OBSERVABLE INDICATORS OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) IN SCIENCE CLASSROOMS THROUGH VIDEO RESEARCH

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ABSTRACT

OBSERVABLE INDICATORS OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) IN SCIENCE CLASSROOMS THROUGH VIDEO RESEARCH

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The purpose of the study was to examine the observable indicators of science teachers' technological pedagogical content knowledge (TPACK) through a multiple case study with video research. The study was carried out in a private campus school offering primary and secondary education level of education. Following multiple case study methodology, design and implementation of process of technology-enhanced science instruction among in-service science teachers were investigated in-depth in order to explore observable indicators of science teachers' TPACK. 4 in-service science teachers, teaching at the private campus school in 2015-2016 spring semester, were the participants of the study. Data sources were semi-structured pre-video interviews, video recordings of classroom teaching and semi-structured post video interviews. Multiple case study methodology in support of video research was conducted in the lessons of four in-service science teachers, embracing an organized and systematic attitude towards the analysis of teaching performance. The results of the study provided rich contextual information of the cases, observable TPACK indicators emerged in the design and implementation processes of technology enhanced science instruction as well as teachers' motives towards technology integration.

Keywords: TPACK, TPACK in Science Education, Observable TPACK Indicators, Video Research Method

ÖZ

FEN BİLİMLERİ SINIFLARINDA VİDEO ÇALIŞMASI ARACILIĞI İLE GÖZLEMLENEN TEKNOLOJİK PEDAGOJİK ALAN BİLGİSİ (TPAB) GÖSTERGELERİ

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Bu çalışmanın amacı, Fen Bilgisi öğretmenlerinin sınıflarında video çalışması aracılığı ile bulgulanan, gözlemlenebilir teknolojik pedagojik alan bilgisi (TPAB) göstergelerini araştırmaktır. Bu araştırma, ilk ve orta dereceli seviyede eğitim veren bir özel okulun akıllı kampüsünde yürütülmüştür. Çoklu durum çalışması özelinde, gözlemlenebilir TPAB göstergeleri, teknolojinin entegre edildiği fen derslerinin tasarım ve uygulama sürecinin detaylı olarak incelenmesi yolu ile ortaya koyulmuştur. Belirtilen özel okulun 2015-2016 eğitim ve öğretim yılı içerisinde, fen eğitimi alanında farklı branşlarda çalışan 4 hizmet içi öğretmen, araştırmada katılımcı olarak yer almıştır. Veri kaynakları video öncesi yarı yapılandırılmış görüşme formu, ders süreci video kaydı ve video sonrası yarı yapılandırılmış görüşme formundan oluşmaktadır. Dört hizmet-içi fen öğretmeninin sınıfında çekilen ders süreci video kayıtları, düzenli ve sistematik bir yöntem ile analiz edilerek, çoklu durum çalışması ile entegre edilmiştir. Sonuçlar, incelenen her bir durumun geçtiği bağlam hakkında zengin bilgi sunmasının yanı sıra, teknolojinin entegre edildiği fen derslerinin tasarım ve uygulama aşamalarında bulgulanan gözlemlenebilir TPAB göstergelerini ve fen öğretmenlerinin teknoloji kullanımları ile ilgili motivasyonlarını ortaya koymuştur.

Anahtar Kelimeler: TPAB, Fen Bilgisi Derslerinde TPAB, Gözlemlenen TPAB Göstergeleri, Video Araştırma Yöntemi

To Freedom

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INTRODUCTION

1.1. Background of the Study

History of civilization sheds light on the role of technology in the transformation of societies. Since the first days of humankind, technology has been a great contributor of social progression through the manipulation of the nature with intent to better suit conditions for survival (Rutherford & Ahlgren, 1990). This implies that, the driving force behind the technological developments originates from the instinct to comprehend the facts of the universe and improve the conditions in favor of humanity. Clearly, scientific knowledge accelerates the advancements in the field of technology (Longbottom & Butler, 1999). The other way around, apart from providing innovative tools for science, technology provides continuous encouragement and guidance for scientific research and development (Rutherford & Ahlgren, 1990). Taking strength from each other, science and information technologies have complementary functions to transform society's (Bull & Bell, 2008; Campbell & Abd-Hamid, 2013) attitude towards the "knowledge work" (p.49), the way of "teaching, learning and thinking" (Halverson & Smith, 2009, p.49). Provoking paradigm shift in individual's knowledge management, Papert (1984) anticipated that computers would feature in revolutionizing educational systems. That is to say, centralizing learners role through the opportunity of production and assessment of own knowledge, information technologies today promise to enhance learner's experiences (Halverson & Smith, 2009). To illustrate, technology use in inquiry-based science classrooms enables students to work like scientists (Guzey & Roehrig, 2009; Novak & Krajcik, 2006).

Science is a way to attach meaning to the world that human being's reside. Inarguably, science looks for valid and concrete answers towards the facts of the universe for centuries, as being non-stop, evidence-based and cumulative effort of the mankind. Briefly, science includes by all means of progression of scientific knowledge as well as grasp of natural facts and laws (National Academy of Sciences, 2007). Addressing to this twofold notion of science learning, Smith and Siegel (2004) claims that initial goal of science education is to target student knowledge in collaboration with development in cognitive functioning unique to the discipline, that is "the claims and theories of science, the current best explanations of how things work as well as the nature and methods of science" (p.562). In consequence, by virtue of science education, students should gain the ability of creative and critical thinking, inquiry, and argumentation by adopting scientist's perspective.

Science in 21st century, on the other hand, relies upon innovative technologies such a large extent that existence of certain disciplines and resultant scientific progression would be inconceivable without certain technologies (Bull & Bell, 2008). Therefore, science education not being touched by technological revolution remains incapable of raising innovative workforce and addressing the needs of globalized world, in turn. On that account, to instill scientist's perspective and engage learners with actual steps of scientific investigation, teachers are encouraged to integrate various information technologies in science classrooms (Guzey & Roehrig, 2009; NRC, 1996; Pringle, Dawson, & Ritzhaupt, 2015). Broad range of these technologies such as probeware, microprocessors, smart boards, mobile applications, and 3-D modeling programs etc. are now being used by science teachers to motivate students towards learning science and increase the rate of comprehension towards natural events (Hug, Krajcik, & Marx, 2005; Park, 2008; Pringle et al., 2015). Such a variety of technologies offered to teachers and students, put the subject domain in an advantaged position (Jimoyiannis, 2010). Hence, the key concern is how to design and present powerful teaching processes (Angeli & Valanides, 2009) by drawing maximum advantage from educational technologies offered to science education.

Learning science is more than "accumulation of the knowledge" (Niess, 2005, p.510), accordingly science education is supposed to create opportunities for students to conduct scientific research by following relevant practices and procedures in the context of stimulated working conditions of scientists. Putting emphasis on scientific knowledge cannot evolve without scientific research, phases of scientific research is of vital importance. Today, computer technologies are accepted as basic and necessary component of conducting scientific research by the scientific communities (La Velle Baggott, Mcfarlane, & Brawn, 2003). In this regard, inquiry-based technological tools enable students to work like scientists in science classrooms (Guzey & Roehrig, 2009; Novak & Krajcik, 2006).Thus, not only the members of science community but also their educational counterparts should follow the research trends. However, there is an evident gap between "pedagogic subject knowledge in science education in schools and the applied academic knowledge" (Byrne & Brodie, 2012, p.103) stemming from the absence of emphasis on technological components in the educational settings. In consideration of the fact that pedagogical use of technologies are highly influenced by the content which they are integrated with (Graham et al., 2009), lack of knowledge about the pedagogical implications of technological tools would limit the quality of teaching and learning experiences in answering the needs of innovative science education (Jang & Tsai, 2013). Therefore, how to design and present powerful teaching processes by taking the advantage of educational technologies is of crucial importance in science teaching (Angeli & Valanides, 2009). Teachers are required to re-examine their pedagogical attitudes and re-organize teaching processes in this direction (Pamuk, 2012).

Additionally, governments spend large amounts of money to equip educational institutions with ICT infrastructure in an attempt to improve the quality of education. This implies that traditional educational environments are now being transformed into high-tech learning environments. To illustrate, between the years of 2008 and 2009, government of the United States spent $ 6.5 billion to educational establishments and government of New Zealand spends $ 410 million on each your to ICT infrastructure (Buabeng Andoh, 2012). Moreover, Movement of Enhancing Opportunities and Improving Technology Project (FATİH Initiative), which was launched by Turkey's Ministry of Education (MoNE) in 2012, aimed to equip 40.000 schools and 620.000 classrooms with ICT hardware (Tablet P.C, Interactive white boards (IWB)) and it is predicted that the government of Turkey will have spent $ 25 billion by the academic year of 2017-2018. However, this does not guarantee effective use of provided technologies in classroom environments. Even though studies indicated that technology use during instruction is on the increase (Tondeur, Kershaw, Vanderlinde, & van Braak, 2013), efficient integration of available technologies is an issue of concern. In other words, technology use in the classroom setting remains as an “add-on” (p.1259) activity which limits the potential of ICT usage in classrooms (Jimoyiannis, 2010). Technological progressions centralize teachers’ role as change agents in the process of successful technology adoption (Yu, 2012). Correspondingly, epistemology of technological pedagogical content knowledge (TPACK) is proved to be an efficient framework to guide teachers in effective use of technology in various subject domains (Jang & Chen, 2010; Lin, Tsai, Chai, & Lee, 2012). In this regard, Technological Pedagogical Content Knowledge (TPACK) theoretical framework sheds light on the knowledge that teachers of 21st century should possess in order for effective use of technology in various subject domains (Jang & Chen, 2010; Lin, Tsai, Chai, & Lee, 2012).

This special kind of knowledge stands for the ways that technology facilitates in coping with “the pedagogical challenges specific to the curriculum, students, and classroom setting” (Maeng, Mulvey, Smetana, & Bell, 2013, p.840). Clearly, the knowledge required for the efficient technology adoption differs greatly by the context it is proposed for. By quoting the motto of “teachers teach the way they were taught” (p.43), Flick and Bell (2000) put emphasis on the need for content-specific examples among the ways of technology advances the teaching and learning processes in reference to science teachers’ professional development. Nevertheless, there is a lack of substantive evidences of TPACK indicators among science content to inform science community about efficient technology integration (Lin et al., 2012). Absence of context-specific, naturally occurring TPACK indicators decelerates the pace of teachers’ professional development due to falling short of experiences to be set as an example to teach with technology. No doubt, the experiences take the lead in determination of teachers’ strengths and weaknesses in the process of technology adoption by identification and verification of TPACK constructs in science classrooms. Therefore, it is significant to observe nature and development of TPACK in action in order to examine science-specific indicators by evaluating the evidences in their own contextual features and set them as an example. Therefore, it is crucial to centralize studies towards meaningful technology adoption, accordingly internalization of technology adoption process by the teachers rather than what the technological tools offer solely (Otrel- Cass, Khoo, & Cowie, 2012), in an attempt discover "how and when to incorporate such technologies" (Niess, 2011, p.299).

Addressing the 21st century teachers' professional growth, researchers continuously search the nature and development of TPACK since the framework was put forward by Mishra & Koehler (2006). In this regard, technologically literate teachers are not only expected to use technology efficiently but also as a requirement of their profession, they should manage to combine technology, pedagogy and content knowledge as a whole. In order to provide this "nuanced understanding of the complex relationships between technology, content, and pedagogy" (Mishra & Koehler, 2006, p.1029), an authentic and experience-driven approach towards documentation and analysis of context-specific epistemology of TPACK is required, which is embedded in actual teaching performances of teachers. Besides, video research method enables researchers to study complex teaching processes by dividing the video recordings into meaningful segments and analyzing the fragments accordingly. However, there is lack of studies following real time observations through video research method in an attempt to observe development of TPACK in its own context and digging for instantaneous decisions behind the actions of teachers. In brief, the nature and development of TPACK. Accordingly, video recordings of actual teaching performances promise to reveal science-specific TPACK indicators within the contextual boundaries.

1.2. Purpose of the Study

The purpose of the study was to examine the observable indicators of science teachers' TPACK through a multiple case study with video research. Particularly, the study investigated research questions as follows:

- What are the indicators of science teachers' TPACK in the design of technology-enhanced teaching?

- What are the indicators of TPACK in teachers' actual teaching in science classrooms?

1.3. Significance of the Study

As proposed by Graham et al. (2009), pedagogical implications of the technologies vary across the subjects being integrated with. Concordantly, TPACK searches for (1) "how technological tools transform pedagogical strategies and content representations for teaching particular topics (2) how technology tools and representations impact a student's understanding of these topics"(Graham et al., 2009, p.71). Therefore, TPACK, in the context of being evaluated stand for specialized and unique form of knowledge system, which cannot be either generalized to all subject domains or confined to seven constructs arising from the framework itself. Likewise, Angeli and Valanides (2009) also propose that transformation of the content and pedagogy under the influence of what technology promises is of vital importance, which necessitates the context-level specialization of the TPACK model. However, lack of solid evidences concerning science teachers' TPACK in guiding literature (Lin et al., 2012) is the reason of ambiguity between the researchers on nature and development of domain specific epistemology of TPACK (Guzey & Roehrig, 2009), which hinder professional development of science teachers in the long run.

Another reason of the conflict concerning the issue is the effort to discriminate and classify identified evidences under the sub-components of TPACK in the literature in order to provide clarity on the boundaries of constructs (Cox & Graham, 2009). However, it is not easy to separate and classify the sub-components in the actual teaching performance (Angeli & Valanides, 2013; Archambault & Barnett, 2010; Jang & Tsai, 2013) by reason of the situated nature of TPACK. Therefore, the literature should lay emphasis on transformative indicators of science TPACK rather than following an integrative philosophy. That is, instead of investigating TPACK indicators for each sub-component separately, the focus should be shifted towards how the indicators are being transformed under the common construct of TPACK. On the other hand, studies designed to reveal nature of science TPACK predicated on the teachers' reported actions of the teachers (Graham et al., 2009; Jen, Yeh, Hsu, Wu, & Chen, 2016; Jimoyiannis, 2010). Yet, TPACK develops as it gets implemented due to its' situated and experience-driven nature. Therefore, literature falls behind in catching dynamic nature of TPACK because of lacking an authentic research methodology to reveal observable indicators of TPACK drawn from the actions of the teachers.

In an effort to measure TPACK knowledge and reveal it's nature, literature put emphasis on discrimination of the sub-components in consideration of reported evidences that stand for each constituent. Within this scope, various data collection tools are used to identify indicators of domain-specific TPACK components such as surveys (Archambault & Barnett, 2010; Graham et al., 2009) , case narratives (Mouza, Karchmer-Klein, Nandakumar, Yilmaz Ozden, & Hu, 2014), lesson designs (Angeli & Valanides, 2009), questionnaires (Jang & Tsai, 2013), in- depth interviews (Harris & Hofer, 2011; Yeh, Lin, Hsu, Wu, & Hwang, 2015). However, being "highly applied" (Harris & Hofer, 2011, p.212), situated and experience-driven type of knowledge, the nature of TPACK is hidden in the transparency of spontaneous actions of the teachers. This implies that, reported actions of teachers should be triangulated with the indicators drawn from the actual teaching performances in order to reveal the nature of TPACK. Hence, it is of prime importance to follow an authentic research methodology for the disclosure of context specific observable TPACK indicators. Contrary to the research trends in guiding literature, this study followed a video research methodology to close the research gap on nature and development of TPACK in science education by unveiling the process of technology adoption among science teachers (Srisawasdi, 2014).

1.4 Definition of the Terms

- **Pedagogical Content Knowledge (PCK):** A notion proposed by Shulman (1986) as an ability of "transformation of subject matter" (p.64) into teachable units (Koehler & Mishra, 2009)
- **Technological Pedagogical Content Knowledge (TPACK):** A framework, as an extension of Shulman's (1986) conception of PCK, stands for specialized kind of teacher knowledge, which searches for the influence of technology on adopted pedagogical approaches (Jang & Tsai, 2013; Koehler

& Mishra, 2009; Schmidt et al., 2009).

- **Smart Education:** An education system conducted with smart boards and tablet/tablet like devices. The devices are connected with a special kind of software which allow data transfer between devices as well as control over students' devices.
- **3-D High Technology Classroom:** 3-D presentation of the content provided by 3-D glasses.
- **Bring Your Own Device:** School policy allowing students to study with their own devices within the scope of smart education
- **Video Research:** Use of video recordings of classroom teaching as a data collection tool to capture classroom events in depicting the complex and multifaceted nature of instruction process.

CHAPTER 2

LITERATURE REVIEW

The purpose of the literature review is to provide an overview on TPACK in literature particularly in the context of science classrooms. First of all, TPACK as a knowledge system is discussed. Then, TPACK in science education is presented and in the next the indicators of TPACK knowledge system for science education are provided. Besides, the proposed models of TPACK in the guiding literature are explained. Lastly, the implications of video research method regarding TPACK framework are proposed.

2.1. Theoretical Roots of TPACK

Nowadays drawing an upward trend in education, digitalization becomes more of an issue in regard to science education (Baran, Canbazoglu Bilici, & Uygun, 2016). Undoubtedly, offer of high-end teaching and learning experiences stimulates the demand of technology use in the classrooms, as a salient consequence of progress in information technologies. Correspondingly, teachers encounter with practical concerns to decide the extent and scope of the technology integration (Niess, 2011).

Absence of a solid theoretical roots, which had been widely criticized by the field of educational technology (Angeli, Valanides, & Christodoulou, 2016; Mishra & Koehler, 2006) catalyzed need for a systematic knowledge framework for teachers to effectively teach with technology. Being a prominent issue to be addressed, Koehler and Mishra (2009) underlined the interplay of "content, pedagogy and technology” (p.62) along with each constituent, as a key to the successful teaching with technology. In order to reveal the nature of characteristics attached to each knowledge type and their interactions, in 2005, Mishra and Koehler proposed

Technological Pedagogical Content Knowledge (TPACK) theoretical framework to promote teacher's professional development (Angeli et al., 2016; Rosenberg & Koehler, 2015).

Broadening the scope of Shulman's (1986) conception of Pedagogical Content Knowledge (PCK), TPACK searches for the influence of technology on adopted pedagogical approaches within the contextual boundaries (Jang & Tsai, 2013; Koehler & Mishra, 2009; Schmidt et al., 2009). Above all, TPACK, just as PCK its' derived from, is experience-driven body of knowledge based on revelation of teacher's motives directing their instructional choices (Jen et al., 2016; van Driel, Verloop, & de Vos, 1998). Being "highly applied type of knowledge (p.212)", TPACK indicates differentiated implications for practice depending on the context (Graham et al., 2009; Harris & Hofer, 2011).

2.2. TPACK and Implications for Science Education

Science education gains the leverage in expanding the instructional opportunities both offered to teachers and students by the help of availability of various information technologies (Jimoyiannis, 2010). From simulations, animations to data collection devices, microcomputers etc. (Canbazoglu Bilici, Guzey, & Yamak, 2016; Graham et al., 2009; Jimoyiannis, 2010), a broad array of technologies is being applicable for science instruction to upgrade the quality of teaching and learning (Koehler & Mishra, 2009). Taking the advantage of information technologies, technology enhanced science education has a potential to facilitate knowledge acquisition, scientific cognition, and learner's motivation and overall attitude towards learning science (Sancar-Tokmak, Surmeli, & Ozgelen, 2014).

Based upon the critics of add-on attitude towards technology integration, TPACK for science teachers stresses the pedagogical representations of the technologies by taking into account the contextual features of ICT's being adopted such as curriculum, cognitive functions of the learners (Jen et al., 2016; Jimoyiannis, 2010; Lin et al., 2012). In this respect, special attention should be paid to unique implications of epistemology of TPACK towards science classrooms. In an attempt to customize epistemology of TPACK within the context of science, Jimoyiannis (2010) proposed TPASK (Technology Pedagogy Science Knowledge) model in order to provide context specific preparation, which is offered to science teachers in efficient technology integration. Adopting an integrative approach, the model specified the constituents and reorganized the interactions between the TPACK components (science, technology and pedagogy), especially in reference to the interwoven points, which are pedagogical science knowledge (PSK), technological science knowledge (TSK) and technological pedagogical knowledge (TPK). To illustrate, fostering scientific inquiry with ICT (TPK), science curriculum (PSK) and transformation of scientific processes (TSK) were the striking components revealing the situated and context specific nature of TPACK once again. In sum, blended with the pedagogical aspects, the model laid emphasis on transformational evidences of science TPACK categorized under the constituents of the framework.

2.3. Indicators of TPACK in Science Education

Development of epistemology of TPACK, which is essential to foster 21st century teachers' professional development, is the main concern of the researchers. Thus, the literature embraces wide variety of research on the nature and development of TPACK, measurement of TPACK knowledge and related constructs (Canbazoglu Bilici et al., 2016) and the design and implementation of TPACK professional development programs (Doering, Veletsianos, Scharber, & Miller, 2009; Guzey & Roehrig, 2009; Jimoyiannis, 2010; Niess, 2005; Srisawasdi, 2014).

Identification of transformational evidences of TPACK, being at the heart of the research chamber, is under the spotlight of the researchers mainly searching the question of "how teachers use technology to support their teaching". Emergent indicators documented for the further development of TPACK knowledge. In this regard, Graham et al. (2009) classified observable indicators of TPACK as content specific activities (science) and general activities to search the ways of using digital technologies in support of science teaching as to both teachers and students actions. To illustrate, content-specific indicators obtained from the interviews with in-service science teachers are as follows:

TPCK1: Using online resources with topic-specific content (Teacher Use)

TPCK5: Use of digital data collection like probes and scales (Student Use)

Likewise, observable indicators of technological practices among the teachers were determined in order to classify science teachers' proficiency levels through TPACK framework in the study of Yeh, Lin, Hsu, Wu and Hwang (2015). On the basis of the claim that TPACK development differs regarding the level of experience that teachers possess, Yeh, Hsu, Wu, Hwang, and Lin (2013) proposed TPACK-Practical (TPACK-P) model taking its strength from teachers' practical teaching. Here are the exemplary TPACK indicators of TPACK-P drawn from the semi-structured interviews with in-service science teachers:

Level 2 (simple adoption)/Actual Teaching: Using basic word processor to manage instructional resources.

Level 3 (infusive application)/Assessment: Rationalizing why and how they used online assessments to understand students' learning progress

Level 4 (reflective applications)/ Planning and Designing: Commenting on their previous experience in planning and designing instruction with ICTs

In this respect, special attention should be paid to unique implications of epistemology of TPACK towards science classrooms.

2.4. Proposed Models of TPACK

Being approved by the studies of Angeli and Valanides (2009), complementary contextual elements render TPACK a unique kind of knowledge different from the coalescence of its constructs. In other words, "TPACK is greater than the sum of its constituent areas of knowledge; it represents a transformative body of knowledge that arises when teachers consider technology, pedagogy, and content in their teaching" (Rosenberg & Koehler, 2015, p.188). Hence, stemming from the situated and complex nature of TPACK, the methods of measuring TPACK increasingly becoming the issue of concern (Jen et al., 2016). With the purpose of mapping this complex relationship between the constructs of TPACK, various models are suggested in consideration of related literature.

TPACK, as a specialized body of knowledge seeking to optimize quality of technology enhanced instruction, has been modeled as integrative and transformative (Angeli & Valanides, 2009, 2013; Canbazoglu Bilici et al., 2016; Niess, 2005) on the basis of the literature. Integrative model is meant to investigate TPACK by its components and their intersections; on the other hand, transformative model treats

TPACK as a special kind of knowledge different and more than the sum of its components (CK, PK and TK) by intertwinement (Canbazoglu Bilici et al., 2016).

Being in the scope of integrative model, in order to measure TPACK related constructs, Graham et al. (2009) investigated science teacher's TPACK confidence level by classifying teacher's actions under five dimensions of the framework (TPACK, PCK, TPK, TCK, TK). Similarly, Survey of Pre-service Teachers' Knowledge of Teaching and Technology aimed to measure pre-service teachers' knowledge by categorizing their actions in terms of seven dimensions of TPACK (Mouza et al., 2014). To set an another example, Kafyulilo, Fisser, & Voogt (2014) in their study, used the TPACK survey (adopted from Graham et al., 2009 and Schmidt et al., 2009), constructs of which are classified in terms of seven dimensions of TPACK to measure knowledge and skills of in-service science teachers within the framework. Clearly, there are various attempts to reveal and measure TPACK indicators through the categorization of teacher's behaviors within the scope of integrative model approach. Even though the boundaries of each constituent resides in TPACK framework is clearly defined by Koehler and Mishra (2009), it is not easy to separate and classify the sub-components in the actual teaching performance (Jang & Tsai, 2013) by reason of the situated nature of TPACK. This is proved to be too complicated to identify the boundaries of the components regarding the results driven by integrative philosophy (Angeli & Valanides, 2013).

Transformative perspective is also applied in various studies to understand teacher's TPACK. For instance, Canbazoglu Bilici et al. (2016) investigated teacher's TPACK in terms of "science teaching orientations and knowledge of learners, curriculum, assessment, and instructional strategies (p.239)" for promoting ease with identification and assessment in TPACK. Moreover, Harris and Hofer (2011) designed a rubric to assess the quality of technology adoption with respect to the "curriculum goals and technologies, instructional strategies and technologies, technology selection and fit (p.2) " instead of looking at TPACK sub-components separately by the reason of interconnectedness of TPACK constituents.

Third, TPACK-practical (TPACK-P) is proposed to reveal the science teachers' TPACK practices developing out of years of experience (Yeh, Hsu, Wu, Hwang, & Lin, 2013). Stressing the differences emanating from disciplines itself, TPACK-P searches for the evidences of TPACK in actual teaching as well as the reasons behind the teacher's technology adoption under the domains of assessment, planning and designing and practical teaching (Yeh et al., 2015; Yeh et al., 2013).

2.5. TPACK and Video Research Method

Video as a data collection tool increasingly attracts researchers' attention due to ease it provides with the analysis of classroom events including the situations falling out of teacher's zone of awareness (Hiebert, 2003). Video based fieldwork is the zone where the "naturally occurring data" (p.4) is gathered in social studies (Jewitt, 2012). Furthermore, video technologies are called as "powerful microscopes" (p.6) for providing in-depth details of interactions, besides it enables researchers to analyze the data repeatedly not only by themselves but also by other researchers (Derry et al., 2010). This implies that, video recordings are ideally suited tools to capture classroom events in depicting the complex and multifaceted nature of instruction process.

Correspondingly, in search of TPACK, conducting observations in the field is one of the counted methods in order to investigate technology enhanced teaching routines of the teachers by using field notes or video recordings (Koehler, Shin, & Mishra, 2012). As reported by Koehler et al. (2012), 29 of the 66 studies aimed at revealing the participants' TPACK on different ways. To illustrate, in the study of Jang and Chen (2010), pre-service science teachers designed and videotaped TPACK lessons to discuss their teaching performances with colleagues on purpose of further development of their TPACK knowledge. Likewise, microteachings of pre-service science teachers in an alignment with their lesson plans were used as a data collection tool to assess pre-service science teachers' TPACK. Yeh et al. (2015) also, in their research, used videotaped TPACK-P performances of in-service science teachers in order to triangulate the data gathered from the semi-structured interviews.

Video as a data collection tool increasingly attracts researchers attention intending to study on "specific contextual features of classrooms" (Stigler, Gallimore, & Hiebert, 2000, p.89) by providing particular understanding about teaching and learning unity (Brückmann et al., 2007). Video recordings capture crucial details including "verbal and nonverbal behaviors" (Mitchell, 2010, p.16). In this regard, video recordings promises to reveal the holistic picture of technology integration process by eliciting the actual performance of the teachers. Moreover, video tools can be analyzed repeatedly not only by the researcher but also other co-observers (Derry et al., 2010) which provides common coding language between the investigators (Roth et al., 2006). On that account, problems developing out of inter-rater reliability would be easily handled by reaching consensus on development of the coding system (Kawanaka & Stigler, 1999)

Even if various advantages of video research are proposed, the constraints should also be considered for the sake of the research. Video as a data collection tool promises to record solid events in their natural context, in micro levels, however video recordings still do not guarantee to reveal the classroom events completely (Stigler et al., 2000) due to existence of hidden messages, cues and emotions. This implies that, the reality is actually confined to the angle of camera view (Jewitt, 2012). Within this regard, video studies should be supported with other kinds of data in order to document whole picture. In this regard, pre and post video interviews were conducted in an effort to reveal the entire teaching routines of science teachers through TPACK framework. Lastly, camera effect might be another concern of the researchers (Stigler et al., 2000). Even though, teaching skills of the teacher cannot be developed considerably by placing the camera in the classroom, the camera effect was still measured in post-video interviews by posing various questions to understand the extent of variations caused by the camera.

2.6 Summary of the Literature Review

The literature pointed out that epistemology of TPACK has been investigated from variety of perspectives. In particular, availability of wide range of innovative technologies such as probes, simulations, and 3-D applications has been a motivating factor for researchers to put special emphasis on TPACK in science classrooms. Most of the studies aimed to reveal practices of science teachers' TPACK have been based on questionnaires, interviews and case narratives, which examine evidences of TPACK in teachers' reported behaviors. Yet, the literature has remained incapable of explaining what actually happens in the classroom and how teachers spontaneously respond against technological agents. In fact, there has been no study using video research method in order to investigate science teachers' observable TPACK in technology-enhanced classrooms. TPACK develops as it gets implemented due to its' situated and experience-driven nature. Therefore, it is significant to follow an authentic and dynamic research methodology in order to reveal indicators of science TPACK, embedded in actual practices of the teachers. Contrary to the research trends in the guiding literature, video research method was followed to close the research gap on revelation of nature and development of science teachers' TPACK by unveiling the process of science teachers' technology adoption in their classrooms.

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CHAPTER 3

METHODOLOGY

3.1. Research Design

This study followed the multiple case study methodology by video research in an effort to examine observable indicators of science teachers' TPACK and investigate the design and implementation process of technology enhanced instruction in-depth. In this regard, the method of multiple case study methodology was supported with video research. Video research method, as an organized and systematic attitude towards the analysis of teaching performance, was conducted in the lessons of four in-service science teachers.

Case study is a qualitative research strategy conducted to investigate "in depth a program, event, activity, process or one or more individuals" (Creswell, 2003, p.15). Case studies are the best options to follow in depth search of context dependent, multifaceted and complex situations (Baxter & Jack, 2008). Case studies involving multiple cases entitled as multiple case studies by Stake (1995), which enables researchers to identify and collate each case to address an issue from different perspectives (Creswell, 2012). Examining more than one case at a time, multiple case studies enable researchers to analyze the data by investigating similarities and differences across the cases (Baxter & Jack, 2008). Criticized by being expensive and time consuming, multiple case studies still offer robust and reliable data for analyses (Baxter & Jack, 2008). In this regard, this study followed the multiple case study methodology in order to examine context-dependent, experience-driven and "situated nature of TPACK" (Mishra & Koehler, 2006, p.1017). In an effort to reveal observable TPACK indicators, lessons of four-science teachers were recorded within the scope of the study, which served robust and reliable data enough to investigate the phenomena from various aspects. Each teacher represented one of the cases investigated and the video data collected from each case triangulated by the interviews conducted right before and after the camera shooting process.

3.2. Research Questions

The purpose of the study is to reveal observable indicators of science teacher's TPACK. In this respect, the study searched for the following research questions:

- What are the indicators of science teachers' TPACK in the design of technology-enhanced teaching?
- What are the indicators of TPACK in teachers' actual teaching in science classrooms?

3.3 Context of the Study

3.3.1.The Setting

The study was carried out in a private campus school offering primary and secondary education level of education in Istanbul, Turkey in 2016. Being founded in the year of 2011-2012, the average student population was approximately ten thousand people scattered around 85 schools located within 30 campuses (eight of which are smart campuses) belonging to same trademark all over Turkey.

On the basis of the mission to foster technological literacy, smart campuses are equipped with various technological hardware and 3-D high-tech classrooms and laboratories. Classrooms are integrated with IWBs, tablet PCs and fiber optic infrastructure to establish high-speed connection as shown in Figure 3.1. In addition to hardware being provided, the school also takes the initiative of "Bring Your Own Device" for the students who want to use their own device on the condition that students upload the common software being used by the school to their own devices.

On purpose of fulfilling the need of e-content, the central office of the smart campuses designs e-learning materials to be delivered to other schools. Also, the school uses digital e-contents approved by the National Ministry of Education. Furthermore, there are various online education platforms (Vitamin, Lisego, Test-

Okul) being suggested and frequently used by the teachers to provide online exercises, examinations, educational videos etc.

Figure 3. 1. The Classroom Setting

The school contracted with a communication and technology company to be able to use the Smart Education Platform within their devices. The platform enables teachers to run the school curriculum on the smartboard as well as conducting interactive quizzes and exams by establishing a connection between smart board, student and teacher devices. Smart platform also enables teachers to monitor student's screen simultaneously and supports file transfer between the devices connected to the network as teacher or student either in or out of the school boundaries. By this means, online education is available for students on purpose of after-school studies. Moreover, the feature of cloud infrastructure among the platform supports the file back up and synchronization of both the teacher and student materials to reuse/recall the previous documents (e-books, written documents, visual materials, video/audio, graphics etc.) with the purpose of lesson review. On the other hand, the platform facilitates teacher-parent collaboration by enabling to learn student's current location, attendance and achievement. Similarly, in the scope of smart education applications, the school uses service-based database as a school information management system (STOYS), which also promotes parent-teacher collaboration by recording and reporting student performance. Besides, the school serves learning management system (Your Learning Space) to support student follow up.

The office of Educational Technologies prepares in-service teacher trainings through TPACK and Substitution Augmentation Modification Redefinition Model (SAMR) framework to support teachers in teaching efficiently with technology. Furthermore, the designers of smart education platform provide both online and face-to-face digital technology trainings in an attempt to familiarize teachers with technological hardware and software provided by the school.

Integration of smart education system with tablets in support of various educational applications and online learning platforms was the reason of preference to conduct this research in above-mentioned context. Moreover, teachers' acquaintance with TPACK framework mediated through in-service trainings was another motive, which renders the research site perfectly suited with the purpose.

3.3.2. Participants

The participants of the study were four in-service science teachers, currently teaching at the private campus school in 2015-2016 spring semester. Due to the fact that TPACK was defined as a "wisdom that teachers develop from their teaching practices" (Jen et al., 2016, p.46), it is critical for participants to have different years of teaching experience to reveal diverse range of TPACK practices accompanied with the reasons of guiding their actions. Table 3.1 shows the demographic information of the teachers.

Table 3.1

Demographic Information of the Participants

Pseudonym	***Gender***	***Subject***	***Teaching Experience***
Lara	Female	Science Teacher	4 years
Zara	Female	Science Teacher	6 years
Leo	Male	Physics Teacher	10 years
Serena	Female	Physics Teacher	12 years

Among four teachers, three of them were female (Lara, Zara& Serena) and one of them (Leo) was male. Teachers were from diverse science backgrounds, two of which (Lara, Zara) were graduated from elementary science education teaching at elementary school students. Other two teachers (Leo, Serena) were the graduates of physics education and teaching to high school students.

The research site was chosen purposefully on serving tablet-based smart education and the teachers working for the school were provided in-service TPACK trainings for being prepared to teach with technology. In the field, science teachers who volunteered to participate in the study were selected as participants.

3.3.2.1. Case 1: Lara

Lara received her bachelor's degree in elementary science education. She was a master student in the department of science education at a public university in Ankara, Turkey. Simultaneously, she had been working for the private school in the level of elementary education in İstanbul. She had four years of experience in teaching.

Lara embraced mastery learning, as a philosophy and instructional strategy. Rooted in the philosophy of mastery learning, she stood up for continuous and efficient lesson reviews. Brainstorming was the strategy that was frequently used by the teacher, as an essential part of her teaching routine. In consideration of the technological background, Lara reported that she gained invaluable experience by teaching with smart technologies in previous years. Smart notebook technology was her favorite. Inclusion of readily available examples in smart notebook, students were provided with various exercises without wasting time in copying them into notebooks. Even though she reported that she still believed in efficiency of traditional methods and strategies, she managed to blend innovative technologies with traditional inclinations, which brought her school leadership for the successful adoption of online education platform (Vitamin) into her teaching. Besides, she told that she owed her success to her individual interest and effort in technology integration. Besides, she added the availability of classroom technologies (smart board, high speed connection and tablet P.C's), which was the supreme motive of her technology use in the classroom.

3.3.2.2. Case 2: Serena

Serena graduated from physics education in secondary education. She had twelve years of teaching experience. Regarding her philosophy of education, Serena told that physics as a nature is hard to comprehend and open to scientific misconceptions. Correspondingly, she emphasized the significance of direct instruction in physics education. Besides, she underlined that students' perceptions towards physics lesson is prejudiced. On the basis of biases, she pointed out she was always in an effort to provide students with the interpretation of physical phenomena in its daily life context. Besides, she kept encouraging students to share their own experiences in relation with natural events.

On the contrary of her colleagues, Serena did not have any teaching experience with educational technologies before starting to work in her current school. However, she developed her skills in teaching with various technologies through in-service trainings that the department of educational technologies provided through TPACK framework. In the guidance of Serena's philosophy of teaching, she emphasized the significance of availability of 3-D laboratories in order to support physics education visually and concretize the physical phenomena. To this respect, as a part of her teaching routine, she organized most of her lessons in 3-D laboratories in terms of consistency with lesson objectives. She also mentioned that reusing the materials stored in the cloud helps to save the time spent on such as drawing figures. In addition to making use of visual representations of physical concepts, efficient use of time and readily available educational materials encouraged Serena to adopt technology into her teaching.

3.3.2.3. Case 3: Leo

Leo was a graduate of physics education. He completed his master's degree in the department of physics in a public university, Turkey. He had ten years of teaching experience. Leo adopted the philosophy behind 5-E learning model into his teachings. Referring to the principles of the 5-E strategy, he mentioned that he always introduce the subject by associating the concepts with its daily life reflections. Moreover, it was essential for him to use online education platform (Lisego) in an attempt to visually present the subject. Nothing but problem solving was the strategy used by Leo in each lesson. To fulfill the needs of contemporary education, Leo conducted problem solving sessions (Test Okul) with tablet P.C's. In this way, as he declared, he managed to screen the solutions by asking students to send their answers to his tablet. Being a clear proponent of technology adoption in the classrooms, however, he proposed the duration of tablet-based education should not exceed 15 minutes since technological problems such as being out of charge might cause different misbehaviors later on. On the other hand, he acknowledged that he started to use innovative technologies upon the request of school administration and the necessity arose from technological infrastructure of the classrooms. However, the benefits of adopted technologies such as instant feedback on student's performance, control on registered student's tablets were the driving forces of Leo to integrate educational technologies into his teaching.

In consideration of his self-development on technology integration, Leo laid emphases on the face-to-face in-service training provided by the designers of smart education platform to improve his technology skills as well as his individual interest. Moreover, he reported that he frequently practiced the educational technologies in 3-D classroom before adopting in teaching time. Besides, he also gained experience with different smart board software than the current smart software of the school.

3.3.2.4. Case 4: Zara

Zara received her bachelor's degree in elementary science education. She had six years of teaching experience. In an effort to determine the scientific curiosity that students posses towards the topic, Zara referred to question and answer strategy as an introductory routine of her teaching. Regarding the attitudes towards educational technologies, she advocated technology use in science classrooms for increasing the rate of retention among the subjects. She also reported that visualization of the abstract concepts was one of the significant benefits of technology provides that she regularly takes advantage of. Besides, simulations hold a significant place for Zara by providing rapid results of the experiments in science teaching. In consideration of motivational factors, Zara found technology integration useful in order for increasing the quality of teaching and learning and saving time.

In terms of her technological background, Zara also mentioned that it had been just 1 year to start using smart education; however she used different smart board software of different schools in the past three or four years. Besides, in service trainings she had in this school contributed much to improve her skills in teaching with technology. She further emphasized that she had a personal interest towards using technology in the classroom.

3.3.3. The Role of the Researcher

I am a master student of Curriculum and Instruction program in the department of Educational Sciences in Middle East Technical University (METU). Prior to my M.S degree, I earned my Bachelor of Science degree from elementary science education at METU. As a researcher, my background and deep interest in innovative use of technology to support teaching and learning are the roots of my aspiration to study on transformative technology integration among in-service teachers in science education. My research experiences concentrated more on applications of technology in science classrooms and in-service teacher education in 3D virtual learning technologies. I took part in variety of projects involving collaborative work with faculty members and in-service teachers to explore and integrate educational technologies in different subject domains as well as science education. I worked as a curriculum developer in collaboration with elementary school science teachers to design teaching assessment materials. In brief, I am experienced in working with in-service teachers especially in the field of science education.

During the study, I took the observer role and I did not intervene with the teachers' judgments. On the ground of my research experiences, I strongly believe the significance of building rapport with the participant. Establishing trust comes into prominence for the studies involving video shootings collected from classroom teaching. Teachers were generally reluctant to invite a stranger to their classrooms and worried about their videos for being watched or posted without their permission. For that reason, I arranged a warm up meeting before the actual study took place on purpose of erasing the worries of participant teachers and breaking the ices. Through the meeting, I emphasized that I was an independent researcher from any kind of institution and the data collected from their classrooms would be available to nobody but the researcher. We planned the date of the interviews and the video shootings together with the teachers and I reminded that they were free to leave from the study in the case of disturbance. Throughout the interviews, I just asked the interview questions and the probes without approving or disapproving the teachers' answers. If I did not understand the answers, I kindly paraphrased the question or the answer in order to get the relevant respond or provide clearance on the issue. Before the lesson that video shootings was recorded, teacher had introduced me to the students in the break. I briefly told about my researcher identity and answered the students' questions if they had any. I assured them only I had an access to the videos recorded in the lesson. Then, I placed the equipment in the angle that would not distract students' attention. I switched on the silent mode of each device not to disturb students. During the shooting, I controlled the camera by standing at the corner of the classroom. The camera was in a stationary position by the help of the tripod. If necessary, I changed the angle of the camera by using the stick of the tripod. I frequently checked if the devices worked properly. Lastly, I carried a small notebook during the video shootings to take notes about my inferences that I would not remember easily while watching the videos again.

3.4. Data Collection Instruments

Data of the study was collected through semi structured interviews and video recordings of classroom teaching among each participant teacher. Semi-structured interviews were prepared under the guidance of in-depth literature survey and discussions conducted between the faculty and the researchers. Expert opinions were collected on finalizing the semi-structured interviews. Afterwards, data collection instruments were piloted and the interviews were put into their final forms by extensive discussions with the field experts, faculty members and researchers studying in the same field to provide consistency and credibility with the data.

3.4.1. Pre-Video Interview

Pre-video semi structured interview (See Appendix A) was conducted to reveal teachers' behaviors associated with TPACK in the process of lesson design, which cannot be observed in actual teaching performance. Correspondingly, each teacher was interviewed right before the lesson going to be recorded. Interviews were recorded digitally and lasted approximately ten minutes.

Pre-video interview (See Appendix A) composed of 18 questions in total; categorized into 3 sections in order of demographic information, lesson description and lesson design. The first section included five questions to identify participants' demographic data such as years of experience, profession of the teachers. In the following, there were seven questions posed to teachers about the lesson going to be recorded. The questions in this section were addressed to learn about the details of the planned lesson, which were the subject of the day, objectives of the lesson, organization of the experiences, technological materials and teaching methods and strategies. The rest of the six questions were asked to identify the process of lesson design and discover the backstage. Besides, student misconceptions about scientific concepts, student's level of readiness, dealing methods of the scientific misconceptions and nature of the subject being told and the effects of these factors on lesson design were also questioned. Each teacher was interviewed right before the lesson going to be recorded for the purpose of to revealing teacher's design practices through TPACK framework.

3.4.2. Video Recordings of Classroom Teaching

The classroom videos were recorded in one lesson hour of the participant teachers in order to identify observable indicators of science teacher's TPACK by eliciting the teaching performance as shown in Table 3.2.

Table 3.2

Details of the Recorded Lessons

The Case	***Grade Level***	***Classroom Size***	***Subject***	***Content***
Lara	7th	18	Atomic Structure	Review
Leo	9th	25	Acceleration	Review
Serena	9th	20	Work/Energy/Power	New Topic
Zara	6th	15	Reproduction	New Topic

In the lesson of Lara being recorded, there were 18 students who were 7th graders. Teaching to level of 9th grade, Leo's classroom involved 25 students whereas in the classroom of Serena, there were 20 students. Lastly, Zara was instructing 15, 6th grade students in the course of recording one hour classroom teaching.

3.4.2.1. The Unique Features of the Recordings among the Cases

Case 1. Lara

The recorded lesson of Lara was an elementary physics lesson. The lesson process included use of online education platform, note-taking and end-of lesson assessment. In the pre-video interview, Lara reported that brainstorming was the main teaching strategy applied and it was a review lesson. However, in the lesson, it was observed that problem solving and question and answer were the main strategies followed. The technological tools used in the lesson were smartboard and tablet PC's. Most of the students did not have their Tablet P.C's with them. Teacher benefited from the educational materials of online education platform (Vitamin) in order to show videos, conduct a simulation and solve problems. Even though not variety of science-specific technologies was adopted in the lesson, Lara used virtual chemistry experiment. She reported that her students learnt best by listening the instruction and following the notes she provided. It can be inferred that she preferred to use teacher-centered technologies instead of using technologies to make inquiry or letting students to conduct scientific research by using proper technologies on their own.

Case 2. Serena

Serena's recorded lesson was a high school physics course, which was about work, power and energy. It was a new topic to the students, however students were familiar with the subject, as they had learnt in elementary school. Direct instruction and Socratic method of teaching was the dominating strategy throughout the lesson, as emphasized by the teacher in the pre-video interview. Smartboard was the main technological tool adopted during the lesson. Teacher did not use any kind of simultaneous tablet-based application due to absence of students' tablets. She preferred to use cloud technologies such as sending e-documents to students' tablets to be revised out of school time. Even though it was not a review lesson, there were many problems solved related with the subject. E-learning lesson modules (Test Okul) embedded in the smartboard were used on purpose of problem solving instead of using the materials of online education platforms. Serena claimed in the pre-video interview that her students learnt best with the method of question and answer and note taking. However, she did not mention and applied student centered teaching methods or scientific inquiry as a part of her teaching routines. Serena adopted neither science specific technologies nor student-centered technologies in her lesson.

Case 3. Leo

Leo's recorded lesson was a high school physics course, which was about acceleration. It was not a new topic to the students. The teaching strategies followed were direct instruction, question and answer and tablet-based problem solving. Teacher preferred to use Tablet P.Cs and smartboard throughout the lesson. Tablet P.Cs' were most frequently used in Leo's case. Due to the frequent use of tablet P.Cs, this was the most informative case about the advantages and disadvantages of tablet-based education and misbehaviors arising from tablet use in the lesson. Most of the students had their tablets with them. Likewise with other cases, Leo also took the advantage of online videos and simulations placed education platform (Lisego) in his lesson. In the Leo's case, the use of science specific technologies was also observed such as real-time acceleration simulation. On the other hand, he reported that his students were visual learners. Accordingly, he frequently took screenshots of e-materials and shared the screenshots of his notes on smartboard and solution of the problems between devices. Likewise, observed technology use in Leo's case was also teacher centered. The students were not encouraged to use the technological tools to get involved in scientific processes.

Case. 4 Zara

The recorded lesson of Lara was an elementary biology lesson and she made an introduction to a new topic with 6th graders. The topic was growth, development and reproduction in animals. The main teaching strategies used throughout the lesson were direct instruction, guided viewing and the method of question and answer. Smartboard and tablets P.C's were the technological tools used by the teacher. However, most of the students did not have their tablets with them. That is why; the teacher designed most of the lesson activities in use of online education platform (Vitamin). She used variety of videos, images and exercises of the platform to strengthen students' learning. However, Zara did not use science-specific technologies such as probes and simulations in her lesson. She reported that her students learnt best visually, which encouraged her to use videos during the lesson frequently. Contrary to other cases, she put emphasis on end-of-lesson assessment. In order to have instant feedback on students' performances, she used the exercises of online education platform by actively engaging students to the session of problem solving. By letting students to answer each exercise one by one, she gave detailed feedback about students' answers, which she rapidly screened the correctness of the answers. Zara, similarly with other cases, did not use technology in order to involve her students with scientific inquiry. The technology adoption in the classroom was also teacher-centered.

3.4.3. Post-Video Interview

Post-video semi structured interview (See Appendix B) was conducted to reveal teachers' behaviors regarding technology selection, context specific technology adoption, methods of troubleshooting, classroom management in technology enhanced mediums and assessment. Besides, validation of the video records with the pre and post video interviews was intended. Post-video interviews for each teacher lasted approximately twenty minutes and conducted right after the lesson to provide convenience with recalling classroom events. Interviews were recorded digitally to facilitate the process of coding.

Post-video interview included 25 questions classified under 3 categories respectively; camera effect, actual teaching performance and technology adoption perspective. The five questions in the first section were asked to provide insight about the probable differences that might come out during teaching due to existence of a camera. It was investigated if teaching methods and strategies, teaching routines and student reactions were different than as usual and what is the extent of these variations. In the section of actual teaching performance, five questions were asked to teachers just for the lesson being recorded. The reasons of using technology in the recorded lesson, concrete examples showing the clear benefits of using technology, methods of uniting teaching methods with technologies and the technical troubles faced were questioned. In the last section, there were fifteen questions aimed to reveal teachers' views, attitudes and practices towards technology use in the science classrooms. Serving different sub-components of the TPACK framework, questions in the third section stood for motivations of technology use, science specific technology adoption, troubleshooting, classroom management and assessment.

3.5. Data Collection Procedures

3.5.1. Before Implementation

Under the guidance of in-depth literature survey and discussions conducted between the faculty and researchers, pre-video and post-video interviews were prepared and video research methodology was set up. In addition to data collection tools, application and consent forms and summary of the study were submitted to Human Subject Ethics Committee of the university in order to receive the approval of the research regarding ethical concerns. After having the approval of the Human Subjects Ethics Committee (See Appendix C), to be able to conduct the study in the private and state schools of Turkey, the approval of Turkish Ministry of National Education was also received (See Appendix D) through the examination of extensive application process. Before the implementation of the research, the pilot study was conducted soon after the completion of permission processes (See Table 3.3 below).

3.5.2 Pilot Study

Pilot study was conducted in order to revise and modify the data collection tools (pre-video interview, post-video interview, video study set up). Within the scope of pilot study, a state school in Ankara, Turkey was visited. The school was chosen for the technological infrastructure of the classrooms. Each classroom was equipped with smart boards and students were delivered with tablet computers even the tablets were not actively used during the instruction.

In the beginning, a meeting was arranged with school management in order to inform administrators about the details of the study and to meet with the teachers. After taking the necessary permissions, the principal suggested teachers who were competent and skillful on technology use. A meeting was arranged with those teachers and a briefing was given about the details of the research. In the level of secondary education, a biology teacher suggested by the principal voluntarily participated to the pilot study. The teacher had 12 years of teaching experience and there were twenty students in the lesson recorded into video. The subject of the day was deoxyribonucleic acid (DNA) and it was a review lesson. After the pilot study, pre-video and post-video interviews were transcribed. On the basis of verbatim transcriptions of interview data, questions were checked if they measured what they intended to measure. Questions were checked in terms of,

- Clearance:
  If the teacher grasped the question in the same way with the researcher
- Repetition:
  If there were questions had the same answers
- Efficiency:
  If the questions were efficient to reveal the phenomena from various perspectives

Accordingly, necessary corrections were made by editing sentences, unifying similar questions, adding new questions and omitting irrelevant questions. In this regard, two researchers, first separately then together discussed the convenience of the questions and a faculty member put both interviews into their final form through the weekly research meetings. On the other hand, video study setup was also checked. The number and the position of the cameras were redesigned in an attempt to increase the efficiency of video shooting. In the pilot study, two cameras were placed in the classroom one of which placed in front of the classroom at an angle to record students' actions whereas the other one placed in the back of the classroom at an angle to record teacher actions. It was observed that front camera distracted students' attention and the idea of being recorded made students nervous. Besides, due to the fact that focus of the study was teacher actions, it was agreed to reduce number of the cameras by placing it at a wider angle and in a mobile position in order to capture the interactions and classroom events efficiently.

3.5.3. Implementation

Implementation process was summarized under six categories. At first, after extensive discussions with the faculty and researchers and through investigation of various private and state schools, there were various schools suggested to conduct the study. Particularly, the school chosen distinguished from others with the feature of tablet based smart education and TPACK trainings it offered to in-service teachers, which provided a good fit with the purpose of the study. Then, the educational technologist of the school was reached out and summary of the study with the permission documents were shared both with school management and the department of educational technologies. After having the approval of the school to carry out the research, the school appointment was scheduled. In the appointment, science teachers of the school were told about the details of the study and teachers who volunteered to participate in the study were selected. Consent forms (See Appendix E) were delivered to the teachers for the approval of their voluntarily participation to the study. Four volunteer teachers in a discussion with the researcher set a date for the study as shown in Table 3. 3.

Table 3.3

Data Collection Timeline

Date	**Scope**
27.02.2015	Ethics Committee Approval
06.04.2015	Ministry of Education Approval
21.05.2015	Pilot Study
04.03.2016	The First Case: Zara
04.03.2016	The Second Case: Serena
06.03.2016	The Third Case: Leo
07.03.2016	The Fourth Case: Lara

Teachers were asked to allocate half an hour before video shooting and forty minutes after the video shooting in consideration of approximate length of interviews. Moreover, before the video shooting, teachers were requested to deliver parent consent forms (See Appendix F) to the students and receive them back for the day of video shooting.

In the phase of preparation (See Figure 3.2 below), before the pre-video interview took place, the voice recorder and interview questions were prepared apart from the appointment time. Before video shooting, each teacher was interviewed approximately ten to fifteen minutes until the lesson break. In pre-video interviews, teachers answered 18 questions under the categories of demographic information, lesson description and lesson design.

Figure 3. 2. The Research Design

At the end of the pre-video interview, in the lesson break, researcher visited the classrooms that were going to be recorded. Researcher briefly introduced herself/himself and explained the purpose of the study briefly with the participation of the teachers. After having the signed consent forms both students and their parents, researcher placed the equipment (video camera, tripod, charge cables) required for video shootings (as shown in Figure 3.3). The camera placed at the back of the classrooms not to distract students' attention.

In order to capture the interactions and classroom events effectively, it was positioned at the corner of the classroom, with a wide angle, which provided to screen the entire classroom. After the placement of the equipment, researcher checked if the devices worked properly.

During the course of video shootings, researcher recorded one lesson hour of each teacher. In the lesson break, researcher packed the equipment and prepared the voice recorder and post-video interview questions for the next stage. In the phase of post-video interview, right after the video shooting, teachers were posed 25 questions classified under 3 categories: camera effect, actual teaching performance and technology adoption perspective which lasted approximately twenty to twenty five minutes.

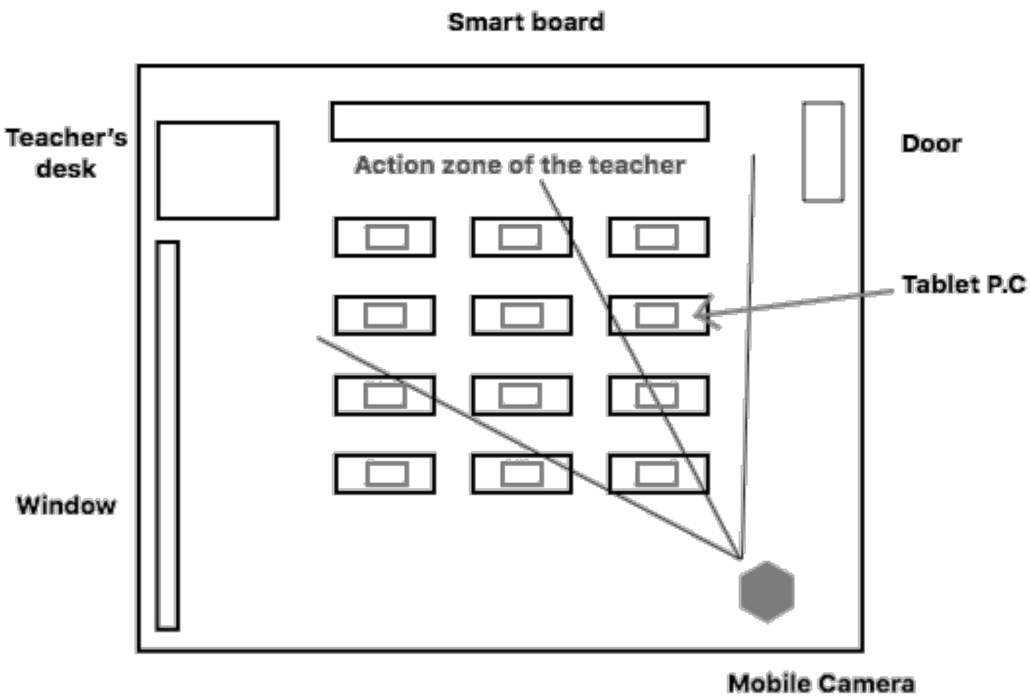

Figure 3. 3. The Video Camera Set Up

3.6. Data Analysis

As Yin (2009) proposed that "the use of multiple sources of evidence in case studies allows an investigator to address a broader range of historical and observable issues (p.115)". Therefore, in search of observable indicators of TPACK of science teachers, data was collected through semi-structured interviews and video recordings. Each data source is defined as "one piece of the puzzle (p.554)" by

Baxter and Jack (2008), that not only enable researchers to examine the phenomena as a whole but also strengthen the findings with converging evidences (Baxter & Jack, 2008;Yin, 2009). In this regard, semi-structured interviews and video recordings were analyzed qualitatively on purpose of triangulation of the research findings.

Through the process, within-case analysis was followed by cross-case comparisons (Meyer, 2001) in order to examine similarities and differences between the cases. Besides, Eisenhardt (1989) suggested that being acquainted with each case enable researchers to map singular features of the cases before revelation of a general pattern through the cases ,which facilitates the cross-case comparison. In this regard, the purpose was to examine each case in-depth first and then check for the emergent patterns between the cases. There were four different cases involved in the study each of which was science teachers from different branches of the field (e.g. physics education, elementary science education). In order to analyze each case in-depth, in the first step, digital records of pre-video and post-video semi-structured interviews were transcribed verbatim for each case. In the mean time, video recordings of each teacher were transcribed second by second regarding teachers' actions (See Table 3.4 below). Additionally, to provide ease through the coding process, a first order analysis was applied by creating memorable codes for each action. As Punch (2009) declared first order analyses are beneficial in summarizing data by creating descriptive codes, prior to higher levels analysis. In brief, transcribing the semi-structured interviews with videos respectively for each case brought a holistic view to the researcher, as an introduction to the coding phase.

In the second step, transcribed interviews and video recordings were imported to MAXQDA qualitative data analysis software. Qualitative analysis tools facilitates the process of data storage, organization and analysis by enabling researchers to "code and categorize large amount of narrative text, as might have been collected from open-ended interviews or from large volumes of written materials" (Yin, 2013, p.28). By doing so, using a particular "database" (p.554) during the process enhances the trustworthiness of the case study, which provides the data to be reached later on (Baxter & Jack, 2008). Stacking transcripts of semi-structured interviews and video recordings, the data of each case was assigned to separate folders categorized as pre-video interviews, post-video interviews and video recordings.

Table 3.4

Section From Video Transcription Table

Time (in seconds)	Action	Observer Notes
02.12- 02.13	***Inserting Flash Drive:*** Teacher inserts the flash drive to use "smart education".	***Technology Use:*** Without inserting the drive unique for each teacher, smart software cannot be started.
02.13- 02.14	***Associative Reaction:*** One of the students directly asks to open his Tablet PC if they are going to use smart education.	
02.14- 02.16	***Tablet PC Use:*** Teacher approves the students and commands students to open their Tablet PC's	
02.16- 02.18	***Student Tablet Action:*** Students directly open their Tablet PC's, which are already placed under the desks.	
02.18- 02.20	***Statement of Objectives:*** Teacher opens the related document to talk about objectives embedded in smart education.	***Classroom Management:*** Teacher refers to objectives

At first, the transcripts of semi-structured interviews of each case were read several times. Pre-video and post-video interview data for each case were descriptively coded through drag and drop method with the help of MAXQDA software. As proposed by Punch (2009), descriptive codes are useful to "to get a feel for data" (p.176) in the first place. Coding as a method enables researchers to classify similar codes by creating relevant categories, which leads a pattern formation afterwards (Saladana, 2008). Accordingly, the formation of descriptive codes list for each case led the formation of relevant categories at the same time. After the categorization, descriptive codes of each case were revealed in the form of Word tables, as suggested by (Yin, 2009) which was the first step to cross case synthesis.

In the second phase, following the approach of Miles and Huberman (1994), an inferential coding phase was applied. Inferential codes (pattern codes i.e.) defined as "sort of meta code" (p.176) formed from consolidation of existing codes to lead more meaningful group of data by Punch (2009). In this regard, Saladana (2008) proposed that how to filter codes is dependent on the "analytical lens"(p.6) that a researcher puts on. Adopting TPACK theoretical perspective, in the second stage, higher level of analysis promoted to scan and filter the existing codes and modify the categories accordingly. In this regard, metaphorically, codes were infiltrated case by case. Taking one of the cases descriptive coding table as a reference point, respectively codes and categories (emerged from the analyses of pre and post-video interviews and video recordings) were reduced, united and modified by comparing and contrasting the cases to one another in order to reveal the pattern across the cases (See Figure 3.4).

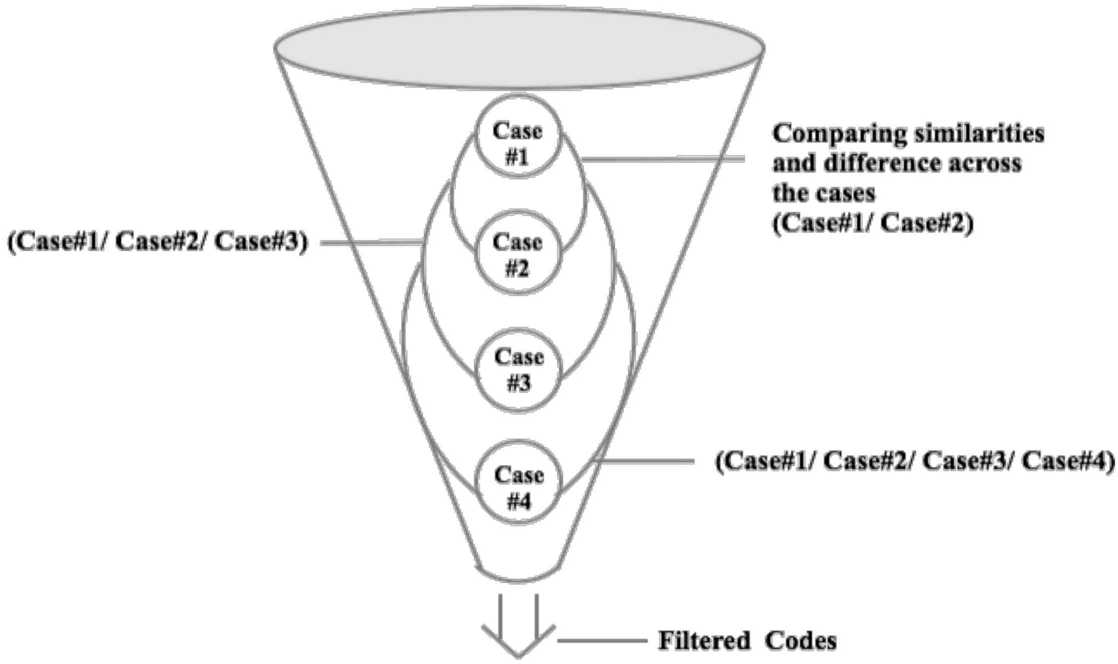

Figure 3. 4. The Cross Case Analysis Filtering Process

As Yin (2009) reported, "the analysis of the entire collection of word tables enabled to study to draw cross-case conclusions"(p.135). In the final step, the "complementary word table" (Yin, 2009, p.135) was constituted to provide a holistic view towards the phenomenon by revealing the similarities and differences across the cases. Table 3.5 presents the main themes and categories, under which the behavioral indicators of science teachers' TPACK examined.

Table. 3.5

Main Themes and Categories Emerged From the Cross-Case Analysis

Themes
A. Design
1. Technology Selection
2. Curriculum Planning
3. Lesson Preparation
4. Assessment
B. Actual Teaching
1. Lesson Entry Behaviors
2. Teaching Methods and Strategies
2.1 Technology Enhanced Science Specific Strategies
2.2 Technology Enhanced Strategies
3. Technology Enhanced Classroom Management
4. Troubleshooting
4.1 Unavailable Student Devices
4.2 Proposed Solutions
4.3 Software Breakdown
4.4 Network Disconnection
5. Assessment

In the table, the data drawn from similarities and differences were displayed case by case by reporting the reported and observed frequencies under the emergent themes and codes. Analysis of the pre-video interview data revealed four categories among the design phase: (1) technology selection, (2) curriculum planning, (3) lesson preparation and (4) assessment. Moreover, there were five main categories with related sub-categories emerged from the analysis of the video recordings of the classroom teachings in support of the analysis of interviews: (1) lesson entry behaviors, (2) teaching methods and strategies, (3) technology enhanced classroom management, (4) troubleshooting and (5) assessment.

3.7 Trustworthiness

Trustworthiness is described by Creswell (2012) as the process of "validating findings" (p.259); in other words, the collection of various strategies to be followed in order to promote the "accuracy or credibility of the findings" (Creswell, 2012, p.259). In this regard, credibility (1), transferability (2), dependability (3) are the main criteria proposed by Lincoln and Guba (1985) to be checked in order for ensuring trustworthiness. Within this scope, strategies followed for promoting the study trustworthy are explained as follows.

Credibility looks for if "study measures or tests what is actually intended"(p.64), the "internal validity" (p.64) in short (Shenton, 2004). In this regard, there are various strategies proposed in order to increase the trustworthiness of the study conducted regarding the criteria of credibility. In the guidance of the related literature, the study followed "triangulation, tactics to help ensure honesty in informants, frequent debriefing sessions and peer scrutiny of the research project", as proposed by Shenton (2004). Enhancing the trustworthiness, triangulation defined as a basic strategy in allowing to discover the research phenomenon from numerous perspectives by using various data collection tools (Baxter & Jack, 2008). In this regard, the video data triangulated by the interviews conducted right before and after the camera shooting process in order to address the issue from different perspectives. In addition to measure how compatible teachers' actions with their statements, data triangulation helped to reveal teachers' routines that cannot be observed in one single lesson. Secondly, promoting honesty in informants is another strategy to increase the credibility of the study. Shenton (2004) claims that participant should be aware of they are free not to participate to the study so that the willingness to participate in the study results in collection of more credible and rich data. Within this regard, teachers who were volunteered to be a part of the study were selected as participants in the study. Besides, as suggested by Shenton (2004), the researcher emphasized the independency from any kind of institution and organization so that participants felt more comfortable in the course of video shootings in order to elicit their actual teaching performance. On the other hand, weekly debriefing sessions were conducted with the supervisor and the researcher studied in the same field to check researchers' assumptions, ideas and intentions and received regular feedbacks throughout the development and implementation of the study, which facilitated researcher to "recognize own biases and preferences" (Shenton, 2004, p.67). Peer scrutiny of the research project was another strategy followed regarding the credibility of the research. In this scope, the researcher searching TPACK in English language learning classrooms was requested to reread the data analysis and results of the study due to the fact that "researcher closeness to the project frequently inhibits his or her ability to view it with real detachment" (Shenton, 2004, p.67) then the convenience of the findings were discussed together.

Transferability, or generalizability of the findings, is another criteria proposed by Lincoln and Guba (1985) to promote trustworthiness. Even though, generalizability is quite controversial issue regarding qualitative studies, one can still strengthen the criteria of transferability in use of various strategies such as "thick description, multi-site designs, sampling within and modal comparisons " (Merriam, 1995, p.59). Merriam (1995) also proposes that generalizability is not the concern of researcher, instead it should be considered by the "consumer of the research"(p.58). In this regard, thick description as a strategy was followed in the study in consideration of transferability criteria. Thick description is briefly described as providing in depth information to the readers about the phenomenon so that they would decide how similar the study conducted with their research in the scope of transference of the findings. Accordingly, in the study, detailed case vignettes of each teacher and extensive information about the context of the study were presented to the reader in order for the decision of the transferability.

Third criteria is dependability of the study searches to what extent "findings will be found again" (p.55) if the research is repeated in the same context (Merriam, 1995; Shenton, 2004). In this respect, Baxter and Jack (2008) proposed that dependability of data would be enhanced by assigning different researchers to code the same data and reach an agreement on emergent codes and categories. In the study, after the completion of coding phase, another researcher studying on the same subject coded the same piece of data. Percent agreement was used to determine inter-coder reliability. The coded data by the observers was compared and 83 % agreement was reached between the observers, which was measured by dividing agreed codes into the number of overall codes. According to Miles and Huberman (1994), the percentage of inter-coder reliability near 90 % is acceptable. The final codebook was finalized by two researchers together and revised by the faculty member as a result of weekly meetings and extensive discussions. On the other hand, in order to enhance trustworthiness of the study, qualitative analysis software was used to store the data of the study, which enabled researchers to access the data later on purpose of coding and analyzing all over again (Baxter & Jack, 2008).

Last but not least, inter-rater reliability was examined by formation of the codebooks in several meetings. Besides, video recordings allowed other researchers to examine the teaching events repeatedly without considering time and location. Additionally, problems that might occur from inter-rater reliability handled by reviewing video-recordings multiple times to reach an agreement between the observers about coding schema (Roth et al., 2006) which was another strategy regarding the trustworthiness of the study.

3.8 Limitations of the Study

It is anticipated that the study would contribute significantly to TPACK literature, especially with respect to applications of TPACK in science education. However, limitations of the study should be mentioned for the sake of further studies. First of all, the context of the study was highly specific regarding the technological infrastructure of the private school. To illustrate, the smart software used by the school had specific educational implications such as allowing teachers to screen students' tablets, take online attendance, share and receive all kinds of data between the devices etc. Even though generalizability was not the concern of this study, distinctness of the context limits the range of settings that the study would be transferred. However, the study provided invaluable data to the features that smart education should possess by in-depth search of affordances and constraints that the context offered. Accordingly, the case study revealed the features of technology classrooms should possess for further research.

Secondly, data of the study collected through semi-structured pre-video interviews, video recordings of classroom teaching and semi-structured post-video interviews. In an effort to triangulate the data of interviews (reported actions of the teachers), the observed actions of the teachers were drawn from the actual teaching performances. Clearly, interviewing with the teachers contributed a rich data to the study regarding reported actions of the teachers through TPACK framework. However, videos recorded in one lesson hour of the participant teachers remained incapable to confirm all reported actions. In this regard, increase in the number of lessons being recorded would enhance the trustworthiness of the study and provide more complete picture of classroom practices among science teachers.

Thirdly, the study was piloted in different context than the actual study took place. This might cause variations on the final versions of the interviews and the video camera set up, which were revised and finalized according to data gathered from the piloted study. This also might have an influence on the trustworthiness of the data gathering tools and accordingly on the findings. Even though questions were still piloted in the science classroom, absence of tablet P.Cs in the piloted setting would result in differences in the perceptions of the teachers, so in their answers. On the other hand, the students would react differently to the existence of the video camera due to different school policies against the camera use in the classrooms. Then the reduction in the numbers of camera would be unnecessary. However, this would be a still threat in the same school, but in different classrooms. Reactions to the existence of the camera would still show differences as the audience change. Additionally, the level of the classrooms and the subjects that video recordings collected among each case were different. Even though this would increase the diversity in the data, it would be argued that these variations would be a limitation depending on the purpose of the researcher.

3.8 Ethical Considerations

The study followed ethical procedures of the university that were declared by Human Subject Ethics Committee. In order to receive the approval of the research regarding ethical concerns, ethics application was sent to Human Subject Ethics Committee with the attachment of data collection tools, summary of the study and consent forms (voluntary participation form, parent consent form, participant information form). Afterwards, the Committee approved the study (See Appendix C), in consideration of ethical principles and found no harm to conduct the study in the school environment. After having the approval of the Human Subjects Ethics Committee, to be able to conduct the study in the private and state schools of Turkey, the approval of Turkish Ministry of National Education was also received (See Appendix D) through the examination of extensive application process. The information of the participants kept confidential and pseudonyms of the teachers were used in reporting results. It was emphasized that participation to the study was on volunteer basis (See Appendix E). Besides, signed consent forms both students and their parents were gathered before video shootings (See Appendix F). Video recordings were stored in the database of the study and used by researchers only on purpose of analysis and coding. Teachers were told that the video recordings would not be shared under any circumstances with third parties. In the end, the results of the study were shared with the participants.

CHAPTER 4

RESULTS

The purpose of the study was to reveal observable indicators of science teacher's TPACK through the method of video study. In this respect, the study searched for the following research questions:

- What are the indicators of science teachers' TPACK in the design of technology-enhanced teaching?
- What are the indicators of TPACK in teachers' actual teaching in science classrooms?

The research presented the exploration of research questions as follows. Besides, in an attempt to provide in-depth information concerning teachers' technological background, motives towards technology adoption and the contextual features of the teaching environment, in-depth information of each case was provided.

4.1. The Indicators of Science Teachers' TPACK Regarding The Design Of Technology-Enhanced Teaching

The first research question investigated the design process of technology enhanced science lessons. The analysis of semi-structured pre-video interviews conducted with four in service teachers led four themes: (1) technology selection (2) curriculum planning (3) lesson preparation (4) assessment as shown in Table 4.1.

Table 4.1

TPACK Indicators Emerged in the Analysis of Pre-Video Interview

Themes	
1. Technology Selection	**Observed Case**
Checking the alignment with the content	Zara, Leo, Serena
Checking the needs of the students	Zara, Leo, Lara, Serena
Checking the affordances of the technology	Zara, Leo, Lara, Serena
2. Curriculum Planning	
Identifying the objectives (Content-Technology Match)	Zara
Organizing the order of the topics	Zara
Identifying the methods and strategies	Zara, Leo, Lara, Serena
3. Lesson Preparation	
Practicing in the IT classroom	Leo
Sharing digital materials with students beforehand	Zara
Informing about the next subject	Zara
4. Assessment	
Using online education platform	Zara, Leo, Lara
Conducting quizzes on tablet P.C	Serena

4.1.1. Technology Selection

Technology selection was one of the main themes emerged from the analysis of pre-video interviews. Technology selection was reported as a significant component in the lesson design process by the interviewees, which they selected the proper technologies to be integrated before the instruction. Accordingly, each of the participants shared their technology selection routines in depth as being an integral part of their lesson design. In this regard, checking the alignment with the content (1), checking the needs of the students (2) and checking the affordances of the technology (3) were the major indicators come up regarding the design process of technology enhanced instruction.

4.1.1.1. Alignment with the Content

Alignment with the content stands for the congruence of the content with the technologies that were being selected. It was significant that most of the participant teachers reported the content of the lesson as a key determinant of technology selection (e.g., the cases of Zara, Leo and Serena). To illustrate, it was claimed that if the content includes abstract concepts such as microorganisms or experiences having low frequency to be lived in a daily life, it becomes a necessity to benefit from technology in visualizing and concretizing these concepts. In this respect, Zara reported that:

> Science lesson, as it's nature requires visual conceptualization. When I talk about hydra or for instance sponge, I see that students do not know how these animals actually look like. That is why I need to show these concepts visually to enhance the rate of comprehension and retention of the knowledge. This is because; I mostly prefer to use videos in my lessons on purpose of increasing the rate of retention (Zara, pre-video interview).

Likewise, Leo stressed the role of content in deciding the kind of technology to be integrated into his instruction from a different point of view. He mentioned that if the topic lays more weight on verbal type skills than mathematic type skills, the technological preferences of him changes accordingly. Accordingly, Leo mentioned that:

> I designate the technologies that I use in the classroom in consideration of the content of the lesson. If the topic attributes to nature of science, I prefer visually supported teaching by addressing audio-visual communication, which I introduce the lesson with a video combined direct instruction. However, if the content is more inclined to mathematical calculations, then I use smart education for promoting problem solving in the classroom (Leo, pre-video interview).

In the same way, Serena reported that she generally uses the available technologies in the environment by giving little attention to the selection phase. However, she stressed that she chooses the teaching environment in accordance with the content. Serena further added on the issue,

> Actually, I use smartboard already because it is available. In addition to that, I run the school's curriculum and the teaching materials embedded in the smart board on purpose of using the questions it includes. In addition to that in consideration of the topic, I decide the teaching environment if the learning takes place in 3-D technology laboratory or in the classroom (Serena, pre-video interview).

In brief, pedagogical reflections concerning technology selection throughout the design process were clearly defined by the comments of the participants. Based on the views of participants, content knowledge has a significant influence on technology preferences of the teachers. It is seen that teachers' decision on the types of technology is not bounded by the knowledge of technology itself, instead there are contextual variables affecting the technology integration into instruction such as the availability of technological infrastructure, the nature of the topic and enhancing the comprehension rate.

4.1.1.2. Needs of the Students

Being an experience-driven knowledge, teachers reported that considering how students learned best was the other substantial factor having an influence on technology selection. Teachers claimed that technology chosen should address the needs of the students and they chose the technologies facilitated students' learning. Teachers, being aware of the learning styles of their students, declared that their student were mostly visual learners and they preferred to use technologies accordingly to increase students' motivation towards the lessons by providing attention grabbing digital materials. In this respect, Leo told that:

> In new generation, students are inclined to be visual learners. They tend to store each kind of data as screenshots. They do not want to waste their time in writing. Within this context, it is significant for them to have smart education and transform the data into visuals simultaneously. That is why; I stress the visual elements in the process of designing my lesson (Leo, pre-interview).

Zara also mentioned that her students are visual learners and told that:

> My students are learning visually. That is why I generally use visual technologies in my classrooms (Zara, pre-video interview).

Similarly, Lara reflected further on that:

> Online education platforms helped me a lot since my students learn best by listening and observing the content rather than writing. That is why I benefit from videos and simulations very frequently (Lara, pre-interview).

On the contrary of what her colleagues think, Serena claimed that her students were read/write learners and she stated her technology preferences as stated below:

> I believe that my students are read/write learner and active inquiry works in my classrooms. That is why, in my teaching routines I try to make my students take notes as much as possible either into their tablets or to their notebooks in the case of technical problems. Besides, I use smart education to conduct question and answer sessions in my classrooms (Serena, pre-video interview).

In regard to opinions of all participant teachers (e.g. the cases of Lara, Zara, Leo and Serena), learning styles of the students either being a visual learner or read and write learner had an impact on technology selection and differences in student's learning preferences caused different type of technologies to be chosen by the teachers. Besides, the demographics of the classroom (classroom size, grade level), the level of students' success were other reported factors affecting technology choice of the teachers as well as the learning styles of the students. This implies that, having a detailed vision of students' educational background is crucial and responsible for variances in the design of technology-enriched instructions.

4.1.1.3. Affordances of the Technology

The affordances of the technology can be defined as what technology offers to support students' learning. The promises of technologies being adopted were reported to have an influence on technology preferences among the teachers. On the basis of analysis of the both interviews (pre-video and post-video interviews), it was inferred that teachers evaluated the technologies in terms of the efficiency in time and retention.

Saving on Time

Providing efficient use of time was one of the criteria that teachers put emphasis on (e.g., the cases of Lara and Serena). Teachers were reported that they preferred to use the technologies for decreasing their workload. In other words, they wanted to do more work in less time. In this respect, Lara reported that:

> I prefer technologies that help me to save the time spent on problem solving. For instance, in addition to existent technologies in the classroom, I particularly use smart notebook which includes various questions and readily available. I do not waste the time by writing the questions (Lara, pre-interview).

In the same manner, Serena told that:

> Readily available lesson materials embedded in the smart board shorten the time required by managing heavy workload. For instance, I do not spend time on drawing shapes; instead I use the templates in the smart board. In this way, I manage to solve more problems than I would without using technology. For this reason, I frequently use the content of smart board and smart education (Serena, post-video interview).

Clearly, teachers agreed on that technologies should provide certain benefits to be used in the classroom. Undoubtedly, teachers view time as a valuable asset. Therefore, it is significant to solve more problems in limited classroom time or not to waste time by retyping the questions or drawing figures. As a result, affordances of various technologies are under consideration while designing the instruction process.

Enhancing Retention

Enhancing retention is the ease that technologies provide in recalling information. Regarding the concerns of promoting permanent learning, teachers reported that they benefited from digital technologies in order to render subjects memorable (e.g., the cases of Leo and Zara). This, in the end, affected their choices of educational technology to be integrated in the classroom setting. Accordingly, Leo commented on the issue:

> Visual representations of the physics concepts increase the rate of retention. For instance, I tell many times about acceleration, gravity etc. However, watching a video including these concepts make learning more permanent (Leo, post-video interview).

Furthermore, Zara agreed on using visual elements in teaching increase the comprehension level among students:

> I use visual contents if I want to picture the scientific events in students' mind, which enhances the rate of understanding and retention (Zara, post-video interview).

All in all, enhancing retention, and saving on time were the two significant factors affecting teachers' technology preferences in designing their instruction. Obviously, teachers' choices were highly influenced by the affordances of the technologies. This implies that, knowing the affordances of the technologies as well as the constraints have pedagogical implications and this knowledge type cannot be explained by the technology knowledge itself. It can be inferred that being an action stimulated knowledge; design process is a resultant entity growing out of the collection of the experiences.

4.1.2 Curriculum Planning

Curriculum planning refers to the consideration of curriculum elements in the process of lesson design. Analysis of the interviews indicated that curriculum planning was the other significant component of teachers' design routines. Respectively, the themes, (1) identifying objectives (2) organizing the order of the topics (3) identifying methods and strategies were investigated under the section of curriculum planning.

4.1.2.1 Identifying Objectives and Organization of the Topics

Investigated under the curriculum planning, identification of lesson objectives was being at the center of the lesson design. The objectives led teachers to identify the scope of the lesson, which eventually affected their choice of technology. In tandem with content and technology selection, Zara mentioned that in her routines, she designs the lessons in terms of pre-determined objectives of school curriculum. She stressed the place of objectives in the designing process as follows:

> To avoid over sharing, I definitely plan my lessons in guidance of lesson objectives. Before the lesson, at first, I decide the topics and their order respectively. Then, I check the content of the videos; if they match with the content of the lesson and then I identify the correct order they are going to be integrated with (Zara, pre-video interview).

As Zara reported, lesson design could be summarized as a chain reaction, triggered by the identification of the objectives than continued with choosing the technology fitting best into context. Even though, other participant teachers laid not much emphasis into the theme, the conclusion can be drawn that identification of objectives, somehow, directly or indirectly would be taken into account through the design process.

4.1.2.2. Identifying Methods and Strategies

Choosing the methods and strategies that fit the content best would be counted as another concern through the design process. In the light of teachers' statements (e.g., the cases of Zara, Lara, Leo and Serena), identification of methods and strategies had a crucial place in their lesson design. Apparently, teachers' attitude towards determination of methods and strategies was an instinctual process shaped by teachers' experiences and their philosophy of education. In this respect, Zara explained that:

> I prefer strategies, which encourage students to actively participate in my lesson. In this direction, I regularly conduct question and answer sessions in the introduction part of my teaching to understand how much students are interested in with this topic. Then, I support my lesson with visual elements (Zara, pre-interview).

Clearly, Zara's case showed that she has a regular trend of teaching and prefers to support this trend with proper technologies. Likewise, Leo had a similar kind of teaching approach towards the designing process. He reported that he certainly uses direct instruction as what Zara thinks about question and answer session. It is crucial that both participants mentioned about how technology supports their instructional choices. Accordingly, Leo reported that:

> In physics education, it is inevitable to give direct instruction. However, I always support the instruction process with question and answer session. I generally choose the technologies accordingly, in a way of supporting the methods of teaching (Leo, pre-interview).

Without mentioning about technological elements, Serena also told about a regular teaching strategies she frequently uses. Serena, on the issue, mentioned that:

> I plan my lessons in terms of the curriculum Inevitably, I use direct instruction and it is required for physics lessons. However, I certainly support my lessons with question and answer sessions involve students (Serena, pre-video interview).

In the same way, Lara further explained that:

> Before starting teaching, I like to see what students already have as a prior knowledge and how this is reflected on their way of thinking. This is because; I always conduct brainstorming as an introduction strategy in my lessons (Lara, pre-video interview).

Consequently, it can be inferred that each teacher had a regular teaching pattern to follow. Other components of the design process such as technology selection and organization of topics were constructed out of these teaching patterns specific to each teacher.

4.1.3. Lesson Preparation

Lesson preparation includes the actions taken in order to increase the level of readiness before the teaching both in view of teachers and students. Even though it was not frequently mentioned, analysis of the both pre and post video interviews indicated that teachers (e.g., the cases of Leo and Zara) had unique methods of preparing themselves and their students to the upcoming lesson in different ways. (1) Practicing in the IT classroom, (2) sharing digital materials with students, (3) informing about the next subject were the indicators came up within the investigation of lesson design.

4.1.3.1. Practicing in the IT Classroom

Practicing the lesson before the actual performance in order to identify the weakness and strengths of the design or to become skillful in new technologies would be considered as an efficient technique regarding teachers' professional development. Accordingly, Leo in his case reported that he practices his planned lesson in the information technologies classroom beforehand. In this regard, Leo stated that:

> There is an information technologies classroom in our school. Before the lesson, I practice my lesson plan in this classroom so that I make better time management and planning by pretending that I am actually teaching. Practicing with smart education and online education platforms is helping me a lot in the designing phase of the lesson (Leo, post-video interview).

In brief, technology not only changed the way of teaching but also came to solve the problems arising from technology itself. Practicing with technology to teach with technology would increase the teachers' self-esteem to integrate technology into their teachings.

4.1.3.2. Informing About the Next Subject and Sharing Digital Materials with Students

Informing students about the topic of next subject in the previous lessons and sharing the related documents to increase their familiarity with the subject before the instruction were the strategies followed regarding the lesson preparation. To illustrate, Zara benefited from cloud computing technologies in the preparation phase before the lesson. Students' tablets connected to the main network enables teachers to perform file transfer between the devices either from home or classroom and either in classroom time or out of the school time. Therefore, being independent from time and location, Lara reported that she prepares her students to the lesson by sharing the digital materials beforehand and aims to increase students' familiarity with the topic. Within this regard Zara told that:

> Before the lesson, I send the videos to the students that I am going to use in the lesson (Zara, pre-video interview).

Besides, Zara further added that in previous lesson, she definitely informs students about the topic and concrete classroom materials as well as the digital content. She stated that:

> I definitely inform students about the next week's topic and I request them to read the related parts from the book. I want them to come next week's classroom as being prepared (Zara, pre-video interview).

To conclude, under the guidance of teachers' statements, preparing students' both cognitively and affectively was also a part of lesson design process. Besides, in the case of Leo, it can be inferred that self-preparation and teaching practice with technology before the actual performance was of importance even for ten year experienced teacher.

4.1.4. Assessment

Formative assessment is conducted to follow students' learning so that simultaneous feedback on students' performance would be provided to increase the quality of learning. Analysis of the interviews revealed that conducting assessment at the end of the lesson is essential, accordingly it is the crucial part of lesson design process based on the statements of the teachers (e.g., the cases of Zara, Leo, Serena and Lara). In this regard, various ways of assessments embraced by the teachers; however each of them, in all sorts of ways, was conducted with the technology. Using online education platforms (1) and conducting quizzes on tablet P.C (2) were the indicators reported in regard to the theme of assessment.

4.1.4.1 Using Online Education Platform and Conducting Quizzes on Tablet P.C

Online education platforms were reported (e.g., the cases of Zara, Leo, Lara) on being used frequently with the purpose of assessment. Especially, the promise of instant feedback and readily available testing materials encouraged teachers to use online education platforms in consideration of the design phase. On the basis of teachers' statements, Zara mentioned that:

> I always allocate last 15 minutes to assessment; it is part of my teaching routine. I aim to measure the knowledge level of the students by using the activities of online education platform (filling the gaps, multiple choice tests etc.). The reason that I use online education platform is to provide instant feedback over students' response. These kinds of online education platforms help me to learn to what extent lesson objectives are achieved. In this way, I

> identify the parts that students have weaknesses and assign them with homework online on these parts (Zara, pre-video interview).

Being a regular part of her lesson design, online assessment tools was reported for being frequently used in Zara's case. Zara's primary preference to conduct assessment during the lesson created the need of receiving instant feedback among students' performance which was provided with online education platforms. Similarly, Leo reported that:

> I use online education platforms and questions embedded in the smartboard to assess students through the lesson as an end-of lesson assessment. I also use tablet network to send questions from smart board to students' tablets and screen the answers to give feedback (Leo, pre-video interview).

Lara also told that she uses online education platforms in order to assess her students by assigning homework. She told that:

> I use online education platforms to send homework to my students at the end of the lesson. On the other hand, at the end of the each lesson, I distribute quizzes to students to see how much they learn about the topic (Lara, pre-video interview).

On the other hand, Serena shared the assessment routine with the reasons guiding her decisions. Serena stated that:

> I generally apply end-of lesson quizzes or mini tests at the end of each subject. If I just give a lecture, then I initiate a question and answer sessions to see the parts that cannot be understood. In terms of assessment, I have two methods to apply. First of all, I send questions to students' tablets and simultaneously receive the answers by screening on either smart board or my tablet so that I am able to provide rapid feedback on students' answers. On the other hand, I can conduct paper-pencil assessment regarding the content and the materials I have prepared (Serena, pre-video interview).

To conclude, availability of technological resources in the classroom has transformed the assessment routines of the teachers, so how they plan their lessons. In the design phase of the lesson, teachers mostly stressed the end of lesson assessment techniques they adopted either with technology or paper-pencil methods instead of long-term assessments. It can be drawn as a conclusion that most of the teachers had an end of lesson assessment plan by making use of technology enhanced techniques as a part of their teaching routines.

4.2. The Indicators of TPACK Observed in Teachers' Actual Teaching in Science Classrooms

The second research question searched for the observable indicators of science teachers' TPACK. Since the observable behaviors of science teachers' was being searched, video analyses of classroom teaching records were analyzed to reveal observable indicators of TPACK. Findings presented in Table 4.2 aimed to show TPACK indicators in terms of the observation frequencies within the cases. Moreover, data gathered from the analysis of pre and post-video interviews presented within the reported frequency column within each case for not being observed during the classroom teaching; yet they were the reported practices of the science teachers on the basis of the interviews. Forwhy, one hour teaching record cannot reveal the entire practices of the science teachers but give an insight, the data was complemented with the teachers' statements. Therefore, it was significant to integrate the results of interviews with the video analyses to provide holistic picture of phenomena by complementing and triangulating the data. In search of observable indicators of TPACK, the analysis of video records and interviews led to six themes: (1) lesson entry behaviors, (2) teaching strategies, (3) technology enhanced classroom management, (4) troubleshooting and (6) assessment as shown in Table 4.2.

Table 4.2

TPACK Indicators Emerged in the Analysis of Actual Teaching Performance

Themes	**Observed Frequency**	**Reported Frequency**
1. Lesson Entry Behaviors	#	#
Inserting flash drive to initiate smart board	Zara/Lara/Leo/Serena	-
Taking online classroom attendance	Zara/Lara/Leo/Serena	-

Initiating smart software	Zara/Lara/Leo/Serena	-
Screening students' tablet connection	Zara/Lara/Leo/Serena	-
2. Teaching Methods and Strategies		
2.1 Technology Enhanced Science Specific Strategies		
Orienting students during video show (Guided Viewing)	Zara/Lara/Leo	Zara/Lara/Leo/Serena
Visualizing abstract concepts (Visual Conceptualization)	Zara/Serena	Zara/Serena/Leo
Simulating experiments	Lara	Zara/Serena/Leo/Lara
Constructing hypothesis on simulated phenomenon	-	Serena
Enhancing reality via 3-D classroom	-	Zara/Serena/Leo
2.2 Technology Enhanced Strategies		
Conducting tablet based problem solving	Leo/Serena	Zara/Serena/Leo
Sharing files between the devices	Serena/Leo/Lara/Zara	Serena/Leo
Using online education platforms	Leo/Lara/Zara	Zara/ Leo/Lara
Using cloud computing for reminding previous lesson	Lara/Leo/Serena	
Practicing with interactive exercises/tests	Serena/Leo/Lara/Zara	Lara/Zara
Running the curriculum on smart board	Leo	Serena
Using smart exercise notebook	-	Lara
Using online notebook	-	Zara
3. Technology Enhanced Classroom Management		
Checking the connection status of student tablets	Serena/Leo/Lara/Zara	Leo
Checking the system notification for disconnected students	-	Zara
Taking the instant screenshots of students' tablets	-	Serena
Walking around to check screens of the tablets	-	Zara/Serena
Changing the settings (marker, screen) to draw attention	Serena/Leo/Lara/Zara	
Sending/Using attention grabbing materials to arouse interest	-	Zara/Leo/Lara
Freezing the scene of the videos	Lara, Zara, Leo	
4. Troubleshooting		
4.1 Unavailable Student Devices		
Having a tablet out of charge	-	Leo
Having a tablet low on memory	-	Leo
Forgetting to bring a tablet	Serena, Leo	
4.2 Proposed Solutions		

Keeping the duration of tablet-based short		Leo
Changing the teaching strategy	Serena	Zara
Sharing tablets with a classmate	Serena	
Sending e-documents to be revised out of school time	Lara, Zara	Serena
4.3 Software Breakdown		
Plugging in-out flash drive	Leo	-
Restarting the software	Leo	-
Asking for student help	Leo	Zara
Asking for colleagues help	-	Leo
Asking for IT instructor help		Lara/Serena/Leo/Zara
Making an individual effort	Leo	Leo/Serena/Leo/Zara
4.4 Network Disconnection		
Sharing the device with the pair	Serena	Serena
Sharing digital files with the pair	Lara	-
Resending the content to the devices	Serena/Leo	Leo
5. Assessment (Summative)		
Using cloud computing to send online homework	-	Zara
Conducting interactive quizzes/tests	-	Serena
Conducting quizzes on tablet	-	Zara/Serena/Leo

4.2.1. Lesson Entry Behaviors

The coding of first 5 to 10 minutes of classroom teaching among each case revealed common entry behaviors schema regarding technology use in science classrooms. Being observed in each case, first action was to insert flash drive into smartboard to be able to initiate smart education. In this respect, Leo stated that:

> There are encrypted flash drives assigned for each teacher. Without these flash drives, it is not possible to initiate smart education. By inserting assigned flash drives into smartboard, the specific lesson content and the assigned classrooms to each teacher is automatically initiated. In the case of myself for instance, I have an access to the physics lesson and related content (curriculum, lesson materials etc.) and each classroom that I am currently teaching in 9th and 10th graders. Besides these flash drives keeps the record of each teaching sessions to be reached later on (Leo, post-video interview).

After inserting the flash drive, each teacher was observed to warn students on connecting to the network, so that data transfer between the devices would be managed in case of need. Once the connection was established, each teacher screened the student connection bar, which indicated the connected students' name colored with green, disconnected students' name with red. This provided teachers with the data of attendance as well as the current presence of the devices in the classroom. Next, in the guidance of each case, teachers initiated smart software on purpose of make an introduction to the topic by giving the headline or informing about the subject. In the final step, each teacher again checked the connection status of students' devices to see if there were any network problems, which may block the teaching process.

4.2.2. Teaching Strategies

Educational technologies feature in enhancing the quality of teaching and learning. Accordingly, it was observed that technology use in the classrooms had a substantive influence on the way of presenting learning experiences. After the introduction of the lesson, development of the lesson process was presented under the themes of (1) technology enhanced science specific strategies (2) technology enhanced strategies with the observed and reported frequencies of each case as shown in Table 3.

4.2.2.1. Technology Enhanced Science Specific Strategies

Being a situated, context dependent knowledge system; science-specific TPACK indicators through the lesson was investigated by focusing the transformative impact of the technology on teaching methods and strategies. Particularly, in the context of science education, the effect of technology on transformation of teaching methods and strategies was explicit. The emergent indicators of science TPACK were examined as follows.

Orienting Students during Video Show (Guided Viewing)

Guided viewing is a strategy that allows teachers to lead students learning during the video show. Rather than solely watching the visual content, students are encouraged to search for particular information by the questions posed by the teacher, which also ensures the active participation of the students. Coding the video recordings, it was observed that teachers frequently used video demonstration during the instruction time (Zara, Lara, Leo). Even though Serena in her teaching did not use video show, she reported that:

> I did not use video showcase today in my lesson due to the nature of the content. However, I mostly take the advantage of science videos in my classroom (Serena, post-video interview).

It was a significant finding that teachers developed various strategies to be implemented with various technologies such as scientific animations, simulations and scientific documentaries. Rather than simply showing the video, teachers guide students to search for particular piece of information during the show (McFarland, 2016). Teachers were observed by the researcher to stop videos periodically in order to:

- Make connections with previous lessons (Zara, video record)
- Explain the information given (Zara, video record)
- Stressing the parts causing misconceptions (Leo, video record)
- Ask related questions with the piece of information (Zara, Lara; video record)
- Paraphrase the information given (Lara, Zara; video record)

The method of guided viewing method was generally accompanied by classroom discussions by interrogating the information inferred from the video (e.g., the cases of Zara, Lara; video recordings). In brief, direct instruction, as a method frequently used in the science classrooms, now evolved and enhanced into guided viewing in support of educational technologies.

Visualizing of Abstract Concepts (Visual Conceptualization)

Scientific knowledge, due to its nature, involves abstract concepts hard to comprehend by the students from time to time. Various technologies are now being used in order to provide solidity within learning experiences. Analysis of the interviews revealed that teachers also (e.g., the cases of Zara, Serena and Leo) laid emphasis on the significance of visualization in science topics. For instance, in this respect Zara reported:

> I used more visuals in the recorded lesson because biology as a subject necessitates visualization of the content (Zara, post-video interview).

Zara also in her lesson used Internet to show what "sponge" actually looks like when she realized that students did not have the image of sponge in their minds (Zara, video record). Besides, on a different purpose, Serena showed an image to explain to the physics term, work on the schema embedded in the lesson material (Serena, video record). Even though Zara and Serena used the method of visualization on purpose of conceptualization in their lessons, Leo and Lara also reported that they frequently use visual conceptualization in their teachings.

In sum, either with videos or images, teachers prefer to use visual tools in science education to enhance the learning quality, the rate of comprehension and retention.

Simulating Experiments

Simulations are the technological tools used to simulate or imitate the real life phenomenon and science education by its nature is open to that kind of inquiry.

Simulations were reported for being used frequently in post-video interviews (Lara, Zara, Serena, Leo). However, simulation was only used in Lara's teaching, which was a chemistry experiment simulation (Lara, video record). In the case of Lara, the simulation was combined with an exercise, which enabled students to fill their direct observations and provided an instant feedback in the end. The most probable reason for that, in the guidance of teachers' statements, there were specific subjects more suitable to combine with simulations. To illustrate, Zara mentioned that:

> Density as a subject is very hard to comprehend by students. I tell students that substances having different densities are placed in different layers when mixed in a cup as in the example oil and water, for instance oil tends to go upward due to its lower density. However, it is not being totally understood by students. That is why, in such cases, I prefer to use simulations (Zara, post-video interview).

Besides, Leo further commented on the issue that:

> I accelerate and decelerate the cars in the topic of velocity by the help of simulations. Moreover, simulations give the related graphics such as velocity/time, distance/time etc. and change in variables instantly are reflected on the graphs, which is amazing. Simulations are great tool to increase students' attention and comprehension (Leo, post-video interview).

Moreover, Serena also mentioned that:

> Simulations are being helpful in recalling information. For instance, I use simulations when teaching the relationship between velocity and water waves (Serena, post-video interview).

Simulations, depending on the nature of the topic, can be counted as significant tools in science teaching, which facilitates learning scientific concepts, principles and theories. This was also agreed by teachers' statements and supported with the findings obtained from the analyses of classroom teachings.

Constructing Hypothesis on Simulated Phenomenon

Science specific technologies are expected to create opportunities to follow scientific procedures for students, which is bounded by the context of working conditions of scientists. Inevitably, constructing hypothesis and testing the claims are the basic steps a scientist would follow in doing scientific research. In this regard, there exist various software designed to help students to work like a scientists.

Even though it was not observed in each classroom teaching, Serena reported that she generally uses simulations or similar contents to enable her students to conduct scientific research. In this respect, Serena stated that:

> Time to time, I make my students to construct hypothesis and reach conclusions in stimulating the natural phenomena by taking the advantage of simulations and simulation like software (Serena, post-video interview).

It can be drawn as a conclusion that variety in instructional technologies not only enhance the quality of teaching and learning union but also enable students to work like scientists in the classroom environment.

Enhancing Reality via 3-D Classroom

3-D classrooms serve an educational environment, which promotes real life situations in three-dimensional format with the equipment of 3-D glasses, 3-D screens and 3-D contents. The number of this type of classrooms is on the increase, which is triggered by the developments in the field of technology. Besides the offer of enhancing the sense of reality in science education encourages teachers to benefit from 3-D classrooms and laboratories. None of the classroom videos was recorded in 3-D classrooms; however most of the teachers reported their visits to 3-D classrooms. Within this regard Leo said that:

> Students put their 3-D glasses on and live the moment within a scenario from daily life (Leo, post-video interview).

Moreover Zara commented that:

> To provide students with real-life experiences, we visit 3-D classroom as much as possible depending on the content (Zara, post-video interview).

Regarding teachers' statements, 3-D classroom was not frequently used and visited by the science teachers. However, on purpose of attracting students' attention and strengthening the learning experiences, science teachers preferred to use 3-D technologies in their teaching routines.

4.2.2.2. Technology enhanced Teaching Strategies

Traditional teaching methods and strategies are now being transformed under the influence of growing use of technology in classrooms. Technological infrastructure of the setting, which the study was conducted, provided rich data on this transition. Throughout the lessons being recorded, various technology enhanced teaching strategies were observed and listed as observable TPACK indicators as shown in Table 4.2, under the theme of teaching methods and strategies. Those TPACK indicators were also supported with the findings from pre and post video interviews as in the column of reported behaviors with the reported frequencies among the cases.

Conducting Tablet Based Problem Solving

Availability of tablet P.C's, in the guidance of classroom videos, changed the way of how problem solving as a teaching strategy practiced in the classroom setting. Through the method, interactive file transfer between the devices (students' device to smartboard) was managed. In the first step, teacher sent the problems to the student' devices and received the solutions back to check their correctness. In return, instant feedback delivered from the main device.

That is, to illustrate, Leo in his teaching, wrote a question to the smartboard at first. Then he framed the question with a smart pen to send students' tablets. After students screened and answered the question on their tablets, they sent the answer back to the smartboard. In the next step, teacher checked the students' answers from the connection bar which colored the students' name with green managing the file transfer. Finally, teacher checked the answers by choosing the names from the bar and called one of them to the smartboard in order to solve the problem (Leo, classroom video). Similar strategy was also observed in Serena's case. In this respect Zara mentioned that:

> Especially, when I conduct end-of lesson quizzes and if I do not want students look at each other's answers, then I use tablet based problem solving so that I can have objective evaluation about students' answers (Zara, post-video interview).

Clearly, tablet-based problem solving one of the technology-enhanced strategies generally adopted and preferred by the teachers in the classroom.

Sharing Files Between Devices (Solutions-Screenshots-Notes)

File sharing allows teachers to send and receive various kinds of data instantly between the connected devices through the network. File sharing between the devices was one of the strategies both most frequently observed in the classroom and reported by the teachers. There were various purposes identified in using file transfer between the devices. To illustrate, Lara sent the atomic structure she drew on the smartboard and sent the screenshots to students' tablets (Lara, classroom video). Besides, Lara sent the solutions of the problems to students' tablets that students solved on the smartboard (Lara, classroom video). Moreover, Zara, after the explanation sexual and asexual reproduction, diagrammed a concept map on the smartboard and sent it to students' tablets (Zara, classroom video). Leo was also observed to use this strategy frequently by sending each page he used of the smartboard. Besides, he was also observed for transferring acceleration diagram and the solution on the problems to the students' tablets (Leo, classroom video). Lastly, Serena, in her lesson, sent the graphics she drew on the smartboard to the students' tablets (Serena, classroom video).

In sum, here are the files chosen by the teachers (both reported and observed by all of the teachers) for being transferred between the devices:

- Sending shapes, graphics or diagrams
- Sending the instant screenshots
- Sending problem solutions
- Sending the embedded curriculum materials
- Sending online exercises, tests and questions

Using Online Education Platforms

Online education platforms are the online systems serving educational materials to support students' learning and teachers take the advantage of these platforms by conducting different kinds of activities during the lesson.

Analyses of the classroom videos indicated that online education platforms were continually used by in the teachers (e.g., the cases of Lara, Zara and Leo) on different purposes. To exemplify, Zara used the two videos among one of the leading online education platforms in her teaching to conduct guided viewing. In the end of the lesson, she also used the online assessment materials such T/F questions, multiple choice and matching questions of the same platform on purpose of assessment (Zara, classroom video). Moreover, Lara also used the same online education platform to conduct a general review and a guided viewing with the videos and simulation it provided (Lara, classroom video). Likewise, Leo also used the secondary education level of the same platform and made a summary by using the videos presented. Afterwards, he used the test questions of the platform on purpose of assessment (Leo, classroom video). On the other hand, Serena did not use any kind of online education platform in her teaching (Serena, classroom teaching); neither she reported the use of online education platforms during the instruction.

Using Cloud Computing For Reminding Previous Lesson

Cloud computing is the feature of smart education software used to store various kinds of data to be reached at a later time without the limits of time and location. All kind of lesson materials, the instruction time or the activities conducted throughout the lesson process would be stored in the database.

Reaching previous lesson content was one of the features of smart education observed in the two of the cases (Lara, Leo; classroom videos). Within this regard Leo stated that:

> At the end of the lesson, smart software asks if the lesson is going to be recorded or not. When it is recorded, after three days or something, even in a different classroom, I reach the problems that I solved and reuse them (Leo, post-video interview).

On the basis of cloud storage, it was observed that Leo made a quick review by using the velocity/time graphs drawn in the previous lesson of the same classroom (Leo, classroom video). Moreover, Lara also checked the previous exercises with students (Lara, classroom video). Serena, also in her lesson repeated the previously solved problem in the scope of lesson review. To conclude, cloud computing was an application that frequently used by the teachers on purpose of lesson review.

Practicing with Interactive Exercises

Teachers also used technology to conduct online exercises to support their teaching. As well as interactive online exercises, they used e-documents embedded in the smartboard. It was observed that conducting online exercises (multiple choice questions, short answers, matching questions, filling the gaps) through online education platforms (Zara, Leo; classroom video) were chosen to have instant feedback on students' answers. On the other hand, teachers were also actively used e-documents (e-testing documents) embedded in the smartboard to conduct mini classroom discussions (Serena, classroom-video), lesson review (Leo, classroom video), and reinforce learning (Lara, classroom video) as well as online education platforms. Besides, teacher statements also supported the observational findings, which were proved by data of the interview analyses.

Running the Curriculum on Smartboard

The school curriculum was embedded in the smartboard in the format of e-book and there was an open access to this document, which can be revised by the students as well as teachers.

Although, it was rarely mentioned (Serena, post-vide interview) and observed (Leo, classroom video), the curriculum materials were also integrated into classroom teaching through using smart board applications. In the case of Leo, it was observed that teacher reminded students to check the objective list and the related question aligned and categorized under the objectives list (Leo, classroom video). This implies that, having the curriculum integrated within the smartboard not only works for the teachers but also students on the purpose of organizing the learning experiences.

Using Smart Exercise Notebook

Smart notebook is online software, which includes written questions, problems and various kinds of exercises to enhance the instruction and students' learning. Being only mentioned by Lara, smart notebook technology was one of the technologies that she preferred to integrate her lessons. In this regard she stated that:

> I use smart notebook in my lessons because I believe that it is the best way of learning the content, when it is combined with the materials of online education platforms. This smart notebook includes various questions on many topics and these readily available questions help me to save from the time spent on writing (Lara, post-video interview).

In conclusion, even though it was not observed in her classroom teaching, in the guidance of her statements, it was revealed that she benefited from the smart exercise notebook to strengthen students' learning.

Using Online Notebook

Online notebook is used for individual note-taking activities and the notes are stored in the database of the software. In this regard, Zara emphasized the importance of note taking in view of students' learning and mentioned about the benefits of note taking. In this respect, she mentioned reported:

> For students, taking notes is significant. It strengthens students' learning. The information I shared through the smart education should be noted down either to notebooks or online notebook software that we currently use (Zara, post-interview).

Clearly, although it was not observed in her classroom teaching, tablet use in the classrooms transformed the way of applying her strategies during the instruction by shifting from handwriting towards online note taking.

4.2.3 Technology enhanced Classroom Management

Educational technologies not only changed the physical environment and the way of teaching but also the way of interacting with students and dealing with the misbehaviors accordingly. Particularly, introduction of the tablets into classroom environment caused teachers to develop new techniques in creating controlled and organized learning environment. Within this respect, keeping students on task gained significance due to the fact that tablet use left students vulnerable and open against virtual stimulants. Based on the analysis of the interviews, teachers reported that gaming during the lesson (Zara, Serena, Leo; post-video interview) or conducting off-task activities on tablets (Zara, Leo; post-video interview) were the two distinguished misbehaviors during the tablet-based activities. In order to deal with these misbehaviors, teachers suggested possible solutions. Within this scope Zara suggested that:

> If I am going to use the tablets actively, then I try my best to walk around to check the screens. Besides if students are disconnected from the network, I get system notifications about the current status of the student. (Zara, post-video interview)

Furthermore, Serena further recommended on the issue that:

> I take instant screenshot of the students' tablets and verbally warn the students displaying off-task behavior. Still, I walk around in the classroom as

> much possible to prevent this kind of misbehaviors (Serena, post-video interview).

In total, checking the connection status of the students either by instant screenshots or system's notifications and walking around the classroom were the suggested solutions to the misbehaviors arising from tablet-based education. This also was confirmed by the codes of the classroom videos, which indicated that teachers continuously checked the current status of students' connection from the connection status bar placed on the bottom right corner of the screen (Lara, Zara, Serena, Leo; classroom video).

In order to prevent misbehaviors before occurring, teachers stated about the certain precautions such as sending attention grabbing materials to the students (Lara, Zara, Leo; post-video interview). In this respect Lara mentioned that:

> I send attention-grabbing materials to students' tablets so that they do not play games or show off-task behaviors (Lara, post-video interview).

Thus, gaining attention was another significant issue in terms of classroom management. On the basis of analyses classroom videos, there were various strategies observed to attract students' attention with respect to application of technological tools. For instance, it was observed that teachers changed the settings of marker by arranging its color, thickness to highlight the important information written on the board (Zara, Leo, Serena, Lara; classroom video). Besides, teachers froze the scenes of the videos to attract students' attention to piece information that students needed to focus (Zara, Leo, Lara; classroom video).

Last but not least, in the breaks students were reported for connecting smartboard in order to use the Internet connection (Leo, post-video interview). In this context, Leo told that:

> Students' effort to use the Internet of smartboard or plug-in their own flash drives in the breaks cause a system breakdown and I need to restart the software all over again in the beginning of the lesson (Leo, post-video interview).

In order to prevent the damage caused by the student use, teachers assigned with their own flash drive, which had a locking system so that students could not have an access to smartboard. To sum up, using technology in the classrooms encouraged teachers to update their strategies of classroom management by taking the advantage of available technologies and specific affordances.

4.2.4. Troubleshooting

Inevitably, teaching with technology brings certain problems with it. The observed and reported problems with the proposed solutions were presented under the categories of hardware problems (1), software breakdown (2) and network disconnection (3) respectively.

4.2.4.1. Hardware Problems

First of all, unavailability of tablets P.C's among majority of the classroom was one of the problems that teachers faced in the classroom within the scope of hardware problems (Lara, Zara, Leo, Serena; classroom video). There were many reasons reported regarding the absence of devices. In this respect, Leo stated that:

> One of the significant problems that we face concerning smart education is the students' tablet that running out of battery. In face of this problem, it is more convenient to keep duration of tablet-based education shorter, may be in first 10-15 minutes of the lesson (Leo, pre-video interview).

On the other hand, he further commented on the issue that:

> I send teaching materials to students' tablet and I actively use file transfer between the devices. However, students do not check their galleries and clean the memory of their devices. Then, we cannot manage the file transfer (Leo, post-video interview).

Briefly, devices being low on memory or out of charge were reported as the probable hardware problems. Besides, it was also observed that there were students who forgot to bring their devices into classroom (Serena, Leo; classroom teaching). In an effort to compensate the absence of tablets, teachers generated alternative solutions. To illustrate, Serena told one of her students to share the tablet with her classmate on her request of borrowing from the other classroom (Serena, classroom video). In an answer to same problem, Zara reported that:

> If each student had their tablet today, I would send the problems to their tablets and receive the answers in doing the last activity. Instead, we solved the exercises together on smartboard, and then I send the solutions anyway for being checked at home from their galleries (Zara, post-video interview).

In support of Zara's statements, Serena was observed while reminding her students not having their devices to take notes on their notebooks instead of their tablets (Serena, classroom video). Likewise, Lara told her students not to take notes instead she sent the screenshots on their tablets for being checked later on (Lara, classroom video). It can be drawn as a conclusion that unexpected hardware problems encouraged teachers to change their teaching strategies by generating alternative solutions against technical problems.

4.2.4.2 Software Breakdown

In regard to software problems, teachers developed various methods to cope with in the case of software breakdown. Even though such kind of a problem was not normally observed, in Leo's case a similar problem arose (Leo, classroom video). Leo could not manage to initiate the smart software on his first try. To manage the problem, he plugged in and out his flash drive. In the meantime, he asked for students help by asking what might be the possible reason of this problem. Then he restarted the software, which worked out. There were other solutions proposed by the teachers on this issue. Within this regard, Lara mentioned that:

> In such situations, I ask for help to our instructional technology teacher (Lara, post-video interview).

On the other hand, Leo mentioned that:

> We have a mobile chat group with our colleagues, which I frequently use to consult about technical problems (Leo, post-video interview).

Zara emphasized the students' help by stating that:

> Now, there are some students who are really competent on the field of technology. Mostly they have been really helpful (Zara, post-video interview).

To conclude, when being confronted with software problems, asking for help from colleagues and students as well as individual help were the possible solutions reported and observed as a result of data analyses.

4.2.4.3 Network Disconnection

In the case of problems related with network connections between the devices, teachers developed alternative solutions for data transfer. For instance, Zara stated that:

> Today, there was a connection problem between the devices in relation with data transfer. Some of the devices could not access the content. That is why, I told some of the students to share their tablets together to be able to screen the content (Serena, post-video interview).

In answer to same problem, Leo reported that:

> I resend the content to students' devices if any disconnection problems occur (Leo, post-video interview).

Moreover, Lara in her teaching told one of her disconnected student to receive the lesson materials from a friend later on (Lara, classroom video). All in all, sharing the devices and digital files and resending the information were the possible solutions proposed by the teachers against network problems.

4.2.5. Assessment

Availability of technological resources in education has an impact on the assessment techniques, which is an integral part of teaching process. Various assessment techniques transformed under the influence of educational technologies were observed through the cases. Conducting online quizzes and tests by using online education platforms was one of the techniques reported on purpose of assessment (Serena, post-video interview). In addition to use of online education platforms, all of the teachers reported that they use tablet-based education to send and receive quizzes for being easy to handle and evaluate the results. Even though teachers mainly reported that they use technology based assessment techniques, more conventional techniques such as mid-term examinations, standardized tests, and national examinations were claimed to have dominance over online techniques regarding summative assessment.

4.3 Summary of the Results

The study aimed to reveal observable indicators of science TPACK both in the design and implementation process of technology enhanced teaching. First of all, the indicators of science teachers' TPACK observed in the design of technology-enhanced teaching were investigated under four themes:

- Technology selection
- Curriculum planning
- Lesson Preparation
- Assessment

In selecting technologies, teachers check the congruence of the chosen technology with the content, the fit between the learning styles of the students and the technology selected, and consider the affordances of technologies would be integrated into teaching. Curriculum planning was the other significant component of design routines of the teachers. Respectively (1) identifying objectives (2) organizing the order of the topics (3) identifying methods and strategies were the main indicators of how teachers design a technology enhanced instruction in consideration of curriculum elements. Before the actual lesson, teachers were observed to prepare themselves and their students to the next lesson in applying different strategies. (1) Practicing in the IT classroom, (2) sharing digital materials with students, (3) informing about the next subject were the indicators emerged under the theme of lesson preparation. Lastly, within the scope of end of lesson assessment, using online education platforms (1) and conducting quizzes on tablet P.C (2) were the indicators reported by the teachers.

Secondly, the indicators of TPACK observed in teachers' actual teaching in science classrooms were examined under five themes: (1) lesson entry behaviors, (2) teaching strategies, (3) technology enhanced classroom management, (4) troubleshooting and (5) assessment. The indicators of lesson entry behaviors observed in each case were listed as below:

- Inserting flash drive to initiate smart board
- Taking online classroom attendance
- Initiating smart software
- Screening students' tablet connection

Teaching strategies of applied in the classroom were classified as (1) technology enhanced science specific strategies (2) technology enhanced strategies in consideration of the observed and reported case frequencies. The TPACK indicators drawn from technology enhanced science specific strategies included (1) orienting students during video show, (2) visualizing abstract concepts, (3) simulating experiments, (4) constructing hypothesis on simulated phenomenon and (5) enhancing reality via 3-D classrooms. On the other hand, indicators emerged under the theme of technology enhanced strategies were (1) conducting tablet based problem solving, (2) sharing files between devices, (3) using online education platforms, (4) using cloud computing for reminding previous lesson, (5) practicing with interactive exercises, (6) running the curriculum on smartboard, (7) using smart exercise notebook and (8) using online notebook.

Besides, teachers reported two main technological misbehaviors seen in technology classrooms, which were gaming during the lesson and conducting off-task activities on tablets. Checking the connection status of the students either by instant screenshots or system's notifications and walking around the classroom were the suggested solutions to the misbehaviors arising from tablet-based education. Additionally, in consideration of classroom management strategies, teachers applied various strategies to attract students' attention such as (1) changing the settings of marker by arranging its color and thickness to highlight the important information (2) freezing the scenes of the videos to attract students' attention to piece information.

The problems stemming from the technology use in the science classrooms were classified under the categories of (1) hardware problems, (2) software breakdown and (3) network disconnection. Hardware problems were the issues related with the devices (1) being low on memory or (2) out of charge or (3) unavailability. The possible solutions to hardware problems were reported and observed as (1) sharing the device with the mate and (2) using cloud computing to send materials in the case of unavailability of the devices. Besides, the suggestions to software problems were identified as asking for help from colleagues and students as well as individual help. On the other hand, sharing the devices and digital files and resending the information were suggested solutions to the network problems.

Lastly, the analyses of interviews and classroom video recordings indicated that summative assessment techniques were conducted in more conventional method in the science classrooms such as mid-term examinations, standardized tests, and national examinations.

CHAPTER 5

CONCLUSION

The study examined the observable indicators of science teacher's TPACK in reference to crucial gaps identified in the wake of systematic analysis of the literature. Addressing to the research gap on nature and development of TPACK in science education (Srisawasdi, 2014), context-specific observable indicators of TPACK were delved in-depth under the investigation of the process of technology adoption among science teachers. In pursuit of uncovering indicators of science teachers' TPACK, the design process of technology-enhanced teaching was explored at first, and then the actual teaching performances were analyzed extensively within the scope of research questions. The study had unique implications for TPACK literature for adopting the video research method and focusing on the teachers' observable behaviors as well as reported actions in order to promote science teachers' professional development and context-specific divergence of TPACK epistemology in science education across the subject domains (Lin et al., 2012). In brief, findings ensued from the research questions were presumed to contribute significantly to TPACK literature and bring an innovative perspective and new insights towards professional development of science teachers due to its' contributions to the nature and development of science TPACK.

5.1. Discussion

The main purpose of the study was to reveal observable indicators of science teacher's TPACK in search of design and implementation process of technology-enhanced instruction in the context of private campus school offering primary and secondary education level of education in Istanbul, Turkey in 2016. The research field was chosen purposefully on smart education it offers with inclusion of various educational applications and online learning platforms. Besides, participants' acquaintance with TPACK framework through in-service trainings expected to contribute rich data among nature and development of science TPACK, particularly when lack of solid evidences regarding science teachers' TPACK in the literature taken into consideration. Moreover, in consideration of guiding literature, there was a lack of research methodology to suit authentic and situated nature of TPACK and consensus between the researchers among discrimination and classification of sub-components as a result of embracing integrative approach in regard to epistemology of TPACK. Therefore, the study put an effort to address these critical gaps in the literature through the examination of observable science TPACK indicators in adopting transformative perspective towards the phenomenon through video research method.

To begin with, the study investigated how science teachers designed their lessons in support of technology. As proposed by Tubin & Edri (2004), how teachers design a technology enhanced teaching is left unknown. The findings revealed that each teacher had a unique teaching pattern emanating from the accumulation of own teaching experiences. Data revealed that curriculum planning was of a virtual importance for being at the core of design process in designating the objectives, organization of the topics and teaching methods and strategies. In the study of Yeh, Lin, Hsu, Wu and Hwang (2015), curriculum design was also found as most significant sort of knowledge after assessment and practical teaching by the expert teachers. In the current study, it was also found that identification of the objectives was the key determinant of how the topics were organized and choosing the relevant technologies accordingly. However, teachers' attitude towards determination of methods and strategies was more of an instinctual process shaped by teachers' experiences and their philosophy of education. It was revealed that teachers' beliefs and perceptions towards best learning strategies were more effective than students' needs (e.g. learning styles, educational background) in identifying the teaching methods and strategies.

Being under the influence of various parameters, technology selection process was literally most complex part of technology-enhanced instruction. The key factor affecting the technology choices of the teachers was found to be its alignment with the content. This proved that technology knowledge solely was not effective on the decisions of technology selection among the teachers. Instead, it was detected that contextual variables such as affordances of the technologies (e.g. enhancing retention, saving on time), availability status had a crucial role on technology selection as well as its' fit with the nature of the topic. Besides, student-learning styles (e.g. visual learner, read and write learner) were found to have a significant influence on technology preferences of the teachers. Likewise, Harris and Hofer (2011) claimed that technology selection primarily connected with the type of learning activity chosen, which implicitly under the influence of students' needs. In sum, being an entity growing out of the collection of the experiences, detailed vision of students' educational background was recorded as a crucial factor contributing to variances in the design of technology-enriched instructions as shown in Figure 5.1. Likewise, Angeli and Valanides (2009) extended the notion of TPACK as a knowledge stemming from the combination of the tools and their affordances, pedagogy, content, learners, and context.

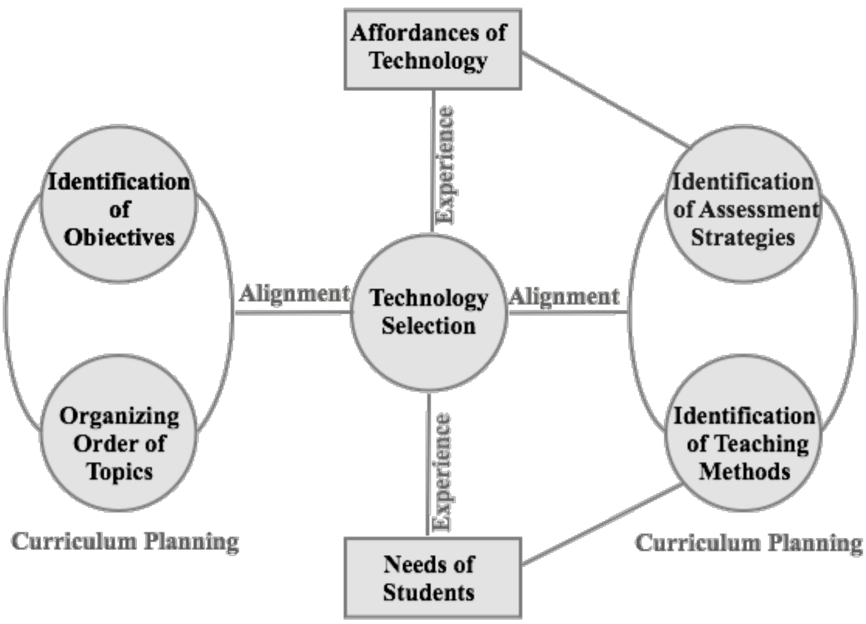

Figure 5. 1. The Components of Technology Enhanced Lesson Design

End of lesson assessment come out as an essential part of lesson design, which was strongly emphasized by the teachers. Various ways of assessments embraced by the teachers; however each of them, in all sorts of ways, was conducted with the technology. In each case, the effect of technology on teachers' assessment routines was clearly observed. It was found that availability of technologies encouraged teachers to transform their assessment routines, so the planning process of the instruction.

Integration of cloud technologies was observed to increase the interaction between the students and teachers. It was revealed that availability of students both in and out of classroom time supported teachers to prepare students' cognitively and affectively to the next lesson by sharing e-documents of the lesson, which was observed as a part of lesson design process. Besides, technology classrooms were reported for providing teachers to make lesson practice before actual teaching performance. Harris, Grandgenett and Hofer (2010) proposed that:

> "Optimally, teachers' planning, instructional actions, interactions with students, and reflections upon those actions and interactions should all be examined to determine the nature and extent of their TPACK" (p.2).

Accordingly, in order to determine nature and extent of science teachers' TPACK, the data of lesson design was supported with the instructional actions in search of observable indicators of science teachers' TPACK. The analyses of classroom videos were triangulated with the interview data by presenting the observed and reported frequencies of the indicators. The indicators of science TPACK emerged from the actual teaching process were discussed as noted below, respectively in terms of proposed TPACK models, specific implications towards science education and video research method.

Addressing the 21^{st} century teachers' professional growth, researchers continuously search the nature and development of TPACK since the framework was put forward by Mishra and Koehler (2006). Adopting different perspectives, researchers mainly examined epistemology of TPACK from integrative and transformative viewpoints. Canbazoglu Bilici et al. (2016) put emphasis on the significance of embracing one of those perspectives for the sake of studies in order to reach more effective and accurate results. In an attempt to reach a consensus about "what is and is not an example of each construct" (p.60), researchers adopted an integrative attitude to discriminate the constructs and identify their scope of practice to understand TPACK knowledge thoroughly (Cox & Graham, 2009). However, the knowledge stemming from the interaction of various constructs complicates the process and it is required to give a great effort to clarify boundaries of each construct, which is still the issue of conflict between the researchers in deciding nature of TPACK knowledge. Besides, Angeli and Valanides (2009) claim that construct-level development in TPACK knowledge does not promise overall improvement in epistemology of TPACK due to the effect of unique knowledge type emerging from intersection points of TPACK constructs. Providing ease with analysis and identification of TPACK knowledge which is a distinct kind of knowledge from its constituents (Canbazoglu Bilici et al., 2016), the study employed transformative approach in order to reveal how science teachers integrate educational technologies to support their teaching. Instead of assigning each science TPACK indicator to separate TPACK knowledge bases, the indicators were investigated under the themes emerged from the cross-case analysis of the data. If the science indicators were investigated under integrative philosophy, some of the indicators would be left unclassified, which was the proof of unique kind of interactions out of pre-determined constructs.

To illustrate; in lesson preparation phase, the indicator of "practicing the designed lesson in the IT classroom before actual teaching" was revealed. This indicator neither would be investigated solely under technology knowledge (TK) nor technological pedagogical knowledge (TPK). Clearly, this indicator has several characteristics to be searched under those categories; yet it carries singular features matching with another constructs such as pedagogical knowledge (PK), content knowledge (CK). It can be drawn as a conclusion that the indicators embraced the combination of all kinds of knowledge types by laying differentiated weight on different TPACK constructs. Clearly, the indicators would be attributed to different kind of TPACK constructs in terms of the context they were utilized within the scope of integrative approach. Not only the context that indicators were evaluated but also the theoretical lens of the researcher possess have significant influence on categorization of the indicators under relevant knowledge bases. Therefore, the

Table 5.1 is a good indicator of the dispute between the researchers about the fuzzy boundaries among TPACK constructs (Angeli & Valanides, 2009; Cox & Graham, 2009).

Table 5.1

Examples of TPACK Indicators of the Study from Transformative and Integrative Perspectives

Themes	**Serving TPACK Area**
Technology Selection	**TK**
Checking the alignment with the content	TCK
Checking the needs of the students	TPK
Checking the affordances of the technology	TK-TPK
Curriculum Planning	**PCK**
Identifying the objectives (Content-Technology Match)	PCK- TCK
Organizing the order of the topics	PCK
Identifying the methods and strategies	PCK
Lesson Preparation	**TPACK**
Practicing in the IT classroom	TK- TPK- TCK- TPACK
Sharing digital materials with students beforehand	TK- PK- TPK
Informing about the next subject	PK
Technology Enhanced Strategies	**TPK**
Conducting tablet based problem solving	TCK
Sharing files between the devices	TPK-TK
Using cloud computing for reminding previous lesson	TCK-CK
Technology Enhanced Science Specific Strategies	**TPCK**
Orienting students during video show	TPCK-TPK-TK-PK
Visualizing abstract concepts	CK-PK-PCK

Besides, as it is seen in the Table 5.1, the emergent themes would serve different TPACK areas than the indicators assigned to each theme. Therefore, integrative classification of TPACK indicators would not allow the related constructs to be evaluated in unity. This might cause a probable confusion in identifying the unique requirements to be met by the teachers related with the different knowledge areas of TPACK knowledge. Hence, it is not a meaningful effort to discriminate and differentiate TPACK constructs from one another in consideration of teachers' professional development. In brief, on the basis of rationales aforementioned, the study followed the transformative approach throughout the analyses of the findings.

Lin et al. (2012) proposed that there is a lack of substantive evidences of TPACK indicators among science content to inform science community about efficient technology integration, which hinder professional development of science teachers in the long run. Table 5.2 shows examples of the evidences of TPACK science indicators drawn from the guiding literature (Graham et al., 2009; Jen et al., 2016; Lin et al., 2012; Mouza et al., 2014). The limited number of studies related with TPACK science indicators have shown distinct similarities and differences from various aspects with the study conducted.

First of all, in the study of Graham et al. (2009), the TPACK science indicators embedded in the questionnaires were used in an attempt to measure the confidence rate of in-service teachers on TPACK. Likewise, Mouza et al. (2014) in their study used a survey and case reports in order to measure TPACK knowledge of the pre-service teachers. Lin et al. (2012) also used survey to measure science teachers' perceptions towards TPACK. All of the studies that used surveys on purpose of measuring TPACK related constructs followed an integrative attitude as shown in Table 5.2. The indicators drawn from teachers' reported actions or from the literature resulted in vagueness in attributed indicators due to absence of specific contextual factors attached. To illustrate, the indicator of "effectively manage a technology-rich classroom" (Graham et al., 2009, p.72) or "facilitate students to use technology to plan and monitor their own learning" (Lin et al., 2012, p.331) are the clear indicators of TPACK knowledge; however these indicators do not lead teachers on how to manage technology enhanced classroom setting or how to follow students' development by taking the advantage of technology. Relying on the teachers' reported actions (e.g. questionnaires, surveys.) on revealing the ways of adopting technology to support teaching processes is the common feature of the studies abovementioned. Therefore, the resultant TPACK science indicators drawn from the observable behaviors of the teachers were more precise when compared with the indicators shown in the literature as shown in Table 5.2.

Table 5.2

Examples of Science TPACK Indicators from the Literature

INTEGRATIVE MODEL	**TRANSFORMATIVE MODEL**
TPACK	ASSESSMENT
1. “Help students use digital technologies to collect scientific data ”. (Graham et al., 2009, p.72)	1. “Construct technology-supported assessments through which students' knowledge of and about science can be evaluated / Level 4”. (Jen et al., 2016)
2. “Use of technology to facilitate subject-specific pedagogical methods”. (e.g., science inquiry, primary sources in social studies, etc.) (Mouza et al., 2014, p.213)	2. “Use online assessments, digital representation or ICT tools to evaluate students' learning / Level 2”. (Jen et al., 2016)
TPK	PLANNING and DESIGNING
3. “Effectively manage a technology-rich classroom”. (Graham et al., 2009, p.72)	3. “Consider and design technology-supported instruction for enhancing instructional effectiveness and students' learning of science/ Level 3”. (Jen et al., 2016)
4. “Facilitate students to use technology to plan and monitor their own learning”. (Lin et al., 2012, p.331)	4. “Use student-centered instructional strategies to accommodate students' learning of and about science from completing inquiry-based tasks in technology-supported environment / Level 4”. (Jen et al., 2016)
TCK	ENACTMENT
5. “Use digital technologies that allow scientists to observe things that would otherwise be difficult to observe.” (Graham et al., 2009, p.73)	5. “Be able to use different technology to manage instructional resources or track student learning progress / Level 3”. (Jen et al., 2016)
6. “Use appropriate technologies (e.g., multimedia resources, simulation) to represent the content of science”. (Lin et al., 2012, p.331)	6. “Implement technology in class to impress students in science learning and make teachers' instruction easier/Level 3”. (Jen et al., 2016)

Table 5.3

Observable TPACK Indicators Emerged in Science Classrooms

LESSON DESIGN
A. Curriculum Planning
1. Identifying the objectives
2. Organizing the order of the topics
3. Identifying the methods and strategies
B. Technology Selection
4. Checking the alignment of content and technology
5. Checking the alignment of technology with students' learning styles
6. Checking the affordances of the technology
C. Lesson Preparation
7. Practicing designed lesson before the lesson
8. Informing students about the topic of next lesson
9. Sharing digital materials by using cloud technologies with students before the lesson
ACTUAL TEACHING
D. Lesson Introduction
10. Inserting flash drive to initiate smart board
11. Taking online classroom attendance
12. Initiating smart software
13. Screening students' tablet connection
E. Lesson Development
a) Technology Enhanced Science Specific Strategies
14. Orienting students during video show
15. Visualizing abstract concepts
16. Simulating experiments
17. Constructing hypothesis on simulated phenomena
18. Enhancing reality via 3-D classrooms
b) Technology Enhanced Strategies
19. Conducting tablet based problem solving
20. Sharing files between the devices
21. Using online education platforms
22. Using cloud computing for reminding previous lesson
23. Practicing with interactive exercises/tests
24. Running the curriculum on smart board
25. Using smart exercise notebook
26. Using online notebook
c) Technology Enhanced Classroom Management
27. Checking the connection status of student tablets
28. Checking the system notification for disconnected students
29. Taking the instant screenshots of students' tablets
30. Walking around to check screens of the tablets

31. Changing the settings (marker, screen) to draw attention
32. Sending/Using attention grabbing materials to arouse interest
33. Freezing the scene of the videos
d) Technology Problems
34. Having a tablet out of charge
35. Having a tablet low on memory
36. Forgetting to bring a tablet
37. Having trouble with software
38. Having trouble with internet connection
e) Troubleshooting
• **Hardware Problems**
39. Keeping the duration of tablet-based short
40. Changing the teaching strategy
41. Sharing tablets with a classmate
42. Sending e-documents to be revised out of school time
• **Software Problems**
43. Plugging in-out flash drive
44. Restarting the software
45. Asking for student help
46. Asking for colleagues help
47. Asking for IT instructor help
48. Making an individual effort
• **Network Problems**
49. Sharing the device with the pair
50. Sharing digital files with the pair
51. Resending the content to the devices
ASSESSMENT
F. End of Lesson
f) Formative Assessment
52. Using online education platform
53. Conducting quizzes on tablet P.C
54. Conducting interactive quizzes/tests
55. Using cloud computing to send online homework

The resultant TPACK science indicators (as listed in Table 5.1.) can be discussed from various perspectives. First of all, Mccain (2005) proposed that 21th century teachers are confronted with training students on how to take the advantage of technological tools in order to make query or become skillful in self-learning instead of solely using technology in the classroom. That is, technology use in the classrooms should be "placed in the hands of students" (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012, p.24). However, the behavioral indicators emerged from the analysis of actual teaching performances indicated that technology use in the classrooms was teacher-centered and students were in the role of passive observers in this respect. As also proved by McCrory (2008, p.197), the implications of technology adoption in regard to science education are threefold as explained below:

1. "Technology designed to do science"
   (e.g., probes, digital microscopes)" (Graham et al., 2009, p.78)
2. "Technology designed specifically for teaching and learning science"
   (e.g., simulations, animations)
3. "Technology unrelated to science that can be used in the service of science"
   (e.g., word processors, spreadsheets, graphic software)

Putting emphasis on the first item, there were no evidences neither observed nor reported by the teachers on using technology with the purpose of scientific inquiry which is a strategy accepted as a cornerstone of effective science learning (Pringle et al., 2015). As also proved by the literature, teachers do not prefer to use technology in order to conduct scientific inquiry (Otrel- Cass et al., 2012; Pringle et al., 2015). According to Tondeur et al. (2013), the way how teachers integrate technology in the classrooms have been affected by the outside factors such as school vision as well as "teacher related characteristics" (p.434). Ertmer (1999) classified those factors respectively as first order and second order barriers to technology integration. While first order barriers were explained as extrinsic factors such as "equipment, time, support" (p.50), second order barriers were the factors related with the teachers' inner values such as "beliefs and perceptions" (Ertmer, 1999, p.52). Clearly, the research site where the study was conducted had a strong technological infrastructure. Furthermore, as declared in the interviews, the school management encouraged teachers for technology integration in the classrooms and provided relevant in-service trainings on technology integration. Nevertheless, the evidences of higher order technology use in the classroom was not observed on the basis of the findings. This underlies the "disparity between practices and beliefs" (p.424) among the teachers (Ertmer et al., 2012). Possibly, the quality of in-service trainings should be enhanced by providing exemplary technology integration experiences to the teachers, which would lead teachers on innovative use of educational technologies. Additionally, the pressure of being bounded by classroom time and the pre-determined curriculum would be minimized in order to increase the inner motivation of the teachers.

In line with the second item, teachers were observed for using "technology designed specifically for teaching and learning science (e.g., simulations, animations) rather than integrating higher level technologies to do science such as "probes, digital microscopes" (Graham et al., 2009, p.78). Correspondingly, a unique method of teaching "guided viewing" (McFarland, 2016) used by the teachers to increase the rate of students' participation, which observed in each single case. Instead of solely watching the science-specific visuals contents (simulations, animations, videos), teachers guided students to search for particular piece of information during the show by asking relevant questions, stressing the information or asking for a summary by stopping the video at random points, which was observed for being followed by a classroom discussion. Additionally, in order to enhance students' learning experiences through virtual learning environment, science teachers were reported about the number ıf visits to the 3-D high technology classrooms were on the increase. It is likely that, teachers preferred video showcases over student-centered technologies due to ease it provides in controlling the content, such as stopping the video to answer students' questions or using a section of the video to provide feedback (Otrel- Cass et al., 2012).

As mentioned in the third item, being independent from science specific technologies, different kinds of technological applications were observed. Clearly, inclusion of tablet devices in education also transformed the way of applying instructional strategies. First of all, it was revealed that online connection between the devices of students and teachers changed the way of communication and transformed teaching routines of the teachers. This was the proof of inevitable transformation in the way of applying context specific and content general teaching methods under the effect of educational technologies. To illustrate, tablet-based problem solving as an innovative teaching strategy involved interactive file transfer (sending questions/receiving answers) between the devices and instant feedback delivered from the main device. Besides, file transfer feature found to be used frequently by the teachers, which evolved into a teaching strategy for sharing problem solutions, sending screenshots instead of note taking, conducting interactive assessments etc. Moreover, on purpose of lesson review and assessment, the frequent use of online education platforms, various software (e.g. online notebook), and cloud computing technologies (e.g. guided viewing, quick summary, testing) was observed. Reported and applied techniques of assessment showed resemblance in each case, which were conducting online quizzes and tests by using online education platforms or sending and receiving quizzes through tablet-based education. However, these techniques were used as end-of lesson assessment in the classroom on purpose of formative assessment. Even though it was detected that technology was transformed the formative assessment techniques, summative assessment were found to be conducted with conventional methods. On the other hand, educational technologies not only changed the way of teaching but also the way of interacting with students and dealing with the misbehaviors accordingly. Particularly, introduction of the tablets into classroom environment caused teachers to develop new techniques in creating controlled and organized learning environment. Within this respect, keeping students on task gained significance due to the fact that tablet use left students vulnerable and open against virtual stimulants. Gaming during the lesson and conducting off-task activities on tablets were found as most frequent misbehaviors stemming from tablet-based instruction. Checking the connection status of the students either by instant screenshots or system's notifications and walking around the classroom were the suggested solutions to the misbehaviors arising from tablet-based education Additionally, gaining attention was another significant issue in terms of classroom management. There were various strategies developed to attract students' attention such as changing the settings of marker or smart-board to highlight significant information.

5.2 Implications for Research and Practice

Video as a data collection tool promises to record the solid events in their natural context to the micro levels. The recorded classroom practices would be analyzed in-depth by the researchers who intend to study on "specific contextual features of classrooms" (Stigler, Gallimore, & Hiebert, 2000, p.89). Although, conducting observations in the field is one of the counted methods in TPACK studies (Koehler, Shin, & Mishra, 2012), most of the TPACK studies have been based on questionnaires, interviews and case narratives, which examine evidences of TPACK in teachers' reported behaviors. There has been no such a study searches for TPACK evidences in the actual teaching performances of the teachers. Therefore, TPACK literature falls short of explaining what actually happens in the classroom and the spontaneous actions of the teachers against technological agents. The study provided a novel video research method for TPACK studies in order to reveal authentic and dynamic nature of TPACK, which is embedded in the actual practices of the teachers.

Video recordings of the classroom teachings collected might also be used for pre-service teacher education by allowing them to analyze actual teaching performances of in-service teachers. In fact, observing classroom videos would facilitate pre-service teacher's capability of transforming theoretical knowledge they have into practice (Seidel, Blomberg, & Renkl, 2013).

Observable indicators of science TPACK revealed in the study would be used as a data collection tool in the field research. Observation checklist formed from observable behaviors of the teachers would facilitate to map a holistic teaching performance when supported with other data collection tools. Additionally, the list of indicators and emergent themes would also be used as coding tool in similar kind of studies. Moreover, observable indicators of science TPACK emerged from the study would be expected to contribute to the lack of solid TPACK evidences regarding science education by the disclosure of science teachers' technology adoption process in their classrooms.

5.3 Recommendations for Future Research

Conducting video research is not an easy process. Even if there have been many advantages that video studies offer for the sake of the research, the obstacles that researchers may face would be daunting. Teachers were generally reluctant to invite a stranger to their classrooms and they had many worries related with being recorded. Firstly, being judged by the researcher for the their competencies was the primary concern of the teachers. On the other hand, they mostly thought that their videos would be watched or posted without their permission. This made nearly impossible to conduct the study due to absence of volunteer participants and starting date of the research had to be postponed many times. Besides, the attitude of the most of the schools' management was disappointing during the phase of scheduling appointment. At this juncture, establishing rapport with the participants and finding right school to communicate gained significance to be able to collect classroom videos. The researchers who intend to conduct video studies should be aware of these problems and take necessary precautions beforehand.

Video shootings of the classroom teachings were collected from one lesson hour of the participant teachers. In order to provide more holistic picture of science teachers' technology practices, the number of video shootings should be increased. Besides, video shootings of each case collected from the different levels of classroom, each of which was learning about different topics from different branches of science. This would be a limitation while comparing and contrasting the emergent themes, categories and codes of the cases. Reduction in the codes would be more reliable by choosing same level of classrooms learning about the same topic. Besides, it would be suggested that recording consecutive lesson hours of the same topic would be useful in seeing all kinds of technological applications of the topic, so it would be more informative to the readers. On the other hand, researchers should be aware of that this would turn out data in abundance, which requires more time and effort for organization and analysis. Within this scope, drawing case propositions from related literature would facilitate the data collection process in guiding researchers on what to look for in the data.

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APPENDICES

APPENDIX A: PRE VIDEO INTERVIEW

Demografik Profil Bilgileri

1. Öğretmen:
2. Toplam tecrübe yılı:
3. Branş:
4. Sınıf seviyesi:
5. Videoya çekilen derse katılan öğrenci sayısı:

Video Çekimi Öncesi Görüşme Soruları

Ders Künye Bilgisi:

1. Bugünkü işlenecek olan dersin konusu nedir?
2. Bu konu yeni bir konu mu, daha önce başladığınız bir konunun devamı mı yoksa ders tekrarı mı?
3. Kazanımları nedir?
4. Ders sürecinizden kısaca bahsedebilir misiniz?
5. Kullanacağınız öğretim yöntem, teknik ve stratejileri nelerdir? Niçin? Bu yöntemleri neye göre belirlediniz?
6. Kullanacağınız teknolojik materyaller (yazılım ve donanım) nelerdir? Niçin? Bu teknolojileri neye göre belirlediniz?
7. Kullanacağınız teknolojiler için herhangi bir yardım aldınız mı?

Süreç Planlama:

8. Bugünkü dersinizi nasıl planladınız? Dersinizi planlarken nelere dikkat ettiniz?
9. Bugünkü ders vereceğiniz sınıftaki öğrenciler en iyi ne şekilde öğrenmektedirler?
10. Sizce öğrencilerinizin bugünkü ders için hazır bulunuşluk düzeyleri nedir? Nasıl karar verdiniz?
    Sonda: Öğrencileriniz bugünkü dersin konusunu rahatlıkla öğrenebilecek mi?
11. Bugünkü dersin konusu sizce kavram yanılgısı yaratılabilecek bir konu mu? Buna nasıl karar verdiniz?
12. Kavram yanılgıları ile nasıl başa çıkmayı düşünüyorsunuz?
13. Bugünkü dersin sonunda öğrencilerinizi nasıl değerlendireceksiniz? Süreçte teknoloji kullanacak mısınız?

APPENDIX B: POST-VIDEO INTERVIEW

Ders Öğretim Süreç Bilgileri (Bu kısım araştırmacılar tarafından doldurulacaktır.)

1. Konu:
2. Ders saati ve süresi:
3. Teknolojik materyaller ve donanımlar:

A. Bu kısımda size kayıt altına alınan dersiniz ile ilgili birkaç soru yönelteceğiz.

1. Ders öncesinde anlatmayı planladığınız konuyu tümü ile kapsayabildiniz mi? Hayır ise sizce sebebi nedir?

B. Bu kısımda normal bir günde verdiğiniz ders ile kayıt altına alınan ders arasındaki farklar ile ilgili birkaç soru yönelteceğiz.

2. Ders anlatım süresince ders anlatım yöntem ve teknikleri;
- € Her zaman olduğu gibiydi
- € Her zaman kullandığım yöntem v tekniklere oldukça yakındı. Sizce buna ne sebep olmuştur?
- € Bir şekilde her zaman kullandığım yöntem ve tekniklerden biraz farklıydı. Sizce buna ne sebep olmuştur?
- € Her zaman kullandığım yöntem ve tekniklerden tamamen farklıydı. Sizce buna ne sebep olmuştur?

3. Video kaydı altına alınan derse katılan öğrenci sayısı ve öğrenci reaksiyonları her zamankinden farklı mıydı? Evet ise açıklayınız.

4. Sizce kayıt altına alınan dersiniz rutin dersleriniz ile kıyaslandığında olağandan daha iyi, daha kötü veya her zaman olduğu gibi miydi?
- € Daha iyiydi
- € Her zaman olduğu gibiydi
- € Daha kötüydü

5. Eğer bugün verdiğiniz dersi bir kez daha verme şansınız olsaydı (öğretim yöntem ve teknikleri, ders materyalleri vs.) ne gibi değişiklikler yapardınız?

C. Bu kısımda size bugünkü dersinizde teknoloji kullanımınıza yönelik sorular yönelteceğiz.

6. Bu derste sizi teknoloji kullanmaya teşvik eden sebepler nelerdir? Açıklayabilir misiniz?

7. Bugünkü verdiğiniz dersi düşündüğünüzde, Fen Bilgisi öğreniminde ,teknolojinin öğrencilerin öğrenme sürecine etkisini gözlemleyebildiğimiz somut bir örnek var mı? Evet ise nedir?

8. Bugünkü dersinizde Fen Bilgisi alanında kullandığınız öğretim metot ve stratejilerini teknoloji ile nasıl birleştirdiniz?

9. Bugünkü dersinizin konusu, teknoloji kullanımına elverişli miydi?

10. Bugünkü dersinizde sınıfınızda teknolojiyi kullanırken herhangi bir zorlukla karşılaştınız mı? Evet ise açıklayabilir misiniz?

D. Bu kısımda size, derste teknoloji kullanımına bakış açınız ile ilgili genel sorular yönelteceğiz.

A. Motivasyon

1. Sizi derslerinizde teknoloji kullanmaya teşvik eden şey nedir?

2. Derslerde teknolojiyi kullanma becerinizi nasıl geliştirdiniz? Bu konuda hangi kaynaklardan yararlanıyorsunuz?

B. Hazırlık

3. Derste kullanacağınız teknolojileri neye göre belirliyorsunuz?

4. Fen Bilgisi derslerinize teknolojiyi entegre etme sürecinde izlediğiniz herhangi bir yöntem, metot veya prosedür var mı? Varsa, süreci açıklayabilir misiniz?

C. Entegrasyon

5. Fen Bilgisi derslerinizde bir konuyu akıllı tahta veya tablet (ya da her ikisi) kullanarak nasıl anlatıyorsunuz?

6. Fen Bilgisi dersinde teknoloji kullanarak daha rahat anlatabileceğinizi düşündüğünüz kavram ve konseptler var mı? Varsa nelerdir?

7. Fen öğretimi alanına özel kullandığınız teknolojiler nelerdir? Sizce fen öğretiminde hangi teknolojiler öğrenim sürecini kolaylaştırmaktadır?
6.1 Sizce bu teknolojiler nasıl ve ne şekillerde derste kullanılmalıdır?

8. Teknolojiyi kullanarak öğrencilerin fen alanına olan ilgi ve motivasyonlarını artırabiliyor musunuz? Evet ise nasıl, açıklayabilir misiniz?

9. Öğrencileriniz teknolojiyi kullanarak bilimsel araştırma süreçlerini kolaylıkla izleyebiliyorlar mı? Evet ise nasıl, açıklayabilir misiniz?

D. Problem Çözümü

10. Dersinizde kullandığınız teknolojiler olması gerektiği ya da planladığınız gibi çalışıyor mu ? Eğer çalışmıyorsa, olası problemler ile nasıl başa çıkıyorsunuz? Örnek verebilir misiniz?

E. Sınıf Yönetimi

11. Derste teknoloji kullanımı sınıf yönetiminizi nasıl etkiliyor? (Olumlu, Olumsuz)

12. Sınıfta teknolojiyi var olan sınıf yönetim problemlerini çözmek amacı ile kullanıyor musunuz? Evet ise nasıl?

13. Öğrencilerinizin gelişimini nasıl takip ediyorsunuz? Bu süreçte teknoloji kullanıyor musunuz?

14. Ders verdiğiniz sınıfınızdaki öğrenci profili, ders esnasında kullandığınız teknoloji seçiminize etki ediyor mu?

F. Değerlendirme

15. Teknoloji kullanarak öğrencilerinizin bir konuyu öğrenip öğrenmediğini nasıl değerlendiriyorsunuz?

APPENDIX C: APPROVAL OF THE ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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27 Şubat 2015

Gönderilen: Y. Doç. Dr. Evrim Baran
Eğitim Programları ve Öğretim

Gönderen : Prof. Dr. Canan Sümer
IAK Başkan Vekili

İlgi : Etik Onayı

"Teknoloji Sınıflarında Öğretmen Bilgisi Göstergelerini Video Çalışması Yöntemi ile İnceleme ve Araştırma Çalışması" isimli araştırmanız "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

27/02/2015

Prof.Dr. Canan Sümer
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkan Vekili
ODTÜ 06531 ANKARA

APPENDIX D: APPROVAL OF TURKISH MINISTRY OF NATIONAL EDUCATION

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

ÖĞRENCİ İŞLERİ
DAİRESİ BAŞKANLIĞI
Ev. Arş. Md. Saat :

Sayı : 81576613/605/3674351 06/04/2015
Konu: Araştırma izni.

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
(Öğrenci İşleri Daire Başkanlığına)

İlgi: a) 27-03-2015 tarih ve 54850036-300-1326 sayılı yazınız
b) 07/03/2012 tarih ve B.08.0.YET.00.20.00.0/3616 sayılı genelge

İlgi (a) yazı ile Eğitim Fakültesi Eğitim Bilimleri Bölümü öğretim üyesi Yard. Doç. Dr. Evrim BARAN'ın "Teknoloji Sınıflarında Öğretmen Bilgisi Göstergelerini Video Çalışması Yöntemiyle İnceleme ve Araştırma Çalışması" konulu araştırması kapsamında hazırlamış olduğunuz veri toplama araçlarının İstanbul ve Ankara'da bulunan Milli Eğitim Bakanlığına bağlı resmi ve özel ilköğretim ve ortaöğretim kurumlarında görev yapan öğretmenlere uygulanmasına yönelik izin talebi Genel Müdürlüğümüzce incelenmiştir.

Onaylı bir örneği Bakanlığımızda muhafaza edilen ve uygulama esnasında da imzalı ve mühürlü örnekten çoğaltılan veri toplama araçlarının gönüllülük esas olmak üzere; kamera çekiminde yer alan öğrenci velilerinin muvafakatı alınmak ve eğitim öğretim faaliyetlerini aksatmamak kaydıyla 2014-2015 eğitim öğretim yılında İstanbul ve Ankara'da bulunan Milli Eğitim Bakanlığına bağlı resmi ve özel ilköğretim ve ortaöğretim kurumlarında göre yapan öğretmenlere uygulanmasına ilgi (b) genelge esasları doğrultusunda izin verilmiştir.

Gereğini bilgilerinize rica ederim.

Mustafa Hakan BÜCÜK
Bakan a.
Daire Başkanı

Ek:Veri toplama araçları (dört sayfa)

Güvenli Elektronik İmzalı
Aslı ile Aynıdır
07/04/2015

Yazının aslını elden aldım.
13.04.2015 CEREN OCAK

09-04-2015 - 6128

Konya Yolu Nu:21 /ANKARA
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APPENDIX E: CONSENT FORM

Teknoloji Sınıflarında Öğretmen Bilgisi Göstergelerini Video Çalışması Yöntemi ile İnceleme ve Araştırma Çalışması, ODTÜ Eğitim Bilimleri Fakültesi, Eğitim Programları ve Öğretim Programı yüksek lisans öğrencisi Ceren Ocak tarafından, Eğitim Bilimleri öğretim üyesi Yrd. Doç. Dr. Evrim Baran danışmanlığında yürütülmesi planlanan bir araştırma çalışmasıdır. Sözü geçen çalışma, ilköğretim ve liselerde (2-12. sınıf), teknolojik unsurları etkin bir şekilde kullanabilen öğretmenlerin sınıflarında bir ders saati süresince video çekimi gerçekleştirilmesini içermektedir. Video çekimi öncesi öğretmenler ile kayıt altına alınacak ders ile ilgili bir ön görüşme yapılacaktır. Daha sonra, öğretmenlere çekim yapılan ders hakkında sorular yöneltilecek olan bir video sonrası görüşme yapılacaktır. Araştırma kapsamında toplanan veriler TPAB göstergelerinin belirlenmesinde kullanılacaktır. Bu çalışmaya katılımınız, ileride meslektaşlarınıza sınıflarında teknolojiyi etkin bir şekilde kullanmaları konusunda rehberlik edecek ve literatürde tespit edilmiş önemli eksikleri gidermek amacı ile araştırmacıya yardımcı olacaktır. Çalışmaya katılım tamamıyla gönüllülük temelindedir. Görüşmeler ve ders video kayıtları kesinlikle gizli tutulacak ve sadece çalışmaya yürüten araştırmacılar tarafından değerlendirilecektir. Çalışma sonucunda elde edilen verilerin analizinden çıkarılacak sonuçlar ve toplanan veriler ile ilgili her türlü bilgi, araştırma ile ilgili tüm verilerin saklandığı Dropbox arşivinde korunacak, sadece ve sadece bilimsel yayınlarda kullanılacaktır. Kişisel ve mesleki bilgileriniz ise kesinlikle gizli tutulacaktır. Bu bilgilere araştırmacı ve danışmanı dışında kimsenin erişimi söz konusu değildir.

Veri toplama araçları, genel olarak kişisel rahatsızlık verecek soruları içermemektedir. Ancak, katılım sırasında görüşme sorularından ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda, araştırmacıya, tamamlamadığınızı söylemek yeterli olacaktır. Çalışma sonunda ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için aşağıda bilgileri verilen araştırmacı öğrenci Ceren Ocak ve öğretim üyesi Yrd. Doç. Dr. Evrim Baran ile iletişim kurabilirsiniz.

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

İsim Soyisim Tarih
İmza

----/----/-----

APPENDIX F: PARENT CONSENT FORM

Sayın Veli,

Teknoloji Sınıflarında Öğretmen Bilgisi Göstergelerini Video Çalışması Yöntemi ile İnceleme ve Araştırma Çalışması, ODTÜ Eğitim Bilimleri Fakültesi, Eğitim Programları ve Öğretim Programı yüksek lisans öğrencisi Ceren Ocak tarafından, Eğitim Bilimleri öğretim görevlisi Yrd. Doç. Dr. Evrim Baran danışmanlığında yürütülmesi planlanan araştırma çalışmasıdır. Sözü geçen çalışma, ilköğretim ve liselerde (2-12.sınıf), teknolojik unsurları etkin bir şekilde kullanabilen öğretmenlerin sınıflarında bir ders saati süresince video çekimi gerçekleştirilecektir. Derslerden alınan video kayıtları, bir öğretmen bilgi türü olan TPAB (Teknolojik Pedagojik Alan Bilgisi) bileşenlerinin sınıf içi uygulamalarının tespiti amacıyla yapılmaktadır. Bu video kayıtlarının analizinden toplanılan bilgi daha sonra öğretmenlerin teknolojiyi var olan içerik ve pedagoji bilgisi ile etkin bir şekilde harmanlayarak, teknolojik unsurları sınıflarında optimum verimlilik ile kullanmalarında öğretmenlere yol gösterecektir. Bu mektubun yollanış amacı araştırma çalışması süresince ve daha sonrasında hiçbir öğrencinin şahsi ve kimliksel bilgilerinin paylaşılmayacağına ve süreçte öğrencilere herhangi fiziksel, psikolojik ve ekonomik zarar gelmeyeceğine dair güvence vermektir. Bu çalışmaya katılım gönüllülük esasına dayanmaktadır. Öğretmenin yanı sıra öğrencinin de gönüllülüğü ve onayı esastır.

Çalışmaya ya da çocuğunuzun katılımına yönelik daha fazla bilgi için başvurulacak kişi/kişilerin adresi, telefon numarası ve e-posta adresleri aşağıda olduğu gibidir.

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Teşekkürler;

Yukarıda açıklamasını okuduğum çalışmaya, oğlum/kızım ______________________’nin katılımına izin veriyorum. Ebeveynin:

Adı, soyadı: ___________________________ İmzası: ________________________
Tarih: _______

İmzalanan bu formu lütfen .... aracılığı ile ....'e ulaştırın.

APPENDIX G: TURKISH SUMMARY

21. yüzyılda fen alanı, yenilikçi teknolojilere kucak açmıştır. Bugün, bilim ve teknoloji alanında kaydedilen gelişmeler teknolojinin varlığı olmadan hayal dahi edilemezdi (Bull & Bell, 2008). Bu nedenle, teknolojik ögelerden yoksun olarak tasarlanan fen eğitimi, yenilikçi iş gücü yetiştirmede ve küresel dünyanın sürekli gelişen ve değişen ihtiyaçlarına cevap verme konusunda yetersiz kalacaktır.

Fen öğrenimi, literatürde sunulan bilginin koşulsuz ezberlenmesinden fazlasıdır (Niess, 2005, p.510). Fen eğitimi, bilim insanlarının çalışma prensipleri ve uygulamaları hakkında öğrencileri bilgilendirerek, onlara bilimsel araştırma süreçlerini takip edebilecekleri fırsatlar sunmalıdır. Bugün, bilişim ve iletişim teknolojileri, öğrencileri sorgu tabanlı öğrenmeye teşvik etmektedir ve fen sınıflarında öğrencilerin gerçek bir bilim insanıymış gibi çalışmasına olanak sağlamaktadır (Guzey & Roehrig, 2009; Novak & Krajcik, 2006). Öğrencilere bilim insanı bakış açısını aşılamak ve çeşitli teknolojiler yardımı ile öğrencileri gerçek bilimsel araştırma süreçlerine dahil etmek, Fen Bilgisi öğretmenlerini sınıflarda yenilikçi eğitim teknolojilerini kullanmaya teşvik eden faktörler arasındadır (Guzey & Roehrig, 2009; NRC, 1996; Pringle, Dawson, & Ritzhaupt, 2015).

Fen Bilgisi öğretmenleri, sınıflarında çeşitli mobil uygulamalar, animasyonlar, simülasyonlar, mikro işlemciler, deney probları, üç boyutlu modelleme programları gibi çeşitli teknolojiler kullanarak öğrencilerin fen öğrenimine karşı motivasyonlarını artırmakta ve bu teknolojiler aracılığı ile öğrencilerin günlük yaşamda karşılaştıkları bir çok doğa olayını daha rahat kavramalarını sağlamaktadırlar (Hug, Krajcik, & Marx, 2005; Park, 2008; Pringle et al., 2015). Fen derslerine özel olarak kullanılabilecek teknolojilerin bu denli geniş bir yelpazede olması, diğer alanlar ile karşılaştırıldığında fen alanını avantajlı kılmaktadır. Bu noktada asıl merak konusu olan, öğretmenlerin güçlü öğretim süreçleri tasarlayabilmek için, fen derslerinde bu teknolojileri sınıflarında nasıl kullanacaklarıdır. Derslerde teknoloji kullanımının artış gösterdiği bilinmektedir (Tondeur, Kershaw, Vanderlinde, & van Braak, 2013). Fakat, eğitim teknolojilerinin sınıflardaki pedagojik etkileri hakkındaki bilgi eksikliği, bilişim ve iletişim teknolojilerinin sınıflarda maksimum verimlilik ile kullanılmasına ve ihtiyaç duyulan yenilikçi fen eğitiminin verilmesine engel teşkil etmektedir (Jang & Tsai, 2013). Etkin teknoloji entegrasyonun önemi bu noktada öne çıkmaktadır.

Teknolojik Pedagojik Alan Bilgisi (TPAB) kuramsal çerçevesi, etkin teknoloji kullanımı konunda öğretmenlere yol gösteren etkili bir bilgi türüdür (Jang & Chen, 2010; Lin, Tsai, Chai, & Lee, 2012) ve bu konuda 21'inci yüzyıl öğretmenlerinin sahip olmaları gereken bilgi ve becerilere ışık tutmaktadır (Jang & Chen, 2010; Lin, Tsai, Chai, & Lee, 2012). Bu kapsamda, öğretmenlerden sınıflardaki teknolojik altyapıyı kullanmalarının yanı sıra mesleklerinin gereği olarak sahip oldukları teknoloji, pedagoji ve alan bilgisini etkin bir şekilde bir araya getirmeleri beklenmektedir. TPAB kuramsal çerçevesi, Mishra ve Koehler (2006) tarafından ortaya konulduğundan beri, araştırmacılar öğretmenlerin profesyonel gelişimini hedefleyen bu bilgi türünün doğasını ve gelişimini yakından incelemektedirler. Fakat, Lin et al. (2012) fen eğitimi alanında, derslerde etkin teknoloji kullanımını kanıtlayacak TPAB delillerinin eksikliğini raporlamıştır. Aynı şekilde, Flick ve Bell (2000)'de fen eğitimi alanında teknolojinin öğrenme ve öğretim süreçlerine etkisinin somut olarak gözlemlenebildiği, içeriğe özel örneklere duyulan ihtiyacın altını çizmiştir.

TPAB bilgi türü, doğası gereği uygulandıkça gelişen ve ilerleyen bir bilgi türüdür. Bu nedenle, TPAB göstergeleri incelendiği alandan alana, hatta konudan konuya farklılık göstermektedir. Bunun yanı sıra, TPAB, doğası gereği bağlamsaldır. Bu nedenle, TPAB göstergeleri, öğretmen eylem halindeyken gözlemlenmeli ve incelendiği bağlam içerisinde değerlendirilmelidir. "Teknoloji, pedagoji ve içerik arasındaki karmaşık ve incelikli ilişki" (Mishra & Koehler, 2006, p.1029), öğretmenlerin sınıf içi ders performanslarına dayanan, özgün ve deneyimsel bir yaklaşım ile ortaya konulabilir. Bu kapsamda, video araştırma yöntemi, karmaşık öğretim süreçlerinin anlamlı parçalara bölünerek analiz edilmesini sağlayarak araştırmacılara kolaylık sağlamaktadır. TPAB çalışmaları kapsamında yürütülen saha gözlemi literatürde altı çizilen yöntemlerden biri olmasına rağmen (Koehler, Shin, & Mishra, 2012), literatürde yer alan TPAB göstergelerinin araştırılmasına yönelik çalışmalarda kullanılan veriler çoğunlukla anket ve görüşme gibi öğretmenlerin sözlü ifadelerine dayanan veri toplama araçlarından elde edilmektedir. Fen Bilgisi sınıflarında TPAB göstergelerini video çalışması aracılığı inceleyen benzer bir çalışma bulunmamaktadır. Bu da öğretmenlerin, gözlemlenen TPAB davranışları ve sınıftaki teknolojik uyaranlara karşı verdikleri simültane reaksiyonlar hakkında çok az şey bilinmesine sebep olmaktadır. Bu kapsamda, video kaydı altına alınan sınıf içi ders anlatım performansları Fen Bilgisi alanına özel, gözlemlenebilir öğretmen davranışlarına dayanan TPAB göstergelerini ortaya çıkarmayı vaat etmektedir.

Bu çalışma, Fen Bilgisi öğretmenlerinin sınıflarında video çalışması aracılığı ile bulgulanan, gözlemlenebilir TPAB göstergelerini çoklu durum incelemesi yöntemi ile incelemiştir. Bu çalışma, teknolojinin entegre edildiği fen derslerinin tasarım ve uygulama sürecinin detaylı olarak incelenmesi yolu ile aşağıda belirtilen araştırma sorularına cevap aramıştır.

1. Fen Bilgisi öğretmenlerinin teknolojik ders tasarım sürecinde tespit edilen TPAB göstergeleri nelerdir?
2. Fen Bilgisi öğretmenlerinin sınıflarında, ders anlatım sürecinde tespit edilen TPAB göstergeleri nelerdir?

Bu araştırma, 2015-2016 eğitim ve öğretim yılı içerisinde, İstanbul'da ilk ve orta dereceli eğitim veren bir özel okulun akıllı kampüsünde yürütülmüştür. Araştırma alanı, kampüsün teknolojik altyapısı, tablet ve akıllı tahtanın kullanıldığı akıllı eğitim sistemi göz önünde bulundurularak kasıtlı olarak seçilmiştir. Bu okulun seçilmesinin diğer bir sebebi TPAB konulu hizmet-içi eğitimlerdir. Araştırmaya gönüllü olarak, 2015-2016 eğitim ve öğretim yılı bahar dönemi içerisinde aktif olarak okulda çalışan, fen eğitimi alanında farklı branşlardan mezun, üçü kadın biri erkek olmak üzere dört hizmet içi öğretmen katılmıştır. Katılımcılardan iki öğretmenin branşı Fen Bilgisi öğretmenliği olup ilköğretim düzeyinde çalışmaktayken, diğer ikisi fizik öğretmenliğinden mezun olup lise düzeyinde ders vermektedir. Katılımcıların okul tecrübe yılları dört ile 12 yıl arasında değişkenlik göstermektedir. Çalışmada katılımcıların gerçek adları yerine takma isimler kullanılmıştır.

Çalışmada kullanılan veri kaynakları, ders çekimi öncesi ve sonrasında uygulanan iki adet yarı yapılandırılmış görüşme formu ve katılımcıların ders süreci video kayıtlarından oluşmaktadır. Yarı yapılandırılmış görüşme formları detaylı literatür taraması ve TPAB alan uzmanlarının görüşleri doğrultusunda hazırlanmıştır. Veri toplama araçlarının geçerlilik ve güvenilirliğini artırmak amacı ile asıl uygulamadan önce pilot testleri yapılmıştır. Görüşme formları, öğretim üyeleri, araştırmacılar ve alan uzmanları ile yoğun müzakereler sonucunda son haline getirilmiştir. Uygulamalı Etik Araştırma Merkezi ve Milli Eğitim Bakanlığı'ndan gerekli izinler alındıktan sonra araştırma yapılacak okulun eğitim teknoloğu ile iletişime geçilerek okul yönetimine ve öğretmenlere araştırmanın kapsamı ile gerekli belgeler sunulmuştur. Gönüllü dört öğretmen ile çalışmanın gerçekleştirileceği ortak bir zaman dilimi belirlenmiştir.

Ders çekimi öncesi yarı yapılandırılmış görüşme formu, öğretmenlerin ders tasarım süreçlerindeki TPAB göstergelerini ortaya çıkarmak amacı ile hazırlanmış olup, araştırmacı sınıf videolarında gözlemlenmesi mümkün olmayan süreçler hakkında bilgi sahibi olmayı hedeflemiştir. Video çekimi yapılacak derslerden önce, her öğretmen ile yaklaşık olarak on dakika süren ve ses kaydı alınan birer görüşme gerçekleştirilmiştir. Bu görüşme 3 farklı bölüm altında (demografik profil bilgisi, ders künye bilgisi, süreç planlama) toplamda 18 soru içermektedir.

Video çekimi, öğretmenlerin gözlemlenebilir TPAB göstergelerini tespit etmek amacı ile gerçekleştirilmiş olup, çekimler katılımcı öğretmenlerin ve araştırmacının ortak kararı ile belirlenen bir ders saatinde gerçekleştirilmiştir ve 40 dakika sürmüştür. Lara'nın 7. sınıf öğrencileri ile atomun yapısını işlediği dersi video kaydı altına alınmıştır. Sınıfta toplam 18 kişi bulunmakta olup işlenmekte olan konunun ders tekrarı olduğu öğretmen tarafından belirtilmiştir. Leo'nun 9. sınıflara ivme anlattığı dersi video kaydı altına alınmış olup, sınıfta 25 kişi bulunmaktaydı. Aynı şekilde, öğretmen tarafından, konunun ders tekrarı olduğu söylenmiştir. Serena 9. sınıflara, öğrenciler için yeni bir konu olan iş, güç ve enerji adlı konuyu anlatmıştır. Çekim esnasında derste 20 öğrenci bulunduğu gözlemlenmiştir. Son olarak Zara 6. sınıf öğrencilerine, öğrencilerin ilk defa öğrenecekleri hayvanlarda üreme ve gelişme adlı konuyu anlatmıştır. Çekim esnasında sınıfta 15 kişinin bulunduğu gözlemlenmiştir.

Ders çekimi sonrası yarı yapılandırılmış görüşme formu, öğretmenlerin derste teknoloji kullanımlarını, teknoloji entegrasyon sürecini etkileyen bağlamsal faktörleri, sınıfta karşılaşılan teknolojik problemler ile baş etme yöntemlerini, teknoloji sınıflarında kullanılan sınıf yönetimi metotlarını ve bu ortamlara özel ders değerlendirme süreçlerini ortaya çıkarmayı amaçlamıştır. Ayrıca, video kayıtları ile toplanan verinin, yarı yapılandırmış görüşme formlarından elde edilen bilgi ile validasyonunun yapılması ve üçgenleme yolu ile elde edilen sonuçların birbirini destekler nitelikte olup olmadığının gözlemlenmesi hedeflenmiştir. Ders çekimi sonrası görüşme yaklaşık olarak 20 dakika sürmüş olup, çekimden hemen sonra gerçekleştirilmiştir. Görüşmeler, veri analizi esnasında kolaylık sağlaması için ses kaydı altına alınmıştır.

Veri analiz sürecinde, dört hizmet-içi fen öğretmeninin sınıfında çekilen ders süreci video kayıtları, düzenli ve sistematik bir yöntem ile analiz edilerek, çoklu durum çalışması ile entegre edilmiştir. Her bir örnek olay arasındaki benzerlik ve farklılıkların ortaya çıkarılması amacıyla, örnek olayların kendi içerisinde analizini, çapraz vaka analizi izlemiştir (Meyer, 2001). Her durumu derinlemesine çözümlemek amacı ile ilk olarak kayıt altına alınan, çekim öncesi ve sonrası yarı yapılandırılmış görüşme formlarının kelimesi kelimesine transkripsiyonu gerçekleştirilmiştir. Video kayıtları da aynı şekilde, öğretmen eylemlerinin saniyesi saniyesine kayıt edilmesi yoluyla çözümlenmiştir. Ayrıca, kodlama sürecinde kolaylık sağlaması amacıyla, her davranış için hatırlanması kolay kodlar oluşturularak, verinin birincil derece analizi gerçekleştirilmiştir. İkinci adımda, çözümlenen görüşme ve video kayıtlarının, MAXQDA nitel veri analiz yazılımına girişi yapılmıştır. Daha sonra, TPACK teorik bakış açısı benimsenerek, birincil derece analiz sonucunda ortaya çıkan kodlar ve kategoriler filtrelenmiş ve değiştirilmiş, böylelikle verinin ikincil derece analizi gerçekleştirilmiştir. Son olarak, analiz edilen örnek olaylardan biri referans noktası olarak alınarak, var olan kodlar ve kategoriler diğer örnek olayların analizi sonucunda ortaya çıkan kodlar ve kategoriler ile teker teker karşılaştırılarak bir araya getirilmiş, azaltılmış ve sonuç olarak TPAB göstergeleri tablosu ortaya konmuştur. Sonuçlar, incelenen her bir durumun geçtiği bağlam hakkında zengin bilgi sunmasının yanı sıra, teknolojinin entegre edildiği fen derslerinin tasarım ve uygulama aşamalarında bulgulanan gözlemlenebilir TPAB göstergelerini ve fen öğretmenlerinin teknoloji kullanımları ile ilgili motivasyonlarını ortaya koymuştur.

Bu çalışma süresince, bulguların doğruluğunu veya güvenilirliğini sağlamak için çeşitli stratejiler izlenmiştir. Bu bağlamda, bir çalışmanın güvenilirliğini sağlamak için Lincoln ve Guba (1985) tarafından ortaya konulan üç ana kriter olan

(1) geçerlilik, (2) güvenilirlik ve (3) transfer edilebilirlik, izlenilen yöntem ve stratejiler kapsamında tartışılmıştır. Çalışma süresince Üniversite Etik Komitesi tarafınca belirlenen etik prosedürleri takip edilmiştir ve çalışmanın belirlenen okulda yürütülmesinin herhangi bir zararı olmadığı sonucuna varılmıştır. Sonuçlar raporlanırken katılımcı öğretmenlerin bilgileri gizli tutulmuş ve kendilerinden takma isimler kullanılarak bahsedilmiştir. Video verileri çalışmanın veri tabanında saklanmış olup, bu veriye ulaşım araştırmacının kendisi ile sınırlandırılmıştır. Bu araştırmanın sonucunda elde edilen veriler bizzat katılımcılar ile paylaşılmıştır.

Bu çalışmanın amacı, Fen Bilgisi öğretmenlerinin teknoloji sınıflarındaki, gözlemlenebilir TPAB göstergelerini ortaya çıkarmaktır. İlk olarak, öğretmenlerin teknolojik ders tasarım süreçlerinin incelenmesi yoluyla ortaya konulan TPAB göstergeleri, aşağıda belirtilen dört ana kategoride incelenmiştir:

1. Teknoloji seçimi
2. İçerik planlama
3. Ders hazırlama
4. Değerlendirme

Öğretmenlerin derste kullanacakları teknolojileri belirlerken, seçilen teknolojinin derste kullanıldığında sağlayacağı olası faydaları ve kısıtlamaları göz önünde bulundurdukları belirlenmiştir. Ayrıca seçilen teknolojinin, içerik ve öğrencilerin öğrenme stilleri ile ne kadar uyumlu olduğu da sınıfta kullanılacak teknolojilerin belirlenmesinde önemli bir rol oynamıştır. İçerik planlamanın öğretmenlerin ders tasarım rutinlerinin önemli bir bileşeni olduğu gözlemlenmiştir. Sırasıyla, (1) ders kazanımlarının belirlenmesi, (2) anlatılacak olan konu başlıklarının sıralanması ve (3) ders anlatım yöntem ve stratejilerinin belirlenmesi, öğretmenlerin teknoloji destekli ders tasarım süreçlerinin analizi ile ortaya çıkan TPAB göstergeleridir. Bunun yanı sıra, öğretmenlerin kendilerini ve öğrencilerini bir sonraki derse hazırlamak amacı ile farklı yöntem ve stratejiler kullandıkları gözlemlenmiştir. Ders hazırlama sürecinde ortaya çıkan göstergeler şu şekildedir: (1) bilişim teknolojileri sınıflarında dersin provasını yapmak, (2) online ders materyallerini ders öncesinde öğrenciler ile paylaşmak ve (3) bir sonraki dersin konusu hakkında öğrenciyi bilgilendirmek. Ders sonu değerlendirme kapsamında ortaya çıkan göstergeler şu şekildedir : (1) online eğitim platformlarını kullanmak ve (2) tablet bilgisayar aracılığı ile quiz yapmak.

Fen Bilgisi öğretmenlerinin, ders anlatım süreçlerinin analizi ile elde edilen TPAB göstergeleri altı ana başlık altında incelenmiştir. Bu başlıklar aşağıda belirtildiği gibidir.

1. Derse giriş davranışları
2. Teknoloji sınıflarında öğretim yöntem ve teknikleri
3. Teknoloji sınıflarında ders yönetimi
4. Teknolojik problemler ile baş etme
5. Değerlendirme

Derse giriş davranışları altında ortaya çıkan TPAB göstergeleri aşağıda belirtildiği gibidir.

1. Akıllı tahtayı başlatmak için USB bellek kullanmak
2. Online sınıf mevcudu almak
3. Akıllı yazılımı başlatmak
4. Öğrencilerin akıllı tahta ile olan bağlantılarını kontrol etmek

Teknoloji sınıflarında gözlemlenen öğretim yöntem ve teknikleri kategorisi, (1) teknoloji destekli fen alanına özel stratejiler ve (2) teknoloji destekli stratejiler olmak üzere ikiye ayrılmıştır. Teknoloji destekli fen alanına özel stratejiler şu şekildedir: (1) video gösterimi sırasında öğrenciyi yönlendirmek, (2) soyut kavramları görselleştirme, (3) deney simülasyonları göstermek, (4) canlandırılan gerçeklik hakkında hipotez kurmak, (5) üç boyutlu teknolojiler aracılığı ile artırılmış gerçeklik sunmak. Diğer bir yandan, teknoloji destekli stratejiler şu şekildedir: (1) tablet temelli soru çözümü yapmak, (2) ana bilgisayar ve öğrenci tabletleri arasında dosya paylaşımı yapmak, (3) online eğitim platformları kullanmak, (4) bir önceki dersle ilgili hatırlatmalar için bulut teknolojileri kullanmak, (5) interaktif ve online alıştırmalar ile öğrenciye pratik yaptırmak, (6) akıllı tahtada aracılığı ile ders programını kullanmak ve (7) online defter kullanmak. Ayrıca, teknoloji sınıflarında ders yönetimi kapsamında, öğretmenler tablet ile eğitim esnasında karşılaştıkları istenmeyen davranışları bildirmişlerdir. Bu davranışlar, ders esnasında oyun oynama ve tablet ile ilgili ders dışı aktiviteler yürütmektir. Öğrencilerin ana bilgisayara bağlı olma durumlarını, öğrenci tabletlerinin anlık ekran görüntüsünü alarak veya sistem bildirimlerini inceleyerek takip etmek bu tip problemlere karşı öğretmenler tarafından önerilen çözümlerdir. Dahası, öğretmenlerin teknolojik ögeleri kullanarak öğrencilerin dikkatini çekmek için farklı yöntemler geliştirdikleri gözlemlenmiştir. Bunlar (1) akıllı kalemin kalınlık ve renk ayarları ile oynayarak önemli görülen bir bilgiyi vurgulamak ve (2) video izlerken ekranı dondurarak buradaki bilgiye öğrencinin dikkatini çekmektir.

Diğer bir yandan, Fen Bilgisi sınıflarında teknoloji kullanımından kaynaklanan problemler, (1) donanım sorunları, (2) yazılım problemleri ve (3) ağ bağlantı problemleri kategorileri altında sınıflandırılmıştır. Donanım sorunları, öğrencileri tabletlerinin (1) hafızasının dolması, (2) şarjının azalması ve (3) evde bırakılması olarak belirtilmiştir. Bu tip problemlere karşı önerilen çözümler şu şekildedir: (1) tabletin sıra arkadaşı ile paylaşılması, (2) online materyallerin evde incelenmek üzere tabletini getirmeyen öğrenci ile paylaşılması. Yazılım ile ilgili problemlerde öğretmenler meslektaşlarından, okulun bilişim teknolojileri öğretmeninden veya öğrencilerden yardım talep ettiklerini belirtmişlerdir. Ağ bağlantısı problemlerinde ise (1) dijital dosyaların veya tabletin bağlantı kuramayan öğrenci ile paylaşılması ve (2) dosyaların yeniden aktarımı önerilmiştir.

Son olarak, yarı yapılandırılmış görüşmelerin ve sınıf video kayıtlarının analiz edilmesiyle elde edilen sonuçlar göstermiştir ki ders sonu değerlendirme süreçlerinin aksine özetleyici ve genel değerlendirmelerde teknoloji kullanılmamaktadır. Öğretmenler genel değerlendirmelerde ara ve dönem sonu klasik sınavları, standart testleri ve ulusal sınavları baz aldıklarını belirtmişlerdir. Ders sonu değerlendirmelerin ise bütün örnek olaylarda teknoloji kullanılarak yürütüldüğü gözlemlenmiştir.

Bu çalışma sonucunda ortaya çıkan göstergeler literatürde yer alan göstergeler ile karşılaştırıldığında görülecektir ki, öğretmenlerin gözlemlenebilir davranışlarından elde edilen TPAB göstergeleri daha kesin ve bağlamsaldır. Literatürde yer alan göstergeler, genellikle anket ve benzeri veri toplama araçları aracılığı ile elde edildiği için kendilerine eşlik eden bağlamsal faktörlerden bağımsız olarak, anketin öğretmenleri yönlendirdiği oranda okuyucu bilgilendirmektedir. Dolayısı ile bu göstergeler, TPAB bilgi türünün alana özel özelliklerini ortaya çıkarmak konusunda yetersiz kalabilmektedir.

Bunun yanı sıra ortaya çıkan TPAB göstergeleri göstermiştir ki, çalışmanın yürütüldüğü bağlam içerisinde teknoloji kullanımı öğretmen merkezlidir. Bunun yanı sıra, öğretmenler derslerde fen alanına özel simülasyon ve animasyon gibi derslerin içeriğini görselleştirmeye yönelik teknolojileri daha çok tercih etmişlerdir. Öğrencilerin kullanılan çeşitli teknolojilere rağmen pasif dinleyici rolüne sahip oldukları görülmüştür. Kullanılan teknolojilerin kontrolünün yine öğretmenin kendisinde olduğu gözlemlenmiştir. Bunun yanı sıra, öğretmenler sınıftaki teknolojileri fen eğitiminin önemli bir parçası olan sorgu tabanlı öğrenme stratejilerini uygulamak için kullanmamışlardır. Bu veri literatürdeki verilerle uyumluluk göstermektedir (Otrel- Cass et al., 2012; Pringle et al., 2015). Teknolojilerin öğretmenlerin ders süreçlerini kolaylaştırdığı kesin olarak gözlemlenmesine karşın, öğretmenler öğrencilerin sınıfta bir bilim insanı gibi çalışmasını sağlayacak teknolojileri (deney probları, mikro işlemciler, dijital mikroskoplar) derslerine entegre etmemişlerdir. Buna sebep olabilecek olası nedenler Ertmer (1999) tarafından birincil ve ikincil derece bariyerler olarak tanımlanmaktadır. Teknoloji entegrasyonunu etkileyebilecek birincil derece bariyerler zaman, donanım ve teknolojik destek gibi dışarıdan gelen etkenler olarak tanımlanırken, ikincil derece bariyerler öğretmenlerin inanç ve algı düzeyleri gibi iç motivasyonları ile ilgili unsurlar ile ilişkilendirilmektedir (Ertmer, 1999). Araştırmanın yürütüldüğü okulun sağlam bir teknolojik altyapıya sahip olduğu göz önünde bulundurulduğunda, kısıtlı ders süresi ve ders programına bağlı kalma zorunluluğu gibi faktörler öğretmenleri, sınıflarında yüksek seviye teknolojileri kullanmak konusunda kısıtlamış olabilir. TPAB konulu hizmet içi eğitimlerin kalitesinin artırılması ve öğretmenlerin üzerindeki müfredat ve zaman baskısının azaltılması yolu ile bu bariyerler aşılabilir.

Sonuç olarak, Fen Bilgisi sınıflarında TPAB göstergelerini video çalışması aracılığı inceleyen benzer bir çalışma bulunmamaktadır. Bu da teknoloji destekli eğitim süreçlerinde neler olup bittiği ve öğretmenlerin teknolojik eğitim süreçlerindeki gözlemlenebilir davranışları hakkında çok az şey bilinmesine sebep olmaktadır. Bu çalışma literatüre, TPAB'in özgün ve dinamik yapısını ortaya koyan, öğretmenlerin sınıf içi performanslarının esas alındığı yenilikçi bir araştırma metodu kazandırmayı hedeflemiştir.

Bu çalışma ile, gelecekte yapılacak çalışmalara ışık tutacak öneriler sunulmuştur. İlgili literatürde, video çalışmaları ile ilgili bir çok avantaj sunulmasına karşın, süreçte araştırmacıların karşılaşabileceği problemler yıldırıcı olabilir. Öğretmenlerin sınıflarında yabancı birinin varlığından rahatsız oldukları gözlemlenmiştir ve çoğunluklu kayıt altına alınan derslerin, kendi izinleri dışında üçüncü şahıslar ile paylaşılabileceği korkusunu taşıdıkları araştırmacıya iletilmiştir. Dahası, araştırmayı yürüten kişinin öğretmenlerin yeterliliği ile ilgili yargılayıcı bir pozisyonda olabileceğinden çekinmişlerdir. Bu da, çalışmaya katılacak gönüllü öğretmen bulunamamasından ötürü, araştırmanın başlangıç tarihinin birkaç kez ertelenmesine sebep olmuştur. Bunun yanı sıra, bazı okul yönetimlerinin akademik çalışmalara karşı olan tutumları, araştırmanın ilerlemesi konusunda sıkıntılara sebep olmuştur. Bu nedenle, araştırmanın yürütüleceği okul yönetimi ve katılımcı öğretmenler ile güvene dayalı bir ilişki kurabilmenin önemi çok büyüktür. Bu kapsamda, video çalışması yürütmek isteyen araştırmacılara olası problemlerin farkında olarak, araştırma öncesinde gerekli önlemleri almaları önerilmektedir.

Çalışmada kullanılan veri toplama araçlarının pilot testi, gerçek çalışmanın yapıldığı sahadan farklı bir okulda yürütülmüştür. Bu, pilot çalışmaya göre revize edilen veri toplama araçlarının, okul bağlamı değiştiğinde olduğundan daha farklı bir içeriğe sahip olabileceği anlamına gelmektedir. Çünkü okul yönetiminin derslerde kamera kullanımına bakış açısı, öğrenci profili, derslerde kullanılan teknoloji türleri şüphesiz toplanılan veriler üzerinde yadsınamaz bir etkiye sahiptir. Bu nedenle araştırmacılara, pilot testleri gerçek çalışmanın yapılacağı bağlamda yürütmeleri tavsiye edilmektedir.

Çalışmanın yürütüldüğü okul teknolojik altyapısı sebebi ile fazlasıyla özeldir. Bu nedenle bu çalışma ortamından elde edilen veriler transfer edilebilir değildir. Çalışma sonucunda genellenebilir sonuçlar elde etmek bu çalışmanın amacı olmasa da, bu araştırma ile okuyucuya akıllı eğitim sağlayan okullar ile ilgili detaylı bağlamsal bilgi sunulmuştur. Sonuçlar, incelenen her bir durumun geçtiği bağlam hakkında zengin bilgi sunmasının yanı sıra, teknolojinin entegre edildiği fen derslerinin tasarım ve uygulama aşamalarında bulgulanan gözlemlenebilir TPAB göstergelerini ve fen öğretmenlerinin teknoloji kullanımları ile ilgili motivasyonlarını ortaya koymuştur.

Diğer bir yandan, bu çalışmada katılımcıların bir ders saatleri video kaydı altına alınmıştır. Fen Bilgisi öğretmenlerinin ders içi teknolojik uygulamalarına dair daha bütünsel bir çerçeve elde etmek için çekim yapılan ders sayısının artırılması şiddetle tavsiye edilmektedir. Bunun yanı sıra, çekim yapılan ders seviyelerinin ve bu sınıflarda işlenmekte olan konuların her örnek olay için farklı olması, verilerin analiz süreci düşünüldüğünde sınırlayıcı olabilir. Bu nedenle kodların ve temaların filtrelenmesi süreci düşünüldüğünde, aynı konuyu işlemekte olan aynı seviye sınıflarda çekim yapılması daha güvenilir sonuçlar elde edilmesini sağlayacaktır. Dahası aynı konuyu takip eden ders saatleri kayıt altına alındığında bu okuyucu için daha bilgilendirici olacaktır. Diğer bir yandan, sınıf çekimlerinin sayısının artırılması analiz edilecek olan veri miktarında artış anlamına gelmektedir ki bu da verinin düzenlenmesi ve analizi sürecinde araştırmacının daha fazla zaman ve çaba harcamasına sebep olacaktır. Bu kapsamda, her örnek olay için durum önermeleri belirlemek veri analiz sürecinde araştırmacının işini kolaylaştırarak, ona veride ne araması gerektiği konusunda yol gösterecektir.

APPENDIX H: TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü

Sosyal Bilimler Enstitüsü

Uygulamalı Matematik Enstitüsü

Enformatik Enstitüsü

Deniz Bilimleri Enstitüsü

YAZARIN

Soyadı : Ocak
Adı : Ceren
Bölümü : Eğitim Programları ve Öğretim

TEZİN ADI (İngilizce) :

TEZİN TÜRÜ : Yüksek Lisans Doktora

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir.
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir.
3. Tezimden bir (1) yıl süreyle fotokopi alınamaz.

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: