama	-2.989	.003	15	-0.77

Null Hypothesis (H0): Science methods course enhanced by the application of the TPACK-IDDIRR model has no effect on Technology integration qualities of pre-service science teachers.

In order to decide on accepting or rejecting null hypothesis the new significance level assigned via Bonferroni correction and it was found as 0.006 (0.05/9). Considering the results in the table 11, all the p values except Argumentation method were smaller than 0.006 which means that the null hypothesis should be rejected excluding hypothesis for Argumentation method. In other words, when the significance level of the Z value was found evaluated, there was a significant change between the measurements for each teaching method except measurements of argumentation method. In order to measure the effect size of this significant change, "r" value, which is recommended by Field (2009) and calculated by the formula $r = Z/\sqrt{n}$, was calculated. When the "r" values obtained from the calculations were examined, it was seen the values varied between 0.58 and 0.85. In the light of all these output, it could be said that the effect size was large for each teaching method that the difference was significant. Cohen (1988) stated the guidelines that effect size considered as low if r value is greater than 0.1, as medium if greater than 0.3 and as large if greater than 0.5 in interpretation of effect size. The conclusion that would be drawn looking all these outputs that science methods course and given feedback as a requirement of the TPACK-IDDIRR model had a large effect on pre-service science teachers' quality of technology integration for different teaching methods excluding Argumentation method.

4.2.1. Research Question 2a

RQ2a: What is the quality of technology integration of unrevised lesson plans prepared by per-service science teachers with respect to different teaching methods of science?

The results obtained from the “Technology Integration Assessment Rubric” were used to evaluate the quality of technology integration of pre-service science teachers. For this purpose, first of all, the mean of the scores out of 4 obtained from 135 lesson plans prepared according to different teaching methods were calculated for each criterion of the rubric and overall mean scores were presented in Figure 13 below.

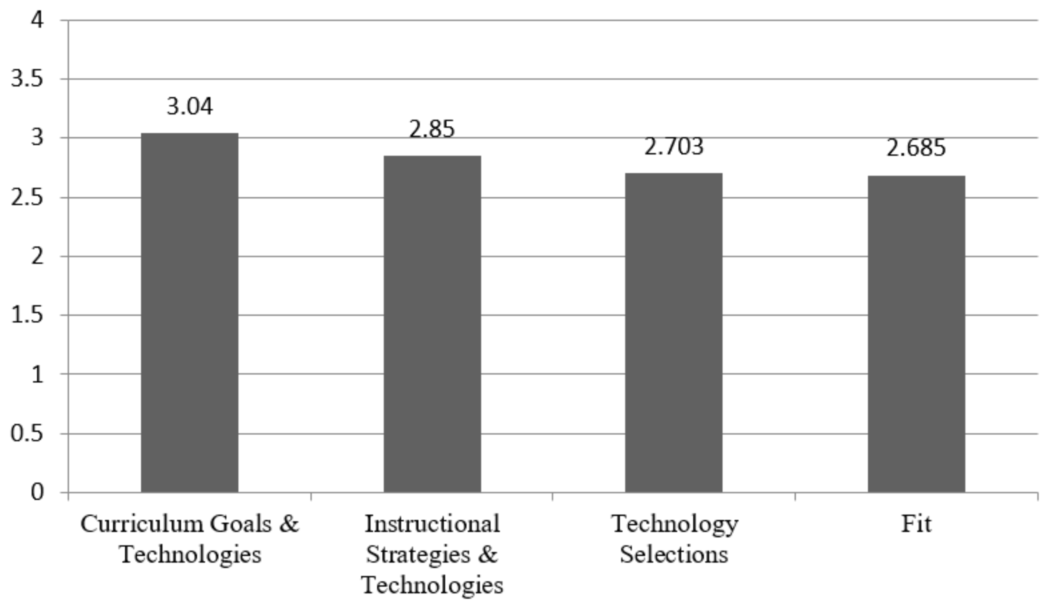

Figure 13. Overall mean scores obtained from unrevised lesson plans for criteria of the Technology Integration Assessment Rubric

When the results obtained were evaluated, it was seen that pre-service science teachers get the highest score in Curriculum Goals & Technologies which is the first criterion of the rubric. In other words, pre-service science teachers were more competent in selecting technologies that were aligned with their goals or objectives in their unrevised lesson plans compared to other criteria. Moreover, the pre-service science teachers appeared to be less competent in the last criterion, which is Fit, although the average scores of them for all criteria were very close and high. That is to say, pre-service science teachers were less competent constructing lesson plans within selected technologies, instructional strategies and content suit each other with respect to other criteria of the rubric.

Secondly, to examine how the results of each criterion change for different teaching methods, the results obtained from the unrevised lesson plans prepared according to these methods were evaluated separately and descriptive statistics of these results presented. In this regard, the mean and standard deviation scores were presented in Table 12 for first criterion Curriculum Goals & Technologies.

Table 12. *Curriculum Goals & Technologies scores with respect to different teaching methods*.

Teaching Methods	N	Mean	SD
Demonstration	15	2.73	.704
Learning Cycle	15	2.93	.884
Argumentation	15	3.33	.900
Field Trip	15	3.00	.378
Laboratory Approaches	15	3.20	.676
Project-Based Learning	15	2.80	.414
Problem-Based Learning	15	3.00	.845
Analogy	15	3.27	.704
Role Playing/Drama	15	3.13	.743
Overall	135	3.04	.346

In the light of the obtained results, it was seen that while avarage scores of the pre-service science teachers very close to each other and relatively high, the pre-service science teachers' ability to choose technologies suitable for their curriculum goals changed with respect to different teaching methods. Argumentation and Concept Cartoon method (*M*=3.33) was found to be the most successful area for the first criterion among all teaching methods. Argumentation and Concept Cartoon Method was followed by Analogy (*M*=3.27) and Laboratory Approaches (*M*=3.20) methods. The teaching methods where pre-service science teachers performed less than the other teaching methods for the first criterion were Learning Cycle (*M*=2.93), Project-based Learning (*M*=2.80) and Demonstration (*M*=2.73) respectively.

After examining the results for the first criterion, the second criterion "Instructional Strategies & Technologies" results were examined. This criterion evaluated the pre-service science teachers' instructional strategies in the unrevised lesson plans supported in what extent by the technologies used. Descriptive statistics were also presented for this criterion and the results obtained were shown in Table 13.

According to the obtained results for the second criterion of the Technology Integration Assessment Rubric, it has been cocluded that pre-service science teachers had different levels of technology selection abilities in order to support instructional strategies with respect to different teaching methods. While the pre-service science teachers have the highest performance in the lesson plans prepared for Analogy (*M*=3.13) method, they took the lowest average score in the lesson plans prepared for Demonstration (*M*=2.40) method as in the first criterion of the rubric. When the general table is evaluated, it has been seen that the pre-service science teachers performed above the overall average score for the second criterion. They had higher mean scores than overall mean scores (*M*=2.85) in Analogy (*M*=3.13), Role Playing/Drama (*M*=3.00), Argumentation (*M*=3.00), Field Trip (*M*=3.00), Project-based Learning (*M*=2.93) and Problem-based Learning (*M*=2.87) methods. In addition, pre-service science teachers performed below the overall average scores in the Laboratory Approaches (*M*=2.73), Learning Cycle (*M*=2.60) and Demonstration (*M*=2.40) methods' lesson plans, while they had the same average scores in Argumentation (*M*=3.00), Field Trip (*M*=3.00) and Role Playing/Drama (*M*=3.00) methods' lesson plans.

Table 13. *Instructional Strategies & Technologies scores with respect to different teaching methods.*

Teaching Methods	N	Mean	SD
Demonstration	15	2.40	.632
Learning Cycle	15	2.60	.828
Argumentation	15	3.00	.926
Field Trip	15	3.00	.845
Laboratory Approaches	15	2.73	.704
Project-Based Learning	15	2.93	.704
Problem-Based Learning	15	2.87	.743
Analogy	15	3.13	.915
Role Playing/Drama	15	3.00	.756
Overall	15	2.85	.398

The third criterion which was "Technology Selections", evaluated the compatibility of selected technologies with goals or strategies regarding curriculum or instruction in unrevised lesson plans of the pre-service science teachers. When the descriptive statistics were examined for third criterion, the results were similar with first and second criteria. The mean and standard deviation scores obtained were given in table 14 as follows.

According to the results obtained for the third criterion in Tables 14 was considered, it might be said that pre-service teachers showed lower performance than the first and second criteria in general and the results were more variable with respect to different teaching methods. Pre-service teachers showed the highest mean scores in Field Trip (*M*=3.00) and Role Playing Drama (*M*=3.00) methods' lesson plans. These teaching methods were followed by Analogy (*M*=2.80), Argumentation (*M*=2.73) and Project-based Learning (*M*=2.73) methods. Moreover, pre-service science teachers' score in Demonstration (*M*=2.20) method's lesson plans was the lowest, while they showed performance below the overall mean scores in Laboratory Approaches (*M*=2.67), Project-based Learning (*M*=2.60) and Learning Cycle (*M*=2.60) methods' lesson plans too.

Table 14. *Technology Selections scores with respect to different teaching methods*.

Teaching Methods	N	Mean	SD
Demonstration	15	2.20	.862
Learning Cycle	15	2.60	.737
Argumentation	15	2.73	.704
Field Trip	15	3.00	.535
Laboratory Approaches	15	2.67	.617
Project-Based Learning	15	2.73	.704
Problem-Based Learning	15	2.60	.507
Analogy	15	2.80	.561
Role Playing/Drama	15	3.00	.535
Overall	15	2.70	.322

Lastly, the fourth criterion which is the "Fit" of the scale examined with respect to different teaching methods. In this criterion it was evaluated the abilities of pre-service science teachers in building lesson plans within the content, technology and instructional strategies suit each other. The results obtained to evaluate Fit criterion of the rubric were presented in the Table 15.

Table 15. *Fit scores with respect to different teaching methods*.

Teaching Methods	N	Mean	SD
Demonstration	15	2.47	.516
Learning Cycle	15	2.47	.743
Concept Cartoon Argumentation	15	2.73	.799
Field Trip	15	2.93	.458
Laboratory Approaches	15	2.73	.594
Project-Based Learning	15	2.67	.488
Problem-Based Learning	15	2.60	.737
Analogy	15	2.93	.704
Role Playing/Drama	15	2.73	.458
Overall	15	2.70	.326

Fit criterion, which was the last criterion of the scale, was the criterion in which the pre-service teachers in general showed the lowest performance compared to the other criteria of the "Technology Integration Assessment Rubric". According to the results, pre-service teachers had the highest scores in Field Trip (*M*=2.93) and Analogy (*M*=2.93) methods' lesson plans. Furthermore, unlike other criteria, pre-service teachers performed below the overall average in more teaching methods in this criterion. Project-based Learning (*M*=2.67) and Problem-based Learning (*M*=2.60) were the teaching methods' lesson plans in which pre-service teachers had scores below the overall average score (*M*=2.70), while Demonstration (*M*=2.47) and Learning Cycle (*M*=2.47) were found to be the teaching methods' lesson plans with the lowest score in fourth criterion.

After examining how each criterion of the rubric changed according to the different teaching methods, it was examined how the total scores obtained from the rubric changed according to different teaching methods. In this context, first of all, Descriptive statistics (minimum, maximum, mean and standard deviation scores) of the different teaching methods were calculated from descriptive statistics of total results obtained from the rubric. The obtained results were presented in the Table 16 as follows.

Table 16. *Total scores with respect to different teaching methods.*

Teaching Methods	N	Minimum	Maximum	Mean	SD
Demonstration	15	7	14	9.80	2.336
Learning Cycle	15	4	15	10.60	2.898
Argumentation	15	4	16	11.80	3.144
Field Trip	15	8	15	11.93	1.792
Laboratory Approaches	15	8	16	11.33	2.320
Project-Based Learning	15	7	14	11.13	1.767
Problem-Based Learning	15	8	15	11.07	2.404
Analogy	15	8	16	12.13	2.615
Role Playing/Drama	15	9	15	11.86	2.066
Overall	15	9.67	13.56	11.30	1.311

When the results were examined, it was seen that the ability of pre-service science teachers to integrate technology into unrevised lesson plans was generally good level. The results obtained after two weeks have appeared to be increased and they were very close to each other. When the Table 16 is examined, it was seen that pre-service science teachers integrated technology most effectively into lesson plans they prepared in accordance with the analogy method. In addition, it was determined that they performed better than the overall scores in their lesson plans prepared according to Field Trip (*M*=11.93), Role Playing (*M*=11.86), Argumentation (*M*=11.80) and Laboratory Approaches (*M*=11.33) methods. In the lesson plans developed according to the teaching methods of Demonstration (*M*=9.80) and Learning Cycle (*M*=10.60), the pre-service science teachers showed the lowest performance and remained below the average of the overall results. This situation may have been due to the fact that they were in the first two weeks and the feedback provided during the all process helped them improve their abilities.

4.2.2. Research Question 2b

RQ2b: What is the quality of technology integration of revised lesson plans prepared by pre-service science teachers with respect to different teaching methods of science?

The results obtained from the "Technology Integration Assessment Rubric" were again used to evaluate the quality of technology integration of pre-service science teachers in revised lesson plans. For this purpose, first of all, the mean of the scores obtained from revised lesson plans prepared according to different teaching methods were calculated for each criterion of the rubric and overall mean scores were presented in Figure 14.

When the results obtained were examined, it appears to have similarities with the results of the unrevised lesson plans, and it was seen that pre-service science teachers get the highest score in Curriculum Goals & Technologies which is the first criterion of the rubric. Besides, the pre-service science teachers seemed to be less competent in the last criterion, which is Fit, although the average scores of them for all criteria were very close and high. That is to say, pre-service science teachers were less competent constructing lesson plans within selected technologies, instructional strategies and content suit each other with respect to other criteria of the rubric.

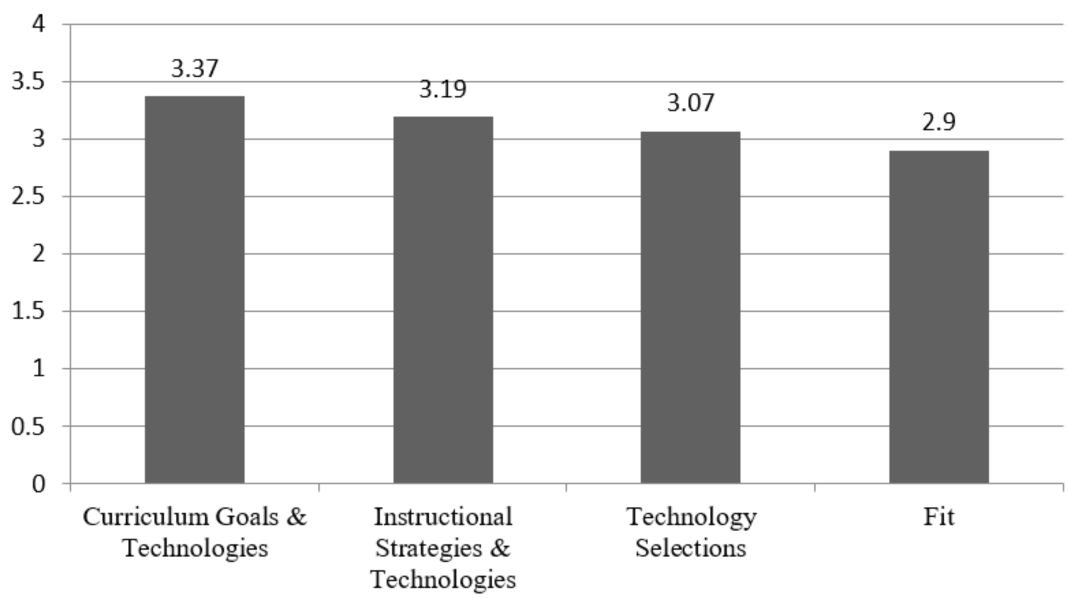

Figure 14. Overall mean scores obtained from revised lesson plans for criteria of the Technology Integration Assessment Rubric

In order to examine how the results of each criterion change for different teaching methods, the results obtained from the revised lesson plans prepared according to these methods were evaluated separately and descriptive statistics of these results presented. In this regard, the mean and standard deviation scores were presented in Table 17 for first criterion Curriculum Goals & Technologies.

In the light of the obtained results, it was seen that while average scores of the pre-service science teachers very close to each other and relatively high, the pre-service science teachers' ability to choose technologies suitable for their curriculum goals were appeared to change with respect to different teaching methods. Argumentation and Concept Cartoon, Analogy and Role Playing/Drama method (*M*=3.53) was found to be the most successful areas for the first criterion among all teaching methods. They were followed by Field Trip (*M*=3.47) and Laboratory Approaches (*M*=3.47) methods. The teaching methods where pre-service science teachers performed less than the other teaching methods for the first criterion were Problem-based learning (*M*=3.40), Project-based Learning (*M*=3.27), Learning Cycle (*M*=3.20) and Demonstration (*M*=2.93) respectively.

Table 17. *Curriculum Goals & Technologies scores in revised lesson plans with respect to different teaching methods*.

Teaching Methods	N	Mean	SD
Demonstration	15	2.93	.594
Learning Cycle	15	3.20	.676
Argumentation	15	3.53	.640
Field Trip	15	3.47	.516
Laboratory Approaches	15	3.47	.640
Project-Based Learning	15	3.27	.594
Problem-Based Learning	15	3.40	.632
Analogy	15	3.53	.516
Role Playing/Drama	15	3.53	.516
Overall	135	3.37	.324

After examining the results for the first criterion, the second criterion "Instructional Strategies & Technologies" results were examined. This criterion evaluated the pre-service science teachers' instructional strategies in the revised lesson plans supported in what extent by the technologies used. Descriptive statistics were also determined for this criterion and the results obtained were shown in Table 18.

According to the obtained results for the second criterion of the Technology Integration Assessment Rubric, it has been observed that pre-service science teachers had different levels of technology selection abilities in order to support instructional strategies with respect to different teaching methods. While the pre-service science teachers have the highest performance in the lesson plans prepared for Field Trip (M=3.47) method, they took the lowest average score in the lesson plans prepared for Demonstration (M=2.80) method as in the first criterion of the rubric. When the general table is evaluated, it has been seen that the pre-service science teachers performed above the overall average score for the second criterion. They had higher mean scores than overall mean score (M=3.19) in Field Trip (M=3.47), Analogy (M=3.40), Argumentation (M=3.33), Role Playing/Drama (M=3.27) and Problem-based Learning (M=3.20) methods. In addition, pre-service science teachers performed below the overall average scores in the Laboratory Approaches (M=3.07), Learning Cycle (M=3.07), Project-based Learning (M=3.07) and Demonstration (M=2.80) methods' revised lesson plans.

According to the obtained results for the second criterion of the Technology Integration Assessment Rubric, it has been observed that pre-service science teachers had different levels of technology selection abilities in order to support instructional strategies regarding different teaching methods. While the pre-service science teachers have the highest performance in the lesson plans prepared for Field Trip (M=3.47) method, they took the lowest average score in the lesson plans prepared for Demonstration (M=2.80) method as in the first criterion of the rubric. When the general table is evaluated, it has been seen that the pre-service science teachers performed above the overall average score for the second criterion. They had higher mean scores than overall mean score (*M*=3.19) in Field Trip (*M*=3.47), Analogy (*M*=3.40), Argumentation (*M*=3.33), Role Playing/Drama (*M*=3.27) and Problem-based Learning (*M*=3.20) methods. In addition, pre-service science teachers performed below the overall average scores in the Laboratory Approaches (*M*=3.07), Learning Cycle (*M*=3.07), Project-based Learning (*M*=3.07) and Demonstration (*M*=2.80) methods' revised lesson plans.

Table 18. *Instructional Strategies & Technologies scores in revised lesson plans with respect to different teaching methods.*

Teaching Methods	N	Mean	SD
Demonstration	15	2.80	.676
Learning Cycle	15	3.07	.704
Argumentation	15	3.33	.724
Field Trip	15	3.47	.516
Laboratory Approaches	15	3.07	.704
Project-Based Learning	15	3.07	.594
Problem-Based Learning	15	3.20	.775
Analogy	15	3.40	.737
Role Playing/Drama	15	3.27	.704
Overall	15	3.19	.368

The third criterion which was "Technology Selections", evaluated the compatibility of selected technologies with goals or strategies regarding curriculum or instruction in revised lesson plans of the pre-service science teachers. When the descriptive statistics were examined for third criterion, the results were similar with first and second criteria. The mean and standard deviation scores obtained were given in table 19 as follows.

According to the results obtained for the third criterion in Tables 19 was considered, it could be stated that pre-service science teachers showed lower performance than the first and second criteria in general. Pre-service teachers showed the highest mean scores in Analogy (*M*=3.33). This teaching method was followed by Role Playing/Drama and Field Trip (*M*=3.27) methods. Moreover, pre-service science teachers' Demonstration (*M*=2.20) method's lesson plans had the lowest score , while they showed performance below the overall mean scores in Learning Cycle (*M*=3.00), Argumentation (*M*=3.00) and Project-based Learning (*M*=2.93) methods' revised lesson plans too.

Table 19. *Technology Selections scores in revised lesson plans with respect to different teaching methods.*

Teaching Methods	N	Mean	SD
Demonstration	15	2.20	.862
Learning Cycle	15	3.00	.845
Argumentation	15	3.00	.378
Field Trip	15	3.27	.458
Laboratory Approaches	15	3.07	.704
Project-Based Learning	15	2.93	.258
Problem-Based Learning	15	3.07	.594
Analogy	15	3.33	.617
Role Playing/Drama	15	3.27	.594
Overall	15	3.07	.278

Lastly, the fourth criterion which is the "Fit" of the scale examined with respect to different teaching methods. In this criterion it was evaluated the abilities of pre-service science teachers in building lesson plans within the content, technology and instructional strategies suit each other. The results obtained to evaluate Fit criterion of the rubric were presented in the Table 20.

Table 20. *Fit scores in revised lesson plans with respect to different teaching methods.*

Teaching Methods	N	Mean	SD
Demonstration	15	2.67	.488
Learning Cycle	15	2.60	.828
Concept Cartoon Argumentation	15	2.87	.640
Field Trip	15	3.20	.561
Laboratory Approaches	15	2.80	.676
Project-Based Learning	15	2.80	.414
Problem-Based Learning	15	2.80	.862
Analogy	15	3.20	.676
Role Playing/Drama	15	3.20	.561
Overall	15	2.90	.294

Fit criterion, which was the last criterion of the scale, was the criterion in which the pre-service teachers in general showed the lowest performance compared to the other criteria of the Technology Integration Assessment Rubric. According to the results, pre-service science teachers had the highest scores in Field Trip (M=3.20), Analogy (M=3.20) and Role Playing/Drama (M=3.00) methods' revised lesson plans.

Furthermore, unlike other criteria, pre-service teachers performed below the overall average in more teaching methods in this criterion. Argumentation (*M*=2.87), Problem-based Learning (*M*=2.80), Laboratory Approaches *M*=2.80), Problem-based Learning *M*=2.80), Demonstration *M*=2.67) and Learning Cycle *M*=2.60) were the teaching methods' revised lesson plans in which pre-service teachers had scores below the overall average score (*M*=2.90) in fourth criterion.

It was also was examined how the total scores obtained from the rubric changed according to different teaching methods. In this context, first of all, minimum, maximum, mean and standard deviation scores of the different teaching methods were calculated from descriptive statistics of total results obtained from the rubric. The obtained results were presented in the Table 21 as follows.

Table 21. *Total scores in revised lesson plans with respect to different teaching methods.*

Teaching Methods	N	Minimum	Maximum	Mean	SD
Demonstration	15	8	14	11.13	1.959
Learning Cycle	15	6	16	11.86	2.748
Argumentation	15	8	16	12.73	2.051
Field Trip	15	11	16	13.40	1.502
Laboratory Approaches	15	8	16	12.40	2.444
Project-Based Learning	15	8	14	12.07	1.580
Problem-Based Learning	15	9	16	12.47	2.532
Analogy	15	9	16	13.47	2.232
Role Playing/Drama	15	10	16	13.27	2.052
Overall	15	10.78	14.89	12.53	1.201

When the results were investigated, it was seen that the ability of pre-service science teachers to integrate technology into revised lesson plans was increased. The results obtained from revised lesson plans appeared to be very close to each other. When the Table 21 is considered, it was stated that pre-service science teachers integrated technology most effectively into revised lesson plans which they prepared according to the Analogy (M=13.47) method. In addition, it was observed that they performed better than the overall scores in their revised lesson plans prepared according to Field Trip (M=13.40), Role Playing (M=13.27) and Argumentation (M=12.73) methods. In the lesson plans developed according to the teaching methods of Demonstration (M=11.83) and Learning Cycle (M=11.86), the pre-service science teachers showed the lowest performance and remained below the average of the overall results.

4.2.3. Research Question 2c

RQ2c: Are there any significant differences between the technology integration qualities of lesson plans prepared by pre-service science teachers with respect to different teaching methods of science?

The scores obtained from revised lesson plans were used and Friedman Test which is another "non-parametric test" was applied in SPSS in order to examine whether the scores of the pre-service science teachers changed or not with respect to different teaching methods. As a result of this analysis, a Chi-Square value and a significance value (Asymp. Sig. or p) was obtained. The Chi-Square calculated from the data was found as 19.410 and the significance (p) value was found as 0.013. Based on these results, it could be said that there was a significant difference between the measurements of different teaching methods when the significance level of the Chi-Square value was examined, because the obtained p value (0.013) was less than 0.05. In other words, the teaching methods have been identified as a variable affecting the quality of pre-service science teachers' technology integration.

Table 22. *Post-hoc analysis results*

Comparison	Z	p	N
Demonstration – Learning Cycle	-1.003	.316	15
Demonstration - Argumentation	-2.441	.015	15
Demonstration – Field Trip	-2.842	.004	15
Demonstration – Laboratory Approaches	-1.686	.092	15
Demonstration – Project-based Learning	-1.643	.100	15
Demonstration – Problem-based Learning	-1.926	.054	15
Demonstration - Analogy	-2.974	.003	15
Demonstration – Role Playing/Drama	-2.577	.010	15
Learning Cycle - Argumentation	-1.450	.147	15
Learning Cycle - Field Trip	-2.024	.043	15
Learning Cycle - Laboratory Approaches	-0.386	.700	15
Learning Cycle - Project-based Learning	-0.221	.825	15
Learning Cycle - Problem-based Learning	-0.601	.548	15
Learning Cycle - Analogy	-1.790	.073	15
Learning Cycle - Role Playing/Drama	-1.642	.101	15
Argumentation - Field Trip	-1.031	.303	15
Argumentation - Laboratory Approaches	-0.473	.636	15
Argumentation - Project-based Learning	-1.266	.206	15
Argumentation - Problem-based Learning	-0.506	.613	15
Argumentation - Analogy	-0.884	.377	15
Argumentation - Role Playing/Drama	-0.319	.750	15
Field Trip - Laboratory Approaches	-1.390	.165	15
Field Trip - Project-based Learning	-2.419	.016	15
Field Trip - Problem-based Learning	-1.365	.172	15
Field Trip - Analogy	-0.162	.872	15
Field Trip - Role Playing/Drama	-0.418	.676	15
Laboratory Approaches - Project-based Learning	-0.594	.552	15
Laboratory Approaches - Problem-based Learning	-0.222	.824	15
Laboratory Approaches - Analogy	-.1.169	.242	15
Laboratory Approaches - Role Playing/Drama	-1.478	.139	15
Project-based Learning - Problem-based Learning	-0.600	.548	15
Project-based Learning - Analogy	-1.822	.068	15
Project-based Learning - Role Playing/Drama	-1.946	.052	15
Problem-based Learning - Analogy	-1.457	.145	15
Problem-based Learning - Role Playing/Drama	-1.257	.209	15
Analogy - Role Playing/Drama	-0.277	.782	15

In order to determine which measurements were different, “Post-hoc analysis with Wilcoxon signed ranks test” was conducted, because non-parametric tests were suggested to be used when the sample size was smaller than 30 by Dwidedi et. al. (2017). In addition, Bonferroni correction, which was resulted in a significance level as $\alpha = 0.001$, was utilized in order to eliminate Type I error. The obtained post-hoc analysis results were presented in Table 22. When the obtained results were investigated it was observed that all the p values for each comparison was bigger than 0.001 indicates that differences among all the measurements of different teaching science methods were not significant.

4.3. Research Question 3

RQ3: What are the pre-service science teachers’ technology integration qualities in practice in the Science Methods Course enhanced by the application of TPACK-IDDIRR Model in practice?

In the present study, not only it has been investigated how pre-service science teachers’ TPACK self-efficacy levels and the quality of integrating technology into lesson plans but also how effectively they operate the selected technologies in the learning environment. For this purpose, one pre-service science teacher from each group was asked to make micro-teachings in accordance with their lesson plans and their micro-teachings were recorded by video. The video recordings were evaluated using “Technology Integration Observation Instrument (Hofer et. al. 2011)”, because it was developed for observation according to the lesson plan evaluating rubric used in the current study which was Technology Integration Assessment Rubric. Four criteria in Observation Instrument were the same with Technology Integration Assessment Rubric’s criteria with only two additional criteria. The first additional criterion was “Instructional Use” which evaluated how effective the chosen technology was in the instruction process. The second additional criterion was “Technology Logistics” that evaluated how effectively the technologies selected by pre-service science teachers were operated.

The micro-teachings of pre-service science teachers were evaluated using Technology Integration Observation Instrument by the researcher. The mean scores of the obtained data from the instrument were calculated in SPSS and the overall scores of each criterion were presented in the Figure 15.

In line with the above results, it was seen that pre-service science teachers were most effective in their micro-teachings in the Instructional Strategies & Technologies criterion (*M*=2.98). In other words, their ability to support the instructional strategy with technology was more developed than other criteria. At the same time, it has been observed that they performed less than other criteria in Instructional Use (*M*=2.65) and Technology Logistics (*M*=2.63) criteria. It has been concluded that pre-service science teachers showed lower performance in ability of using technologies with the purpose of instruction and ability of operating technologies effectively with respect to other criteria.

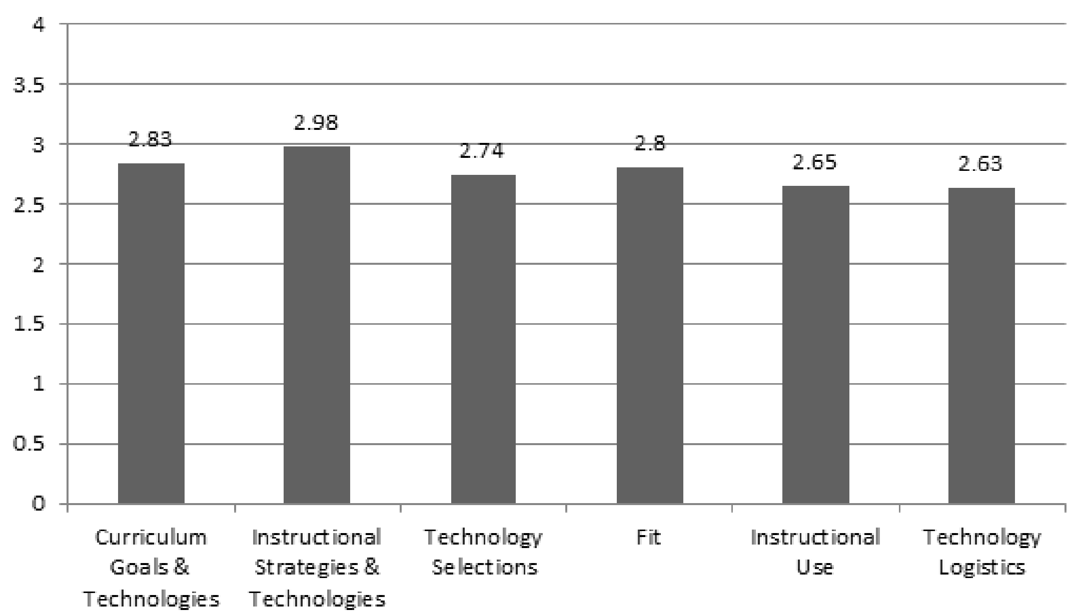

Figure 15. Overall mean scores for criteria of the Technology Integration Observation Instrument

In addition, the total scores obtained from pre-service teachers' micro-teaching in different teaching methods were compared. For this purpose, the scores obtained from each criterion of the scale were added and their mean scores were calculated according to each teaching method. The results were shown in Figure 16.

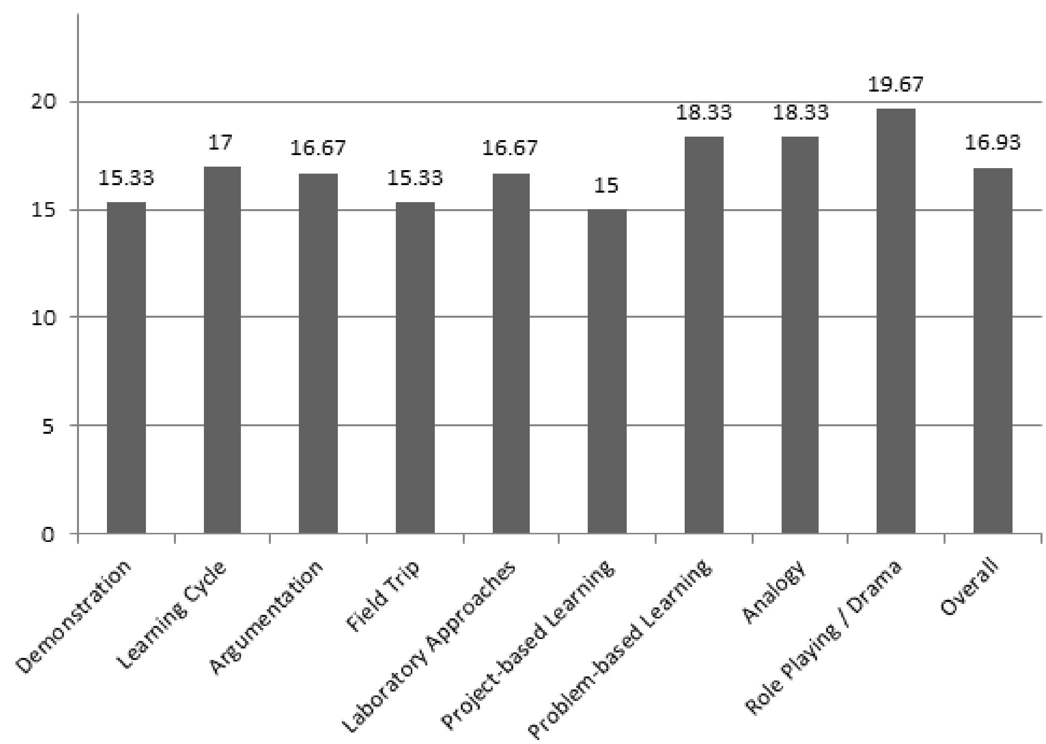

Figure 16. Technology integration qualities in practice with respect to different teaching methods

When the obtained results were interpreted, it was seen that pre-service science teachers showed the highest performance in the Role Playing/Drama (M=19.67) method. In addition, they also performed above the overall score (M=16.93) in the Problem-based Learning (M=18.33), Analogy (M=18.33) and Learning Cycle (M=17.00) methods. When the other data related to the other teaching methods in the figure was examined, it could be stated that the pre-service science teachers' performance were generally below the overall performance. They showed the least performance in Project-based Learning (*M*=18.33) method while they were under the overall performance in Laboratory Approaches (*M*=16.67), Argumentation (*M*=16.67), Field Trip (*M*=15.33) and Demonstration (*M*=15.33) methods.

Furthermore, according to the Technology Integration Observation Instrument results, it was observed that pre-service teachers use ICT tools in general for the purpose of transferring knowledge or assessment. The most commonly preferred ICT tools among teachers were Kahoot, Simulations, Prezi Presentations and Videos, respectively. Although it was less frequent, it has been observed that pre-service teachers integrate more complex ICT tools such as virtual experiments, games, virtual reality or augmented reality tools into their micro-teachings. In addition, it was observed that pre-service science teachers used the same ICT tools for more than one teaching methods such as Nearpod, Mindomo or Edmodo. Moreover, while teachers used 4 types of ICT tools on average in micro-teachings at the first four weeks of the course, after the fifth week it was observed that they used approximately 8 types of ICT tool, which was operated with different aims such as presenting lesson (e.g., Nearpod), assessment (e.g., Socrative), creating concept maps (e.g., Mindomo), and virtual environments (e.g., Smoke City Game or Golabz) in their micro-teachings. It was also observed that the teachers used the technologies taught in general and made great effort to integrate them into their micro-teachings. On the other hand, it was observed that pre-service science teachers were not able to manage the process well when they encountered physical barriers to use technology such as loosing internet connection. Lastly, it could be said that pre-service teachers do not prefer specific science topics; they used various topics from the elementary science curriculum from various grades.

CHAPTER 5

DISCUSSION, IMPLICATION AND RECOMMENDATION

In this section, discussion, conclusion and recommendations of the current study were presented. Firstly, the findings gained from analysis of the data provided by the data collection tools used to gather evidence for the research questions of the study were discussed and concluded briefly. Subsequently, recommendations for future researches and practices were provided.

5.1. Discussion

Even though technology has played an important role in human life throughout history, it has recently evolved to become an integral part of our lives. At the time when technology was consumed so fast, it was unthinkable that education would not take place in this wave. Teachers with technological competence became an inevitable necessity in order to be able to achieve the expectation of alpha generation also called as “children of millennials”, which has achieved significant technological competence before coming to school. As evidenced by the continuous inclusion of ICT in teachers’ developmental needs in OECD TALIS (2009, 2013, 2018) reports, technology competence has become a necessity rather than a need for teachers. Therefore, the reality of integration of technology into education has become an important consideration in the academic environment (Agyei & Voogt, 2012). Simply making teachers competent in technological knowledge is not enough in a field like education that has to be considered in many aspects and has many affecting variables. In this complex structure, it is very demanding to train teachers who can make effective technology integration into educational environment. For this purpose, more than one study has been conducted in the field and it is still being done.

In the light of these requirements, the current study was conducted to examine and develop the pre-service teachers' ability to integrate the teaching environment effectively with technology. In this study, science methods course enriched with TPACK-IDDIRR (Lee & Kim, 2014) model which is one of the TPACK development models was used. The model was chosen because it was believed that the harmony between the setting of the course and the structure of the model would be effective on the development of pre-service science teachers. The current study with experimental design was triangulated via different data collection types (survey, lesson plans, observations) aiming to increase reliability and validity.

Firstly, the TPACK efficacy levels of pre-service science teachers were investigated. When TPACK-Deep scale was applied before the treatment, it was determined that pre-service science teachers perceived TPACK efficacy levels were at an average level. The finding did not align with the results obtained from more than one studies in the field. In other studies (e.g., Simsek, Demir, Bagceci & Kinay, 2013; Keser, Karaoglan Yılmaz & Yılmaz, 2015) TPACK efficacy levels of academic staff and pre-service teachers were found as high level. However, the reason for this difference may be due to the pre-test results of the TPACK efficacy of pre-service teachers. According to post-test results, TPACK efficacy levels of pre-service teachers were found to be high in parallel with the other studies.

The finding of high level of the TPACK efficacy of pre-service teachers after treatment indicated that the science methods course enhanced by the application of TPACK-IDDIRR model had an effect on TPACK efficacy levels of pre-service teachers. In a similar vein, other studies conducted in the field showed that the treatments to improve TPACK efficacy levels of pre-service teachers were effective (e.g., Ersoy, Kabakci Yurdakul & Ceylan, 2016; Gokdas & Torun, 2017). Nevertheless, statistical analyzes were performed to inquire whether this finding was statistically significant or not. As a result of the evidence obtained from the analysis, it has been proved that the science methods course had a significant positive effect on the TPACK efficacy levels of pre-service teachers. In fact, when the effect size of this effect was calculated, it was seen that the effect which increased the TPACK efficacy levels of pre-service teachers from average to high level, was large.

The results were also examined in terms of sub-factors (design, exertion, ethics and proficiency) in order to examine the TPACK efficacy levels of pre-service teachers and the effect of treatment in more depth. In the TPACK efficacy sub-factors, it was revealed that pre-service science teachers perceived themselves sufficient in ethics, exertion, design and proficiency factors, respectively. Similarly, in the studies (Albayrak Sari, Canbazoglu Bilici, Baran & Ozbay, 2016; Coklar & Ozbek, 2017) conducted with teachers, they considered themselves as most efficient in ethic factor and considered themselves less efficient in proficiency factor than other factors. Considering the similarity of both teachers and pre-service teachers in the perception of TPACK efficacy sub-factors, their sensitivity to the importance of ethical principles was remarkable. Furthermore, the fact that teachers and pre-service teachers perceive themselves as inefficient in the proficiency factor compared to other factors might indicate that a certain level had been reached in terms of TPACK development, but that the level of proficiency had not been reached.

The other significant finding of the study was the increase in the post-test results in all sub-factors. Within the scope of the study, development was examined in terms of all sub-factors and a positive change with statistically significant and large effect size was observed in all sub-factors. In addition, it was found that exertion was the most affected factor and ethic was least affected. In the light of all these findings, it could be said that the science methods course had a significant impact in terms of design, exertion, ethics and proficiency on TPACK efficacy levels of pre-service science teachers. The development in the efficacy levels of pre-service science teachers might be due to the fact that pre-service teachers had opportunity to experience many technologies closely throughout the science methods course enhanced by the application of TPACK-IDDIRR model and TPACK training given in the first step (Introduce) of the model used in the current study. In addition, feedback, reflections and discussions on technologies which selected by pre-service teachers within the science methods course might have supported this outcome.

Secondly, pre-service science teachers' quality of technology integration was investigated in the current study. According to the lesson plans evaluated, it was determined that technology selection abilities which are compatible with curriculum goals or objectives were more developed than other skills. In a similar study (McCusker, 2017) conducted with teachers in the field, observed that teachers' technology selection abilities aligned with curriculum goals were quite high, although they did not get the highest achievement in the related ability. In this case, it could be concluded that both pre-service science teachers and teachers can select effective technologies according to their objectives. On the other hand, in both the current study and the study (McCusker, 2017) conducted with teachers, it was determined that ability to bring together pedagogy, content and technology in harmony was less developed than other abilities. The deficiency in quality of this ability of both pre-service science teachers and teachers revealed the necessity of focusing on this ability.

The current study has not only contributed to TPACK research by supporting or refuting the findings of similar studies, but it also contributed to the field by assessing TPACK levels via technology integration quality of pre-service science teachers from a different point of view. Quality of technology integration of pre-service science teachers were investigated regarding different teaching methods of science for each sub-criteria. At the end of the investigation, it was observed that the pre-service science teachers showed best performance in argumentation method in terms of first sub-criteria which was technology selection abilities aligned with curriculum goals. For the second sub-criterion, which was ability to select technologies to support instructional strategies or to use technology in teaching or learning, pre-service teachers demonstrated best performance in teaching with analogy method. It was also observed that their ability to select technologies compatible with goals or strategies regarding curriculum or instructional strategies (third sub-criterion) more developed in field trip and role playing/drama methods than other teaching methods. According to the last criterion, which was the ability to bring together pedagogy, content and technology in harmony, pre-service science teachers performed the best in the field trip and analogy methods. All of these results revealed that TPACK levels of pre-service science teachers might vary with respect to sub-criteria and teaching methods.

When the general results obtained from all sub-criteria were examined, it was seen that pre-service science teachers could integrate technology in different quality and they integrated technology into analogy method in the most effective way. Pre-service science teachers, who were determined to integrate technology effectively in general, showed the inefficient performance in demonstration method. It could be argued that this was due to the first week of the treatment and adaptation process. However, in the results obtained from the revised lesson plans after the treatment and feedback, they again showed the most inefficient performance in demonstration method. This indicates that the reason for the low performance was originated from the teaching method.

The various performances of pre-service science teachers in different teaching methods indicated that teaching methods could be a variable affecting the technology integration quality of pre-service science teachers. In the current study, statistical analyzes were applied to the scores obtained from revised lesson plans in order to prove this situation as evidenced by the results, a statistically significant difference was found among teaching methods. In other words, it was concluded that the quality of technology integration and TPACK levels might be affected by the change of teaching methods. The reasons for this important finding require thorough investigation and could be revealed by qualitative studies.

Another finding of the study about the quality of technology integration was an increase in the level of technology integration quality for all teaching methods after the science methods course. Based on the evidence obtained from the statistical tests, it was concluded that the course had statistically significant effect with large effect size for all teaching methods on the technology integration quality and TPACK levels of pre-service science teachers. This result was in contradiction with the findings of similar study by Price (2003) -the pre-service teachers did not show any observable development in integration of technology from the first and last lesson plan and Integrated Triadic Model (ITM) had no effect on technology integration of pre-service teachers- and this contradiction might be due to the TPACK development model used in the studies.

Lastly, the current study contributed the TPACK research field by investigating pre-service science teachers' quality of technology integration in practice. It has been observed that pre-service science teachers integrate technology with good quality level in micro-teachings in general, although differences may occur. They showed the best performance in practice in terms of technology integration in the role playing/drama method and the lowest performance in the project-based learning method. In addition, when all the teaching methods were examined, the overall results for sub-criteria showed that pre-service science teachers' ability to use technology for instruction and ability to operating selecting technologies effectively was deficient with respect to other sub-criteria. This findings was aligned with the results obtained from the other studies (Clark, Zhang & Strudler, 2015; Heintzelman, 2017) conducted with both pre-service teachers and in-service teachers in the field. The fact that both teachers and pre-service teachers' ability to use technology for instruction and ability to operating selecting technologies effectively were lower than the other sub-criteria might indicate that the desired level of technology integration has not yet been achieved in practice.

To sum up, TPCK efficacies and technology integration qualities of pre-service science teachers were developed significantly during the science methods course enhanced by the application of TPACK-IDDIRR model. Similarly, in the studies (Jang & Chen, 2010; Canbazoglu Bilici, Guzey & Yamak, 2016) it has been reported that technology integration performances were increased when they experienced the TPACK developmental programs or courses. Thus, it could be concluded as creating effective learning environments where pre-service teachers experience the technology integration actively from different aspects (content, pedagogy and technology), was effective on TPACK development of pre-service teachers and their ability to design effective teaching environments with technology.

5.2. Implications

The results of the current study indicated that Science Methods Course enhanced by the application of TPACK-IDDIRR Model had positive effect on TPACK efficacy levels and technology integration qualities of pre-service science teachers. Hence, the setting of the study could be used in the science methods course in order to develop pre-service science teachers TPACK levels and it could be adjusted into the courses focusing the internship of pre-service science teachers in order to develop their technology integration qualities via authentic processes. Moreover, the development program of the study could be utilized in online career development programs for in-service science teachers who need to increase ICT integration quality into their classroom environment.

Throughout the present study, the pre-service science teachers designed the lessons enhanced by the application of ICT tools with respect to different science teaching methods. After they designed the technologically enriched learning environment with appropriate content, they experienced the pros and cons of their ICT tool selections and appropriateness to the chose content and pedagogy in their micro-teachings helped them to discover the importance of TPACK in both practice and lesson designing process. Thus, the academic staff in the educational faculties could consider increasing pre-service science teachers' opportunity to experience classroom environments with content, pedagogy and technology and re-constructing their courses which are aimed to develop their technology integration qualities in learning environments.

5.3. Recommendations

In the light of the findings obtained from the research, suggestions for both future researches and applications are presented below:

- In the study, it was found that TPACK efficacy of pre-service teachers after the treatment were quite good. In order to encourage the teachers to use technology and to integrate new technologies into the curriculum, the textbooks should be rearranged in line with technology-supported courses. It was also recommended that instructors who teach at the universities should incorporate different technologies into their courses and that pre-service teachers should be allowed to experience such technologies actively.

- As evidenced by both current study and similar studies (e.g., Jang & Chen, 2010; Canbazoglu Bilici, Guzey & Yamak, 2016), conducting TPACK development programs for pre-service teachers had a positive impact on their technology integration qualities. Therefore, it is recommended to increase the number of studies in this field and to also construct development programs for in-service teacher in schools.

- In the current study, it has been revealed that science teaching methods are a variable affecting the technology integration quality of pre-service teachers. Therefore, it is recommended to consider this finding in future studies, and it is recommended to repeat the same study with larger groups to ensure the findings of the current study. In fact, qualitative studies might be conducted to investigate the reasons of this situation.

- The study was limited to pre-service science teachers who had a large university in Ankara due to access. Similar studies can be conducted in different provinces or universities and the similarity of the results or the reasons for differentiation can be examined. In addition, different development models can be used, longitudinal studies can be conducted, or similar studies can be done with in-service teachers.

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APPENDICES

A. LESSON PLAN TEMPLATE

(Name of the Teaching Method) Lesson Plan, e.g. DEMONSTRATION LESSON PLAN

Group Members: **Date:**

Duration: 40 or 80 min (not less not more)

Name of the Unit & Topic: Write according to the curriculum, e.g. 6.3.2. Physical and Chemical Changes.

Grade Level:

Prior Knowledge What prior knowledge do you expect students to know related to that topic before they come to the class?

Possible Misconceptions: What might be the possible misconceptions that students have before they come to the class?

Connection with Other Subjects in Curriculum: Write according to the curriculum, e.g. 5.3.1. Changes in States of Matter.

Objectives: Write down the objectives of this lesson using action verbs. You are expected to determine your objectives aligned with the objectives given in the curriculum; you can revise them, or add other objectives as long as you stay in the scope of the curriculum objectives.

Instructional Materials and Technologies: Write all materials and ICT tools that will be used in this lesson, e.g. computer, worksheets (add to appendix if available), mobile app (share the link), simulation (share the link) and so on. Also explain:

· For which purpose the selected ICT tools will be used? (e.g. teaching the topic, making a virtual experiment, getting attention, assessment, classroom management etc.)

· How the particular technologies used in this lesson/project "fit" your objectives?

· How do the particular technologies used in this lesson/project "fit" your teaching method?

· How do these ICT tools, objectives and the teaching method used all fit together in this lesson?

TEACHING PROCEDURE

Introduction: Explain your strategies for starting the lesson. e.g. how you will connect students' prior knowledge to current topic, how you will take their attention, how you will introduce the topic, how you will start the activity and so on.

Middle: Explain your main procedures/strategies/activities for teaching the current topic. e.g. how you will reach your objectives, what is the main activity of the lesson, what questions you will ask, what directions you will give, what students are doing, what teacher is doing and so on.

Closure: Explain how you will end the lesson. e.g. how you will summarize/review the current topic, how you will set the stage for next lesson, how you will assess your students or give homework and so on.

Note: Do not forget to integrate ICT tools in your teaching procedure and explain in detail how you will use the selected ICT tools in this activity part. You are also expected to point out where you reach each objective with parenthesizes as (Obj. 1).

Assessment: Explain which assessment strategies will be used and why. Also match you assessment strategies with your objectives. e.g. a quiz will be used because mainly factual knowledge will be assessed (obj. 3-5).

Appendices: Attach any additional instructional material that will be used in this lesson and referred in the plan. e.g. worksheet, lap report template, quiz and so on.

References: Please add references of all of your sources. Check APA style guidelines website (https://owl.english.purdue.edu/owl/resource/560/01/) for examples and explanations.

B. TPACK-DEEP SCALE

BÖLÜM 1: KİŞİSEL BİLGİLER

1. **Ad / Soyad:** ………………………………………………..
2. **Cinsiyetiniz:**

   ☐ Kadın ☐ Erkek
3. **Kaçıncı sınıftasınız?** ....
4. **Aşağıdaki teknolojik araçlardan hangilerine sahipsiniz?**
   - ☐ Dizüstü bilgisayar
   - ☐ Masaüstü bilgisayar
   - ☐ Netbook
   - ☐ Ultrabook
   - ☐ Tablet
   - ☐ Akıllı telefon
   - ☐ E-kitap okuyucu
   - ☐ Diğer (lütfen yazınız)...
5. **Teknoloji ile ilgili üniversitede aldığınız derslerin isimlerini yazınız lütfen.**
   1. ....
   2. ....
   3. ....
   4. ....
   5. ....
6. **ELE344 (Methods of Teaching Science II) dersini daha önce aldınız mı?**
   - ☐ Evet
   - ☐ Hayır

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

		Karşılama Düzeyiniz				
		Kesinlikle Yapamam	Yapamam	Kısmen Yapabilirim	Yapabilirim	Rahatlıkla yapabilirim
1	Teknolojiden yararlanarak bir öğretim materyalini gereksinimlere (öğrenci,ortam, süre vb.) uygun olarak güncelleyebilme	□	□	□	□	□
2	Öğretim süreci öncesinde öğrencilerin içeriğe dayalı gereksinimlerini belirlemek için teknolojiden yararlanabilme	□	□	□	□	□
3	Öğretme-öğrenme sürecini zenginleştirmek için gereksinime uygun etkinlik geliştirmede teknolojiden yararlanabilme	□	□	□	□	□
4	Öğretme-öğrenme sürecini teknolojik olanaklara uygun olarak planlayabilme	□	□	□	□	□
5	Konu alanı öğretiminin niteliğini artırmak amacıyla kullanılacak teknolojilere yönelik gereksinim analizi yapabilme	□	□	□	□	□
6	Bilgi ve İletişim Teknolojileri uygulamalarını kullanarak (eğitim yazılımı, sanal laboratuar vb.) öğretim süresini optimum düzeye getirebilme	□	□	□	□	□
7	Gereksinime uygun ölçme aracı geliştirmede teknolojiden yararlanabilme	□	□	□	□	□
8	Konu içeriğinin etkili bir şekilde aktarılması için yöntem, teknik ve teknolojilerin özelliklerini değerlendirerek birbirleriyle uyumlu olanları seçebilme	□	□	□	□	□
9	Etkili bir öğretme-öğrenme süreci için gereksinime uygun materyal tasarlamak amacıyla teknolojiden yararlanabilme	□	□	□	□	□
10	Öğretme-öğrenme sürecinin gerçekleştirileceği ortamı teknoloji kullanımına uygun olarak düzenleyebilme	□	□	□	□	□
11	Teknolojinin kullanıldığı öğretme-öğrenme süreçlerinde sınıf yönetimini sağlayabilme	□	□	□	□	□
12	Öğrencilerin öğretim sürecine ilişkin geçerli bilgiye sahip olma durumlarını uygun teknolojileri kullanarak ölçebilme	□	□	□	□	□
13	Bireysel farklılıklara uygun öğretim yaklaşım ve yöntemlerini teknoloji yardımıyla uygulayabilme	□	□	□	□	□
14	Ödev, proje, staj gibi eğitsel etkinlikleri yürütmede teknolojiden yararlanabilme	□	□	□	□	□
15	Öğretim sürecinde teknoloji destekli iletişim ortamlarından (blog, forum, sohbet, e-posta vb.) yararlanabilme	□	□	□	□	□
16	Öğrencilerin konu alanına ilişkin başarı durumlarını değerlendirmede teknolojiyi kullanabilme	□	□	□	□	□

		Karşılama Düzeyiniz				
		Kesinlikle Yapamam	Yapamam	Kısmen Yapabilirim	Yapabilirim	Rahatlıkla yapabilirim
17	Öğretim sürecinde etik kurallara uygun teknoloji kullanımında öğrenciye model olabilme	□	□	□	□	□
18	Öğrencilerin teknolojiye dayalı ürün (sunu, oyun, film vb.) veya etkinlik (ödev, proje vb.) oluşturma sürecine rehberlik yapabilme	□	□	□	□	□
19	Öğretme-öğrenme sürecine destek amaçlı güncel teknolojik yeniliklerden (facebook, blog, wiki, twitter, podcasting vb.) yararlanabilme	□	□	□	□	□
20	Öğretimi gerçekleştirilecek konu alanı bilgi ve becerilerini güncellemede teknolojiden yararlanabilme	□	□	□	□	□
21	Öğretim sürecinde kullanılan teknoloji bilgisini güncel tutabilme	□	□	□	□	□
22	Öğretim sürecine ilişkin bilginin güncel tutulmasında teknolojiden yararlanabilme	□	□	□	□	□
23	Eğitim ortamlarında teknolojinin erişimi konusunda etik davranabilme	□	□	□	□	□
24	Konu alanı öğretiminde yararlanılacak özel/mahrem bilgileri teknoloji aracılığıyla edinmede (ses kaydı. video kayıt. doküman vb.) ve kullanmada etik kurallara uyma	□	□	□	□	□
25	Öğretme-öğrenme sürecinin her aşamasında teknolojiden fikri mülkiyet (telif. lisans vb.) konularına uyarak yararlanabilme	□	□	□	□	□
26	Teknoloji tabanlı öğretim ortamlarında (WebCT, Moodle vb.) sürecin her aşamasında öğretmenlik mesleği etik kurallarına uyma	□	□	□	□	□
27	Öğretme-öğrenme sürecinde öğrencileri geçerli ve güvenilir dijital kaynaklara yönlendirerek doğru bilgiye ulaşmalarına rehberlik edebilme	□	□	□	□	□
28	Eğitim ortamlarında teknolojinin sağlıklı kullanımı konusunda etik davranabilme	□	□	□	□	□
29	Teknoloji tabanlı öğretim ortamlarında (WebCT. Moodle vb.) karşılaşılabilecek problemleri çözebilme	□	□	□	□	□
30	Öğretme-öğrenme sürecinin her aşamasında teknolojiden yararlanırken ortaya çıkabilecek sorunları çözebilme	□	□	□	□	□
31	Konu alanıyla ilgili karşılaşılan problemlere (içeriğin yapılandırılması. güncellenmesi. gerçek yaşamla ilişkilendirilmesi vb.) yönelik çözüm üretmede teknolojiyi kullanabilme	□	□	□	□	□
32	Alanıyla ilgili teknolojik yeniliklerin öğretim sürecinde kullanımının yayılmasına liderlik edebilme	□	□	□	□	□
33	İçeriğin aktarımı sürecinde karşılaşılan problemlerin çözümü için teknolojiden yararlanma konusunda disiplinler arası işbirliği yapabilme	□	□	□	□	□

C. TECHNOLOGY INTEGRATION ASSESSMENT RUCRIC

Technology Integration Assessment Rubric[1,2,3]

Criteria	4	3	2	1
Curriculum Goals & Technologies (Curriculum-based technology use)	Technologies selected for use in the instructional plan are strongly aligned with one or more curriculum goals.	Technologies selected for use in the instructional plan are aligned with one or more curriculum goals.	Technologies selected for use in the instructional plan are partially aligned with one or more curriculum goals.	Technologies selected for use in the instructional plan are not aligned with any curriculum goals.
Instructional Strategies & Technologies (Using technology in teaching/ learning)	Technology use optimally supports instructional strategies.	Technology use supports instructional strategies.	Technology use minimally supports instructional strategies.	Technology use does not support instructional strategies.
Technology Selection(s) (Compatibility with curriculum goals & instructional strategies)	Technology selection(s) are exemplary, given curriculum goal(s) and instructional strategies.	Technology selection(s) are appropriate, but not exemplary, given curriculum goal(s) and instructional strategies.	Technology selection(s) are marginally appropriate, given curriculum goal(s) and instructional strategies.	Technology selection(s) are inappropriate, given curriculum goal(s) and instructional strategies.
"Fit" (Content, pedagogy and technology together)	Content, instructional strategies and technology fit together strongly within the instructional plan.	Content, instructional strategies and technology fit together within the instructional plan.	Content, instructional strategies and technology fit together somewhat within the instructional plan.	Content, instructional strategies and technology do not fit together within the instructional plan.

[1] Harris, J., Grandgenett, N., & Hofer, M. (2010). Testing a TPACK-based technology integration assessment instrument. In C. D. Maddux, D. Gibson, & B. Dodge (Eds.). *Research highlights in technology and teacher education 2010* (pp. 323-331). Chesapeake, VA: Society for Information Technology and Teacher Education (SITE).

[2] Adapted from: Britten, J. S., & Cassady, J. C. (2005). The Technology Integration Assessment Instrument: Understanding planned use of technology by classroom teachers. *Computers in the Schools, 22*(3), 49-61.

D. TECHNOLOGY INTEGRATION OBSERVATION INSTRUMENT

Technology Integration Observation Instrument

Observer ____________________________ Teacher ____________________________ Date____________

Grade Level(s) _______ Subject Area(s) ____

Primary Learning Goals ____

Directions:

We have tried to key the components of this instrument to different aspects of teachers' knowledge for technology integration. Please note, however, that the instrument is *not designed to assess this knowledge directly.* It is designed to focus upon the use of technology integration knowledge in observable teaching. Please record the *key curriculum topics addressed*, *instructional strategies/learning activities observed*, and *digital and non-digital technologies used* by the teacher and/or students in the lesson.

Curriculum Topic	Key Instructional Strategies/Learning Activities	Digital[1] & Non-Digital[2] Technologies

What, if anything, do you know about influences upon what you have observed in this lesson? Examples might include students' learning needs, preferences, and challenges; access to technologies; cultural, language and/or socioeconomic factors.

[1] Computer-based (e.g., software, Web-based resources, video or audio recorder, document camera, calculator)

[2] Not computer-based (e.g., overhead projector, textbook, whiteboard, pen/pencil/marker)

Technology Integration Observation Instrument[3i]

Directions: Referring to the notes you made on the previous page, including your responses to the question about influences, please complete the following rubric, considering the lesson as a whole.

	4	3	2	1
Curriculum Goals & Technologies (Matching technology to curriculum)	Technologies used in the lesson are strongly aligned with one or more curriculum goals.	Technologies used in the lesson are aligned with one or more curriculum goals.	Technologies used in the lesson are partially aligned with one or more curriculum goals.	Technologies used in the lesson are not aligned with one or more curriculum goals.
Instructional Strategies & Technologies (Matching technology to instructional strategies)	Technology use optimally supports instructional strategies.	Technology use supports instructional strategies.	Technology use minimally supports instructional strategies.	Technology use does not support instructional strategies.
Technology Selection(s) (Matching technology to both curriculum and instructional strategies)	Technology selection(s) are exemplary, given curriculum goal(s) and instructional strategies.	Technology selection(s) are appropriate, but not exemplary, given curriculum goal(s) and instructional strategies.	Technology selection(s) are marginally appropriate, given curriculum goal(s) and instructional strategies.	Technology selection(s) are inappropriate, given curriculum goal(s) and instructional strategies.
"Fit" (Considering curriculum, pedagogy and technology all together)	Curriculum, instructional strategies and technology fit together strongly within the lesson.	Curriculum, instructional strategies and technology fit together within the lesson.	Curriculum, instructional strategies and technology fit together somewhat within the lesson.	Curriculum, instructional strategies and technology do not fit together within the lesson.

	4	3	2	1
Instructional Use (Using technologies effectively for instruction)	Instructional use of technologies is maximally effective in the observed lesson.	Instructional use of technologies is effective in the observed lesson.	Instructional use of technologies is minimally effective in the observed lesson.	Instructional use of technologies is ineffective in the observed lesson.
Technology Logistics (Operating technologies effectively)	Teachers and/or students operate technologies very well in the observed lesson.	Teachers and/or students operate technologies well in the observed lesson.	Teachers and/or students operate technologies adequately in the observed lesson.	Teachers and/or students operate technologies inadequately in the observed lesson.

Comments:

E. APPROVAL OF METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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14 MART 2016

Gönderilen: Prof.Dr. Jale ÇAKIROĞLU

İlköğretim Bölümü

Gönderen: Prof. Dr. Canan SÜMER

İnsan Araştırmaları Komisyonu Başkanı

İlgi: Etik Onayı

Sayın Prof.Dr. Jale ÇAKIROĞLU'nun danışmanlığını yaptığı yüksek lisans öğrencisi İskender ATAKAN'ın "TPACK-IDDIRR Modeli Entegre Edilmiş Özel Öğretim Yöntemleri Dersi Aracılığı İle Aday Öğretmenlerin TPACK Gelişimi" başlıklı araştırması İnsan Araştırmaları Komisyonu tarafından uygun görülerek gerekli onay **2016-EGT-033** protokol numarası **30.03.2016-26.06.2016** tarihleri arasında geçerli olmak üzere verilmiştir.

Prof. Dr. Canan SÜMER

Uygulamalı Etik Araştırma Merkezi

İnsan Araştırmaları Komisyonu Başkanı

APPENDIX F: PERMISSION FORM

ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu araştırma, ODTÜ İlköğretim Fen ve Matematik Eğitimi Bölümü Yüksek Lisans öğrencisi İskender Atakan tarafından yüksek lisans tezi kapsamında yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın Amacı Nedir?

Araştırmanın amacı, "Özel Öğretim Yöntemleri (Methods of Teaching Scince II (ELE344)" dersi aracılığı ile öğretmen adaylarının teknolojik pedagojik alan bilgilerinin geliştirilmesidir.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?

Araştırmaya katılmayı kabul ederseniz sizden dönem başı ve dönem sonu olmak üzere iki adet anket doldurmanız ve açık uçlu soruları yanıtlamanız beklenmektedir. Ayrıca mikro-öğretimler esnasında görüntü kaydı alınacak ve ders planlarınız teknolojik pedagojik alan bilgisinin gelişimini değerlendirmek amacıyla incelenecektir.

Sizden Topladığımız Bilgileri Nasıl Kullanacağız?

Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Cevaplarınız tamamıyla gizli tutulacak ve sadece araştırmacılar ve dersin asistanları tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve bilimsel yayımlarda kullanılacaktır.

Katılımınızla ilgili bilmeniz gerekenler:

Araştırma, genel olarak kişisel rahatsızlık verecek sorular veya uygulamalar içermemektedir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz çalışmayı yarıda bırakmakta serbestsiniz. Böyle bir durumda çalışmayı uygulayan kişiye çalışmadan çıkmak istediğinizi söylemek yeterli olacaktır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Araştırma sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için İlköğretim Fen ve Matematik Eğitimi yüksek lisans öğrencisi İskender Atakan (eposta: e173211@metu.edu.tr) ya da İlköğretim Bölümü öğretim üyelerinden Prof. Dr. Jale Çakıroğlu (eposta: jaleus@metu.edu.tr) ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

İsim Soyad Tarih İmza

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G. TURKISH SUMMARY / TÜRKÇE ÖZET

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ TPİB YETERLİK DÜZEYLERİ VE TEKNOLOJİ ENTEGRASYON NİTELİKLERİ: TPACK-IDDIRR MODELİNİN UYGULANMASI

Giriş

Tarih boyunca teknoloji insan hayatında sürekli önemli bir yere sahip olmuştur. Günümüzde ise teknoloji yadsınamaz bir alan haline geldi ve yaşamımızın her alanına entegre olmaya başladı. Günümüzde insanlar modern teknolojilerin kullanımının yaşam kalitesini arttırdığı ve iletişimi güçlendirdiği için yaşamın her alanında bir zorunluluk haline geldiği konusunda hemfikirdir (Younes & Al-Zoubi, 2015). Tüm bu gelişmelerin karşısında eğitimin bu durumdan etkilenmemesi düşünülemez. Ayrıca çalışmalar da teknolojideki hızlı değişimlerin okulları etkilediğini ve öğrenme ortamında birçok multimedya teknolojinin bulunduğunu göstermiştir (Pedretti, Smith ve Woodrow, 1998).

Eğitimin bu dönüşümü göz ardı edilemez ve öğrencilerin akıllı teknolojilerle çevrili bir dünyaya adapte olabilmeleri için geleneksel eğitimden farklı şekilde eğitilmeleri gerekmektedir (Marr, 2019). Ancak, teknolojiyi eğitime entegre etmenin faydalarının yanında birtakım riskleri de beraberinde getirdiği unutulmamalıdır. Teknoloji doğru kullanıldığında oldukça etkili bir araç olabilir. Örneğin, sonuçları hızlandırarak ve sanal ortamlar yaratarak, gerçek hayatta sonuçlarını gözlemlemenin imkânsız olduğu bilimsel olguların sonuçlarını gözlemeyi mümkün kılabilir (McCrory, 2008). Öte yandan, teknoloji sayesinde erişilebilen bilgilerin çoğunluğu bilgi kirliğine sebep olabilir. Bu nedenle, teknolojiyi sınıf içinde etkin ve uygun şekilde kullanmak çok önemlidir.

Teknoloji ve sınıf ortamını etkin bir şekilde bir araya getirmenin yolu, öğretmenleri teknoloji entegrasyon yetkinlikleri ile eğitmektir. Bu da ancak uygun modeller ve bilgi alanları ile olabilir. Bundan dolayı, öğretmenlerin içerik bilgileri, pedagojik bilgileri ve alan bilgileri arasındaki etkileşimi tanımlamak için, Shulman'ın (1987) pedagojik içerik bilgisi modelinin üzerine inşa edilen TPİB kavramı geliştirilmiştir (Koehler & Mishra, 2008).

TPİB çerçevesine göre öğretmenlerin sahip olması gereken içerik bilgisinin, teknolojik bilginin ve pedagojik bilginin harmanlanmasıyla TPİB bilgi alanı doğmaktadır. TPİB çerçevesi, öğretmenlerin teknolojik bilgilerini nasıl kullanabilecekleri ve teknolojiyi sınıfa nasıl etkili şekilde yönlendirebileceklerini anlama konusunda bir kılavuz sunar (Harris, Mishra & Koehler, 2009). Aynı zamanda çerçeve teknoloji alanında çalışmalar yapan araştırmacılar için sağlam bir temel vaat etmektedir. Yine de model alanda çok tartışılmıştır ve bazı eksiklikleri olduğu gün yüzüne çıkmıştır. Her ne kadar çerçevede teknolojik bilgi başlı başına bir bilgi alanı olarak görülse de çerçevede sunulan teknoloji tanımı net değildir. Benzer şekilde Graham (2011), çalışmasında net teknoloji tanımı barındırmamasından dolayı, araştırmacıların TPİB çerçevesini göz önünde bulundurarak teknoloji bilgisinin kapsamını ve tanımı belirlemek amacıyla belirli çalışmalar yönettiklerini belirtmiştir. Örneğin, Angeli ve Valanides (2009), teknoloji tanımını bilgi ve iletişim teknolojileri (BİT) olarak daraltmışlar ve teknolojinin ne anlama geldiği konusundaki karmaşayı gidermek için bilgi birikimi olarak BİT-TPİB kavramını önermişlerdir. Kavram, teknolojik araçlar ve olanakları, içerik, öğrenci, pedagoji ve bağlam hakkında bilginin öğrenciler tarafından öğrenilmesi zor konuların içerisine sentezlenmesi olarak tasvir edilmektedir ve teknolojiyle zenginleştirilmiş öğrenme ortamları geliştirmek amacıyla öğretmenler için bir bilgi tabanı olarak kabul edilir (Angeli & Valanides, 2009). Güncel çalışmada da teknoloji kavramı BİT araçlarıyla sınırlandırılmıştır.

Kısacası, öğretmenler teknolojinin sınıf ortamına etkili bir şekilde entegre edilmesinde en önemli etmendir. Bu, üniversitelerden TPİB yeterliliklerine sahip öğretmen adayları yetiştirmenin arzu edilen başarılı sonuçlara ulaşmayı kolaylaştıracağı anlamına gelir. Gerekli yeterliliklere sahip öğretmenler yetiştirmenin yolu da iyi planlanmış derslerin geliştirilmesinden ve uygun gelişim modellerinin uyarlanmasından geçmektedir.

Çalışmanın Amacı ve Önemi

Birçok alanda ilerleme kaydetmek için teknolojik gelişmeleri takip etmek için teknolojik gelişmeleri takip etmek zorunluluk haline gelmiştir. Çocukların teknolojiyi erken yaşta kullandıkları gerçeği göz önüne alındığında, onları teknoloji yoluyla eğitim sürecine dahil etmek ve teknolojiyle zenginleştirilmiş öğretim ortamlarına erişmelerini sağlamak çok önemlidir. Özellikle fen bilimleri dersinde teknoloji kullanımı kritik bir öneme sahiptir. Çünkü, fen dersleri, günümüzde bilimin çoğunlukla teknolojiye bağlı olmasından dolayı, teknolojiyi kullanmak için doğal ortamlar haline gelmiştir (McCrory, 2008). Ayrıca, Brenner (Ekim, 2015) teknolojinin sınıfın inkar edilemez derecede hayati bir parçası haline geldiğini ve eğitimcilerin yüzde 93'nün şimdi eğitime liderlik etmek için bazı teknolojik araçları kullandığını belirtti. Teknoloji ile ilgili becerilerin geliştirilmesinde ve istenilen sonuçların elde edilmesinde büyük bir sorumluluğa sahip olan öğretmenlerin, kendilerini yaş koşullarına göre eğitmeleri ve mevcut teknolojik yeterliliklerini üniversitedeki uygun derslerle güncellemeleri gerekmektedir.

Ancak sınıflardaki teknolojik araçların arttırılması, öğrenme ve öğretmenin etkinliğinin artacağını garanti etmemektedir. Bir başka deyişle, sınıftaki teknolojik araçlar etkili bir öğrenme ortamı için tek başına yeterli değildir. Teknoloji yardımıyla gerçekleştirilen eğitim aktivitelerinin etkinliği hala öğretmenlere bağlıdır (Koehler & Mishra, 2008). Bu nedenle, Angeli ve Valanides (2008), öğretmenlerin teknolojiyi derslerine entegre etmeleri ve geleneksel öğretimlerini değiştirmeleri için, yeni beceri ve teknikleri öğrenmeleri gerektiğini tavsiye etmektedir.

Tüm bu nedenler, öğretmen adaylarının teknolojiyi etkili bir şekilde sınıf ortamına ve derslerine entegre etmeleri için nasıl eğitilmesi gerektiği ve iyi yapılandırılmış derslerin nasıl olması gerektiği konusunda araştırmaların yapılmasının gerekliliğini ortaya koymuştur. Bu çalışma TPACK-IDDIRR (Lee & Kim,2014) modelinin entegrasyonu ile zenginleştirilen fen bilimleri öğretim yöntem ve teknikleri dersine kayıtlı fen bilimleri öğretmen adaylarının TPİB gelişimlerini incelemeyi amaçlamaktadır. Buna ek olarak, araştırmada sınıf ortamını teknoloji ile zenginleştirmek ve fen derslerinde teknolojinin nasıl kullanıldığını tecrübe etmek için öğretmen adaylarına seçilen modele göre tasarlanmış bir TPİB geliştirme programı önerilmektedir. Bu bağlamda, bu çalışmanın araştırma soruları şunlardır:

1. TPACK-IDDIRR modelinin uygulanmasıyla geliştirilen fen bilimleri öğretim yöntem ve teknikleri dersinin, öğretmen adaylarının TPİB etkinlik düzeylerine etkileri nelerdir?
2. TPACK-IDDIRR modelinin uygulanmasıyla geliştirilen fen bilimleri öğretim yöntem ve teknikleri dersinin öğretmen adaylarının ders planlarındaki teknoloji entegrasyon kalitesi üzerindeki etkisi nedir?
    a. Fen bilgisi öğretmen adaylarının farklı fen öğretim yöntemlerine göre hazırladıkları revize edilmemiş ders planlarının teknoloji entegrasyonu kalitesi nedir?
    b. Fen bilgisi öğretmen adaylarının farklı fen öğretim yöntemlerine göre hazırladıkları revize edilmiş ders planlarının teknoloji entegrasyonu kalitesi nedir?
    c. Fen Bilgisi Öğretmen Adaylarının farklı fen öğretim yöntemlerine göre hazırladıkları ders planlarının teknoloji entegrasyon nitelikleri arasında anlamlı bir fark var mıdır?
3. TPACK-IDDIRR modelinin uygulanmasıyla geliştirilen fen bilimleri öğretim yöntem ve teknikleri dersinde öğretmen adaylarının pratikte teknoloji entegrasyonu nitelikleri nelerdir?

Tanım ve Kısalmalar

Bilgi ve İletişim Teknolojileri (BİT): Bilgisayar ve iletişim teknolojilerinin, cep telefonları, internet ve kablosuz ağlar dahil, bilgi erişimi ve bilgi üretimi sağlayan kablosuz kullanımı ile oluşturduğu işitsel ve yazılı araçlardan oluşan bir koleksiyondur.

Teknolojik Pedagojik İçerik Bilgisi (TPİB): Teknoloji ile başarılı bir öğretimin öncülüğünü oluşturan ve içerik ve pedagojik prosedürlerini kullanarak teknoloji ile etkili eğitimin sunulduğu çerçevedir.

TPACK-IDDIRR Model: Öğretmen adaylarının TPİB seviyelerini geliştirmek amacıyla oluşturulan teknoloji entegrasyon derslerine uyarlanabilir bir çerçeve olarak hizmet veren tasarım modelidir.

Fen Bilimleri Öğretmen Adayı: Eğitim fakültesi, ilköğretim fen eğitim programlarında öğretmenlik mesleğine katılmak üzere yetiştirilecek öğrencileri ifade eder.

Yöntem

Fen Bilimleri öğretmen adaylarının TPİB değişimlerini incelemek amacıyla oluşturulan bu çalışmada, ön-test son-test deneysel tasarım kullanılmıştır. Bu tasarımda, teori bir hipotezi onaylamak veya çürütmek için nasıl veri toplanacağının belirlenmesiyle test edilir. Deneysel işlemlerden önce ve sonra, tasarım katılımcıların tutum ve ürünlerini değerlendirmek için kullanılır. Bu bağlamda, rastgele seçilen bir grup tedaviden önce test edilir, daha sonra çalışmanın amaçları doğrultusunda planlanan işlem uygulanır ve işlem sonunda son testler yapılır. Elde edilen verilerin analizinden sonra, tedaviden önce ve sonra yapılan ölçümlerdeki farklılıkların veya değişikliklerin, yapılan tedaviye bağlı olduğu varsayılmaktadır (Creswell, 2003).

Bu doğrultuda öğretmen adaylarının TPİB seviyelerini geliştirmek ve teknoloji entegrasyon dersinin bir parçası olarak kullanılabilmek amacıyla geliştirilen TPACK-IDDIRR (Lee & Kim, 2014) modeli fen bilimleri öğretim yöntem teknikleri dersinin içerisine entegre edilmiştir. Farklı disiplinlerden katılımcılarla gerçekleştirilen derslere uygun olmasına rağmen, modelin ve öğretim yöntem ve teknikleri dersinin prosedürlerinin ve doğasının örtüşmesi modelin seçilmesinde etkili olmuştur. 6 aşamalı (Tanıtma, Gösterme, Geliştirme, Uygulama, Yansıma ve Revize Etme) bir gelişim süreci öneren model dersin 12 haftalık genel süreci içerisine entegre edilmiştir.

Bu kapsamda öğretmen adaylarına ilk hafta dersin genel özellikleri sunulmuştur ve onlardan beklentiler dile getirilmiştir. Daha sonra dersin ikinci haftası öğretmen adaylarına TPACK-Deep ölçeği ile ön-test uygulanmıştır ve araştırmacı tarafından TPİB genel çerçevesi tanıtılmıştır (Tanıtma Aşaması). Bu aşamadan sonra ilk öğretim metodu ders eğitmeni tarafından sunulmuştur ve akabinde ders asistanları tarafından ilgili metoda uygun BİT araçlarıyla zenginleştirilmiş örnek mikro-öğretim gerçekleştirilmiştir (Gösterme Aşaması). Bu haftadan sonra süreç öğretmen adaylarının katılımının arttığı bir döngü olarak devam etmiştir. Öğretmen adayları 15 gruba ayrıldılar ve her grup bir önceki hafta öğrendiği öğretim metoduna uygun, BİT araçlarıyla zenginleştirilmiş ders planlarını hazırladılar ve dersin online platformuna yüklediler (Geliştirme Aşaması). Daha sonra hazırlanan ders planları doğrultusunda her gruptan 1 öğretmen adayı mikro-öğretim gerçekleştirmiştir (Uygulama Aşaması). Gerçekleştirilen mikro-öğretimler sonun-da ders asistanları pedagojik, içerik ve teknolojik bakış açılarıyla ilgili geribildirimlerini paylaştılar ve diğer öğretmen adayları da mikro öğretimin güçlü ve zayıf yönlerini dikkate alarak arkadaşlarına geri dönüt verdiler (Yansıtma Aşaması). Bu süreç tüm öğretim metotları için tekrarlanmıştır ve döngü her öğretmen adayı ve metot için tamamlanan kadar devam etmiştir. Daha sonra öğretmen adayları verilen geri dönütler doğrultusunda ders planlarını revize etmişlerdir ve portfolyolarını dersin online platformuna yüklemişlerdir (Revize Aşaması). Dersin sonunda öğretmen adaylarına son-test uygulanmış ve süreç tamamlanmıştır.

Katılımcılar

Güncel çalışma ilköğretim fen bilimleri öğretmenliği bölümünde 3. sınıfta fen bilimleri öğretim yöntem ve teknikleri dersini alan 57 öğretmen adayı ile gerçekleştirilmiştir. Öğretim yöntem ve teknikleri dersini alan öğretmenlerle çalışılmasının nedeni daha önceden öğretmen adaylarının teknolojik yeterliliklerini geliştirmeyi amaçlayan iki ders almış olmaları ve daha önceden ders planı hazırlama becerilerini kazanmış olmalarıdır.

Araştırmacının Rolü

Araştırmacı güncel çalışmada genellikle tasarımcı ve gözlemci rolü üstlenmiştir. Dönemin başında ders öncesinde araştırmacı tarafından TPİB çerçevesi öğretmen adaylarına sunulmuştur. Bunun yanı sıra teknolojinin fen dersine entegrasyonunun güçlü ve zayıf yanları da sunulmuştur. Daha sonra araştırmacı, ders asistanlarıyla toplantı yaparak, dersin eğitmenin rehberliğinde ilgili öğretim metoduna uygun BİT araçlarıyla zenginleştirilmiş mikro-öğretim örnekleri tasarlamıştır. Araştırmacı aynı zamanda, öğretmen adalarının mikro-öğretimlerine gözlemci olarak katılmıştır ve mikro-öğretimlerini değerlendirmiştir. Son olarak araştırmacı öğretmen adaylarına yönelik tartışmalar ve geri dönütlerin paylaşıldığı çevrimiçi ders platformunu organize etmiş ve yönetmiştir.

Varsayımlar

1. Fen Bilgisi öğretmen adaylarının veri toplama araçlarına içtenlikle cevap verdikleri varsayılmıştır.
2. Ders asistanlarının kendi görüşlerini içtenlikle yansıttığı ve kullanılan araçlara içtenlikle yanıt verdiği var sayılmaktadır.
3. Veri toplama araçlarının, öğretmen adaylarının TPAB etkinlik ve teknoloji entegrasyon kalitesini makul düzeyde ölçebildiği kabul edilmektedir.

Sınırlılıklar

1. Çalışma ilköğretim fen bilimleri 3. Sınıfına kaydolmuş 57 öğretmen adayı ile sınırlandırılmıştır.
2. Fen bilgisi öğretmen adaylarının teknoloji entegrasyon niteliğini ve TPİB yeterlik sevilerini belirlemek için kullanılacak veri toplama araçları araştırmacı tarafından tanımlanan araçlarla sınırlandırılmıştır.
3. Araştırmada teknoloji kavramı Bilgi ve İletişim Teknolojileri (BİT) ile sınırlandırılmıştır.

Veri Toplama Araçları

Güncel çalışmada veriler üç farklı araç yardımıyla kullanılmıştır. İlk olarak öğretmen adaylarının TPİB yeterliliklerini belirlemek amacıyla TPACK-Deep (Kabakci Yurdakul et al., 2012) ölçeği ön-test ve son-test olarak uygulanmıştır. Ölçek dizayn, uygulama, etik ve uzmanlaşma olmak üzere dört faktörden ve 33 maddeden oluşmaktadır. Dizayn faktörü öğretmenlerin teknolojiyle öğretim ortamını tasarlama ve zenginleştirme yeterliklerini ifade etmektedir. Bunun yanı sıra uygulama faktörü öğretim sürecini yürütmek için teknolojiyi kullanma yeterliklerini ifade ederken, etik faktörü, erişilebilirlik, doğruluk ve mahremiyet gibi teknolojiyle ilgili etik konuları içerir. Ölçeğin son faktörü olan uzmanlaşma faktörü, öğretmen adaylarının mesleğini, teknolojiyi, içerik ve pedagojiyle bütünleştirmek için uzmanlaştırma yeteneklerini belirtir.

Çalışmada bir diğer veri toplama aracı ise Harris, Grandgenett ve Hofer (2010) tarafından geliştirilen "Teknoloji Entegrasyon Değerlendirme Rubriği" olarak belirlenmiştir. İlgili ölçek öğretmen adaylarının farklı öğretim metotlarına göre hazırladıkları ders planlarına teknoloji entegrasyon niteliklerini değerlendirmek amacıyla kullanılmıştır. 4 kriterden oluşan ölçeğin ilk kriteri, müfredat hedeflerine göre teknoloji seçim kalitelerini değerlendirmektedir. İkinci kriter öğretim stratejilerinde teknoloji kullanımının etkinliği değerlendirilirken, üçüncü kriterde seçilen teknolojilerin öğretim stratejileri ve müfredat hedefleri ile uyumluluğu değerlendirilmektedir. Ölçeğin son kriterinde ise teknoloji, pedagoji ve içeriğin bir bütün olarak bir araya getirilip getirilmediği değerlendirilir (Harries et al., 2010).

Öğretmen adaylarının pratikteki teknoloji entegrasyon niteliklerini değerlendirmek amacıyla "Teknoloji Entegrasyonu Gözlem Aracı" (Hofer, Grandgenett & Swan, 2011) kullanılmıştır. Ölçek, Teknoloji Entegrasyon Değerlendirme Rubriğinin ilk 4 kriterinin üzerine 2 ek kriter eklenmesiyle elde edilmiştir. Beşinci kriterde pratikte teknolojinin eğitimsel kullanımını niteliğini değerlendirirken, son kriter gözlenen derste teknolojinin ne kadar etkili işletildiğini değerlendirmektedir.

Analiz ve Sonuçlar

Güncel çalışmada ilk olarak TPACK-IDDIRR modeli ile zenginleştirilmiş fen bilimleri öğretim yöntem ve teknikleri dersinin öğretmen adaylarının TPİB yeterlikleri üzerindeki etkisi araştırılmıştır. Bu amaçla TPACK-Deep ölçeğinden elde edilen ön-test ve son test sonuçları karşılaştırılmıştır. Ön-testten elde edilen toplam sonuçlar incelendiğinde öğretmen adaylarının ortalama 123.46 (Orta Düzey) puan aldığı görülmektedir. Alınan eğitimden sonra uygulanan son-testten alınan sonuçlarda ise öğretmen adaylarının TPİB yeterlik düzeylerinin 146.70 ortalamaya, yani ileri düzeye çıktığı görülmüştür. Bu bağlamda sonuçlardan elde edilen artışın anlamlı olup olamadığını değerlendirmek amacıyla "bağımlı örneklemler için t-testi" uygulanmıştır. Yapılan analiz sonucunda ders öncesi uygulanan ön-test puanları ve ders sonrası uygulanan son-test puanları arasında anlamlı bir fark olduğu gözlemlenmiştir ($t=-9.499$, $p<0.05$). Diğer bir deyişle TPACK-IDDIRR modeliyle zenginleştirilen fen bilimleri öğretim yöntem ve teknikleri dersinin öğretmen adaylarının TPİB yeterlikleri üzerinde pozitif bir etkisi olduğu söylenebilir. Etki büyüklüğünü değerlendirmek amacıyla da eta kare (η^2) değeri hesaplanmıştır ve hesaplamalar sonucunda etkinin büyük ($\eta^2 = 0.62$) olduğu sonucuna varılmıştır. Ayrıca ön-test ve son-test puanları arasında alt faktörler açısından bir fark olup olamadığı yine t-testi ile değerlendirilmiştir. Test sonucu elde edilen sonuçlara göre tüm alt faktörler (Dizayn, Uygulama, Etik ve Uzmanlaşma) açısından ön-test ve son-test sonuçları arasında büyük etkiye sahip istatistiksel olarak anlamlı farklar bulunmuştur.

Daha sonra TPACK-IDDIRR modeli ile zenginleştirilmiş fen bilimleri öğretim yöntem ve teknikleri dersinin, öğretmen adaylarının farklı öğretim metotlarına (Gösteri, Öğrenme Döngüsü, Argümentasyon, Alan Gezisi, Laboratuvar Yaklaşımları, Proje Tabanlı Öğrenme, Problem Tabanlı Öğrenme, Analoji ve Drama/Rol Yapma) göre hazırladıkları ders planlarına teknoloji entegrasyon nitelikleri üzerindeki etkisi araştırılmıştır. Dersin etkisinin olup olamadığına karar vermek için uygulama öncesi hazırlanan ders planlarıyla, uygulama esnasında verilen geri dönütler sonrası hazırlanan ders planlarından elde edilen sonuçlar karşılaştırılmıştır. Sonuçlar incelendiğinde öğretmen adaylarının farklı öğretim metotlarına göre hazırladıkları ders planlarının puanlarında önemli ölçüde bir artış gözlemlenmiştir. Bu artışın anlamı olup olmadığını değerlendirmek için ise parametrik olmayan testlerden biri olan "Wilcoxon İşaretli Sıralar Testi" kullanılmıştır. Test sonucu elde edilen sonuçlar değerlendirildiğinde Argümantasyon ($p=0.24> 0.06$) metodu hariç tüm öğretim metotları açısından büyük etkiye sahip anlamlı farklar bulunmuştur. Tüm bu sonuçlara bakıldığında TPACK-IDDIRR modeliyle zenginleştirilmiş öğretim yöntem ve teknikleri dersinin öğretmen adaylarının teknoloji entegrasyon nitelikleri üzerinde pozitif etkisi olduğu söylenebilir.

Ayrıca öğretmen adaylarının farklı öğretim metotlarına göre hazırladıkları revize edilmemiş ders planlarındaki teknoloji entegrasyonu nitelikleri incelenmiştir. Revize edilmemiş ders planlarından elde edilen sonuçlar incelendiğinde öğretmen adaylarının ilk kriter olan müfredat hedeflerine göre teknoloji seçim kalitelerinin diğer kriterlere göre daha yüksek seviyede olduğu gözlemlenmiştir. Daha sonra kriterler kendi aralarında farklı ders anlatım metotlarıyla hazırlanmış ders planlarından elde edilen sonuçlar açısından değerlendirilmiştir. Ölçeğin ilk kriteri olan eğitim hedefleri doğrultusunda teknoloji seçme niteliklerinin en iyi laboratuvar yaklaşımlarında olduğu gözlemlenmiştir. Ayrıca ikinci kriter olan öğretim stratejilerinde teknoloji kullanımının etkinliği kriterinde en iyi performansı analoji metodunda göstermişlerdir. Üçüncü önemli kriter olan müfredat hedefleri ve seçilen öğretim stratejilerinin teknoloji ile uyumluluğu kriterinde en yüksek puanları Alan gezisi ve drama metotlarında almışlardır. Ders planlarından elde edilen genel sonuçlara göre ise öğretmen adaylarının teknoloji entegrasyon niteliklerinin analoji metodunda en yüksek seviyede olduğu belirlenirken, gösteri metodunda en düşük seviyede olduğu belirlenmiştir.

Öğretmen adaylarının revize edilmemiş ders planlarında teknoloji entegrasyon niteliklerinin incelenmesinden sonra revize ettikleri ders planlarındaki teknoloji entegrasyon nitelikleri araştırılmıştır. Revize edilmiş ders planlarından elde edilen sonuçlar incelendiğinde öğretmen adaylarının yine ilk kriter olan müfredat hedeflerine göre teknoloji seçim kalitelerinin diğer kriterlere göre daha yüksek seviyede olduğu gözlemlenmiştir. Ders planlarından elde edilen genel sonuçlara göre ise öğretmen adaylarının teknoloji entegrasyon niteliklerinin genel olarak yükseldiği ve analoji metodunda en yüksek seviyede olduğu belirlenirken, gösteri metodunda en düşük seviyede olduğu belirlenmiştir.

Daha sonra öğretmen adaylarının teknoloji entegrasyon niteliklerinin öğretim metotlarına göre değişim gösterip göstermediği araştırılmıştır. Bu amaçla revize edilen ders planlarından elde edilen verilere parametrik olmayan testlerden biri olan Friedman Testi uygulanmıştır. Testten elde edilen sonuçlara göre öğretmen adaylarının teknoloji entegrasyon nitelikleri öğretim metoduna göre anlamlı bir farklılık göstermektedir ($p=0.013<0.05$). Hangi ölçümler arasında fark olduğunu belirlemek amacıyla ise post-hoc analizi olarak Wilcoxon işaretli sıralar testi uygulanmıştır. Elde edilen post-hoc analiz sonuçları incelendiğinde farklı öğretim metotlarının tüm karşılaştırılmaları arasında anlamlı bir farklılık bulunmamıştır.

Son olarak ilgili çalışmada öğretmen adaylarının pratikte teknoloji entegrasyon nitelikleri araştırılmıştır. Öğretmen adaylarının gerçekleştirdiği microöğretimlerden elde edilen veriler incelendiğinde öğretmen adaylarının teknolojilerin eğitimsel kullanımı ve teknolojinin derste etkili işletilmesi kriterlerinde diğer kriterlere göre düşük performans gösterdikleri gözlemlenmiştir. Ayrıca gözlemlerden elde edilen genel sonuçlara bakıldığında öğretmen adaylarının uygulamada teknoloji entegrasyon niteliklerinin en iyi Rol Yapma/Drama metodunda olduğu gözlemlenmiştir.

Öneriler

Araştırmada öğretmen adaylarının TPİB yeterliklerinin dersten sonra oldukça iyi seviyeye geldiği görülmüştür. Öğretmenleri teknolojiyi kullanmaya ve yeni teknolojileri müfredata teşvik etmek için, ders kitapları teknolojiyle zenginleştirilmiş dersler doğrultusunda yeniden düzenlenmelidir. Ayrıca, üniversitelerde ders veren öğretim elemanlarının derslerinde farklı teknolojiler kullanmaları ve öğretmen adaylarının bu teknolojileri aktif olarak deneyimlemelerine izin verilmesi önerilmektedir.

Çalışma erişilebilirliğin zorluğundan dolayı Ankara'da büyük bir üniversitedeki fen bilimleri öğretmen adayları ile sınırlandırılmıştır. O yüzden farklı illerde ve farklı üniversitelerde benzer çalışmaların yapılması ve sonuçların benzerlik ve farklık nedenlerinin incelenmesi önerilmektedir. Ayrıca benzer şekilde öğretmen adaylarıyla birlikte daha uzun soluklu çalışmalar gerçekleştirilebilir.

Güncel çalışmada öğretim yöntem ve tekniklerinin öğretmen adaylarının teknoloji entegrasyon kalitelerini etkileyen bir değişken olduğuna dair bazı bulgular edinilmiştir. Bu nedenle gelecekteki çalışmalarda bu bulguya dikkat edilmesi önerilmektedir ve durumun nedenlerinin araştırılması amacıyla derinlemesine nitel çalışmalar yapılması önerilmektedir.

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Pre-service Science Teachers’ TPACK Efficacy Levels and Technology Integration Quality: Application of TPACK-IDDIRR Model

<u>**TEZİN TÜRÜ**</u> **/** <u>DEGREE**:**</u> **Yüksek Lisans** / Master **Doktora** / PhD

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