LEARNING BY DESIGN:
AN INTEGRATED APPROACH FOR TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE DEVELOPMENT

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ABSTRACT

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AN INTEGRATED APPROACH FOR TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE DEVELOPMENT

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The purpose of this research was to investigate the development of technological pedagogical content knowledge (TPACK) as students engaged in learning by design activities in the context of Research and Practice on Technology in Teacher Education course offered at a public university in Turkey in Spring 2013. Following the case study methodology, the research implemented learning by design (LBD) module that included TPACK game activities developed specifically to examine students' TPACK development in the course. Research participants included 10 graduate students from different disciplines in the Faculty of Education such as Mathematics Education, English Language Education, Computer Education and Instructional Technologies (CEIT), Primary School Education, and Science Education. Data sources included the TPACK-deep survey, researcher observations, reflection papers, and LBD artifacts. The research revealed that students used two major strategies in their design process, namely orientation, and focus. This result indicated that there were multiple pathways of reaching TPACK. Students' self-perceived TPACK competency was found to be reflected in their instructional practices. Lastly, LBD module implemented in the study was identified as having positive impact on students' TPACK development.

Keywords: TPACK, teacher education, learning by design

ÖZ

TASARIM YOLUYLA ÖĞRENME:
TEKNOLOJİ PEDAGOJİ ALAN BİLGİSİNE BÜTÜNLEŞİK YAKLAŞIM

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Bu çalışmanın amacı, öğrencilerin teknolojik pedagojik alan bilgisi (TPAB) gelişimlerini araştırmaktır. Bu araştırma 2013 yılının bahar döneminde, Türkiye'de bir devlet üniversitesinin Eğitim Programları ve Öğretim Bölümü'nde verilen, "Öğretmen Eğitiminde Teknoloji Üzerine Araştırma ve Uygulama" yüksek lisans dersindeki aktivitelere katılım bağlamında yapılmıştır. Bu durum çalışmasında, öğrencilerin TPAB gelişimleri, TPAB oyunu aktiviteleri içeren tasarım yoluyla öğrenme modülü ile izlenmiştir. Matematik Öğretmenliği, İngilizce Öğretmenliği, Bilgisayar ve Öğretim Teknolojileri Öğretmenliği (BÖTE), Sınıf Öğretmenliği ve Fen Bilgisi Öğretmenliği olmak üzere, Eğitim Fakültesi'nin farklı disiplinlerinden gelen 10 öğrenci araştırmada katılımcı olarak yer almıştır. Veri kaynakları Teknopedagojik Eğitim Yeterlik (TPACK-deep) ölçeği, araştırmacının gözlemleri, katılımcı görüşleri ve öğrenme materyallerinden oluşmaktadır. Araştırma sonuçlarına göre öğrenciler tasarım süreçlerinde yönlendirme ve odaklanma olmak üzere iki ana yöntem izlemişlerdir. Bu bulgu TPAB'a ulaşmak için birden fazla yol olduğunu göstermektedir. Ayrıca katılımcıların kendileri ile ilgili algıladıkları TPAB yeterliklerini öğretim uygulamalarına yansıttıkları gözlemlenmiştir. Son olarak, araştırmada uygulanmış olan tasarım yoluyla öğrenme modülünün öğrencilerin TPAB gelişimine olumlu yönde katkı yaptığı görülmüştür.

Anahtar kelimeler: TPAB, öğretmen eğitimi, tasarım yoluyla öğrenme

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CHAPTER 1

INTRODUCTION

The purpose of this chapter is to provide an introduction to the present study. First, background of the study was presented. Second, definitions of several key terms were explained. Last, the purpose of the study with the research questions was presented.

1.1. Background of the Study

The advent of recent technologies has changed the ways we access and use information. Those advancements have also affected educational research and practice. Integration of technology in education has increasingly become an important concern among scholars (Agyei & Voogt, 2012; Mishra & Koehler, 2006). While research on educational technology seems to give importance to what teachers need to know about technology integration, how they can effectively integrate those technologies in their teaching process seems to be more critical since merely introducing technology in education is not enough for good teaching with technology (Mishra & Koehler, 2006). Some of those problems in research were attributed to the lack of a theoretical base about the place that the technology stands in teaching (Archambault & Barnett, 2010; Mishra & Koehler, 2006). Accordingly, Mishra and Koehler (2006) have offered a theoretical framework called "technological pedagogical content knowledge (TPACK)". This framework pointed out the interplay among teacher's technological, pedagogical and content knowledge for effective teaching with technology. Hence, global technological advancements put the technology also into educational research and practice bringing the issues of its effective usage with existed educational elements, such as instructional methods or topics to be taught. Dialogs of scholars have led to the necessity of constructing a theoretical base to guide research on technology integration which in turn leaded to the emergence of TPACK as a new framework for teacher knowledge.

When first proposed, TPACK was depicted as a complex, multi-faceted, and situated construct (Mishra & Koehler, 2006). Since then, a wide range of research has been conducted around the world in order to understand how teachers develop such a complex knowledge type (e.g. Fransson & Holmberg, 2012; Guzey & Roehrig, 2009; Kafyulilo, 2010; Koehler, Mishra, & Yahya, 2007; Koehler, Mishra, Hershey, & Peruski, 2004; Koh & Divaharan, 2011; Rienties, Brouwer, & Lygo-Baker, 2013).

The literature on TPACK investigated the TPACK framework in line with different dimensions. Understanding of such complex teacher knowledge is still limited. A comprehensive study conducted by Graham (2011) provides a general picture of the fuzziness in research identifying TPACK as a new theoretical framework. He addressed that the definitions of TPACK constructs are still not clear. He gave example from Cox (2008)'s study in which she identified numerous definitions of TPACK, TPK, and TCK in the literature. He stated that some research used the terms "TPACK" and "technology integration" interchangeably. Furthermore, some studies defined TCK as if it included pedagogical considerations despite of the fact that Mishra & Koehler (2006) articulated its pedagogy-free nature in their work in which they first proposed TPACK. He also contended that those blurry definitions made it difficult to distinguish one construct from another, to illustrate, TPK from TCK. In addition, Graham (2011) pointed out that research has been descriptive in nature rather than prescriptive. In other words, it has provided some descriptive knowledge about the existence and definitions of those constructs. However, it has not proposed hypotheses about how TPACK develops, how its components affect each other, what are possible pathways in reaching TPACK, and how TPACK affects student learning. The current study aimed to fill the gap in TPACK research by examining how TPACK components affected each other and generated different routes in reaching TPACK.

In addition to problems identified by Graham (2011), current trends in TPACK research shifts from studying of what teachers should possess for effective teaching with technology to how these knowledge should be used in the classroom (Doering, Veletsianos, Scharber, & Miller, 2009). Since TPACK is an "interdependent, situated, and complex" (Harris, Grandgenett, & Hofer, 2010, p.3834) entity, its development needs to be investigated through integrated approaches. Research so far, has not allocated enough space for inquiring answers to questions posed about the self-perceived TPACK and its reflection into instructional practices. TPACK literature mainly focused on design activities that included the design of various technology integrated educational materials (e.g. Hofer & Grandgenett, 2012; Koehler et al., 2004; Koehler et al., 2007; Koehler & Mishra, 2005b; Pamuk, 2012; Rienties et al., 2012; Ta Chien, Yen Chang, Kuang Yeh & En Chang, 2012).Those instructional practices aimed to develop participants' TPACK competencies. Nevertheless, how participants reflected their self-perceived TPACK into those design processes and how those practices affected their self-perceived TPACK may call for additional research investigating the interaction between self-perceived TPACK and TPACK in such instructional practices. TPACK research has been limited in investigating questions about TPACK development such as "What teachers do with their TPACK?", "How teachers apply their TPACK in their teaching?". Present study aims to investigate these questions by examining the interaction between students' self-reported TPACK and their TPACK in the process of designing TPACK based learning artifacts.

TPACK literature calls for triangulation of data with self-reported measures, artifacts, and observations to conduct an in-depth analysis of TPACK (e.g. Doering et al., 2009; Graham, Borup, & Smith, 2012; Koehler et al., 2007; Rienties et al., 2013; Shin et al., 2009). "Developing TPCK is a multigenerational process, involving the development of deeper understandings of the complex web of relationships between content, pedagogy and technology and the contexts in which they function" (Koehler et al., 2007, p.758). In order to understand the development of such complex knowledge, a number of measurement techniques have been used in the literature. These techniques can be grouped into three: (1) self-reporting measures such as interviews or surveys; (2) observations, and (3) teaching artifacts such as lesson plans (Harris et al., 2010). Generally, self-reporting measures have been widely used in the literature to investigate the development of TPACK (e.g. Archambault & Barnett, 2010; Doering et al., 2009; Hofer & Grandgenett, 2012; Koehler & Mishra, 2005b). As the name implies, self-reporting measures aimed at collecting data on teachers' self-perceptions about technology integration competency as a reference to understand TPACK development. Apart from self-reporting measures, observations have also been used to examine the development of

TPACK (e.g. Koehler et al., 2004; Koehler et al., 2007; Pamuk, 2012). Furthermore, artifacts were analyzed to examine the development of teachers' TPACK in their process of designing technology integrated educational materials. Unlike self-reports or observations, artifacts provided opportunity for examining teachers' TPACK development through their instructional design processes. (e.g. Hofer & Grandgenett, 2012; Koehler et al., 2004; Koehler et al., 2007; Pamuk, 2012). While a number of these data sources were integrated into the TPACK research to understand how TPACK develops in unique ways, only a limited number of studies combined all these three types of measurement techniques (e.g. Koehler et al., 2004; Koehler et al., 2007; Pamuk, 2012). It is important to investigate the complex and multifaceted nature of TPACK with triangulation of data. In other words, all three types of data collection tools such as self-reported measures, artifacts, and observations could be used. The current study aimed to address this research need by combining different data sources (e.g. survey as a self-reported measure, observations and design artifacts) to generate a more complete and clear picture of TPACK development.

The study included learning by design (LBD) activities to engage students in designing TPACK based learning materials. In learning by design approach, participants come together and design a technology integrated material to understand the nuanced relationship between and among pedagogy, content, and technology (Koehler & Mishra, 2005b). The study used learning by design approach for several reasons. First, LBD approach allows for triangulation. With LBD, the complex nature of TPACK can be examined with multiple sources of data. Second, LBD activities were reported as having positive impact on TPACK development in the TPACK literature (e.g. Alayyar, 2011; Alayyar, Fisser, & Voogt, 2010; Jang & Chen, 2010; Koehler et al., 2004; Koehler et al., 2007; Koehler & Mishra, 2005a, 2005b). The LBD module in the study allowed triangulation of data, combined decision making processes and practices and sought to discover the interaction between them, and provided activities to discover pathways in reaching TPACK. In brief, LBD approach allowed examining the development of TPACK, which has a complex nature, with triangulation of different data sources.

1.2. Purpose of the Study

The purpose of this study is to investigate the possible pathways in reaching TPACK, reflection of self-perceived TPACK into instructional practices, and the impact of LBD module implemented in the study on students' development of TPACK. The study was conducted in the context of the Research and Practice on Technology in Teacher Education course offered at a public university in Turkey in Spring 2013. Participants of the study were 10 graduate students[1] enrolled in the course. Specifically, the present study aimed to investigate the following research questions:

- What pathways students followed while reaching TPACK in the Research and Practice on Technology in Teacher Education course?
- What is the interaction between students' self-perceived TPACK and their instructional practices?
- What is the impact of the LBD module on students' development of TPACK?

1.3. Significance of the Research Questions

TPACK research addressed several gaps to be filled by the future research. One of them is the lack of prescriptive value of TPACK, that is, lack of hypotheses about interactions among TPACK components or pathways could be followed in reaching TPACK, etc. The current study investigated how TPACK components affected each other and led to different routes in reaching TPACK. Other gap is the need of investigations among self-perceived TPACK and TPACK in instructional practices as Lawless and Pellegrino (2007) discussed that teachers' pedagogical beliefs about their selves are not always aligned with their instructional actions. In that sense, the current study investigated the interaction among self-reported TPACK of students and their TPACK competencies in their TPACK based lesson plan design processes. Another issue reported by TPACK research is the need for triangulation of data in examining the development of the TPACK complex and contextually-bound. In the current study, data from different sources were collected during the LBD

[1] Within that context, graduate students attending the study as participants will be mentioned as "students" henceforth.

module. Triangulation of the data helped to understand the situated and context-bounded nature of TPACK.

1.3.1. Definition of the terms.

Pedagogical Content Knowledge (PCK): A concept which was proposed by Shulman (1986b) referring to "the most useful forms of representation of [content], the most powerful analogies, illustrations, examples, explanations, and demonstrations—in a word, the ways of representing and formulating the subject that make it comprehensible to others" (p.9).

Technological Pedagogical Content Knowledge (TPACK): A framework which "builds on Shulman's (1987, 1986) descriptions of PCK to describe how teachers' understanding of educational technologies and PCK interact with one another to produce effective teaching with technology" (Koehler & Mishra, 2009, p. 62).

Learning by Design (LBD): An approach for TPACK development in which students and educators work as groups to find optimal solutions to ill-structured educational technology problems such as designing an online course (Koehler & Mishra, 2005b).

TPACK Game: A game that requires optimal usage of items selected from technology, pedagogy and content pools to brainstorm about and design TPACK lesson plans.

Artifact: Artifacts include learning materials that participants generated through their design process such as lesson plans and online courses.

CHAPTER 2

LITERATURE REVIEW

The purpose of this chapter is to provide an overview of the literature on TPACK development. First, a discussion on TPACK is presented. Second, studies with design activities are explained. Then, studies with LBD approach are discussed. Last, a synthesis of the findings in a summary is provided. In addition, considering one of the research problems of the study (the scarcity of research which preferred to use all three types of measurement techniques, namely self-reports, observations, and artifacts), all studies were examined in terms of their measurement techniques in their data collection process.

2.1. Pedagogical Content Knowledge (PCK): The Framework for Understanding the Relationship between Pedagogy and Content

PCK was first proposed by Shulman (1986b) as a sub category of teacher's content knowledge. In 1986, before introducing PCK, Shulman refocused researchers' attention to teacher's subject matter. He critiqued teacher certification programs at the time he was conducting his studies, which was formerly content based and later pedagogical based mostly (1986b). To put it differently, he identified that teacher certification programs were mainly emphasized measuring content knowledge of teachers by allocating less space for pedagogy-related questions. Later, they shifted their understanding by measuring mainly teachers' pedagogical competencies by ignoring content knowledge level of teachers. In line with those considerations, he attempted to identify knowledge bases of teachers by proposing three knowledge categories, namely subject matter knowledge, pedagogical knowledge, and curricular knowledge (Shulman, 1986a). Shulman also contended that the relationship between a teacher's knowledge of a subject matter and how this knowledge is represented to students might be a *missing paradigm* in educational research. Later, he revised his categorization by subsuming subject matter knowledge and curricular knowledge, and introducing a new type of knowledge base which he called *pedagogical content knowledge* (Gess-Newsome, 1999). In his work, he emphasized that both pedagogy-free content and content-free pedagogy were useless for teaching (Shulman, 1986b) and explained pedagogical content knowledge as the knowledge of best ways to present a specific content to learners including "the most powerful analogies, illustrations, examples, explanations, and demonstrations" (Shulman, 1986b, p.9). In short, it was the knowledge of changing the representation of the content to facilitate learning.

In 1987, Shulman rearranged the knowledge bases and identified seven knowledge domains subsuming pedagogical knowledge, knowledge of students, knowledge of context, and knowledge of educational goals in addition to curricular knowledge, subject matter knowledge, and PCK from his previous work. Still, among them, PCK, the "subject matter knowledge *for teaching"* (Shulman, 1986b, p.9, emphasis in original) gathered more interest than others (Gess-Newsome, 1999; Mishra & Koehler, 2006) since Shulman caused a *paradigm shift* in teacher education research (Carlsen, 1999). In addition to extending knowledge bases for teaching in 1987, Shulman attempted to define PCK as:

> …the special amalgam of content and pedagogy that is uniquely the providence of teachers, their own special form of professional understanding ... Pedagogical content knowledge ... identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to diverse interests and abilities of learners, and presented for instruction. Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue. (Shulman, 1987, p. 8)

When Shulman first proposed PCK, he initiated a new direction of research in teacher education. In fact, he expressed that interconnectedness of pedagogy and content has not been new but has been a forgotten construct since medieval era when there were no visible boundaries between content and pedagogy in teacher preparation programs in universities at that time (Shulman, 1986b). After Shulman's refocus on content-pedagogy dependence for an effective teaching, and articulation of the necessity to reflect this dependence in teacher knowledge domain models, PCK started to be included in teacher knowledge domain models and interpreted in line with different perceptions of teaching (Gess-Newsome, 1999). Some models considered that there is no such a construct called PCK but PCK implicitly emerges when separate knowledge domains are integrated into each other. Others considered that PCK is a new, transformed knowledge domain in which separate knowledge domains are immersed so that they become meaningful for an effective teaching. Furthermore, all models considered that knowledge of subject matter teaching and knowledge of students were the two important elements that have to exist in knowledge domains of teachers (Gess-Newsome, 1999). Discussions on the conceptualization of PCK and on domain identifications for teacher knowledge have grounded a base for further discussions when a new teacher knowledge framework, *technological* pedagogical content knowledge (TPACK) came to the fore in educational research.

2.2. The Emergence of Technological Pedagogical Content Knowledge (TPACK) as a New Framework for Effective Teaching with Technology

Technology knowledge has not been considered as unimportant by Shulman in his work in 1986 (Mishra & Koehler, 2006). He identified teacher knowledge about educational technologies under "curricular knowledge" domain. Shulman (1986b) described curricular knowledge by addressing pre-service biology teachers' curricular knowledge needs. As a university professor, he asked "how many individuals whom we prepare for teaching biology, for example, understand well the materials for that instruction, the alternative texts, software, programs, visual materials, single-concept films, laboratory demonstrations, or "invitations to enquiry?" (p.10). Considering the question, he addressed the importance of knowledge about technologies that can be used in a specific subject matter area by including the words "software" and "programs". Still, Shulman's focus was mainly on how pedagogy and content are related in teaching since technologies before 1980s had become *transparent* after they were routinely used in the teaching process (Bruce & Hogan, 1998). Chalkboards, books, pencils, periodic charts, maps can be regarded as commonplace technologies used in traditional classrooms that have already become transparent. However, the advent of a wide array of digital technologies led to emerging discussions about digital educational technologies such as educational simulations, web sites, games, etc. Scholars started to contend that technology knowledge cannot be treated as an isolated construct and good teaching requires the understanding of how technology is related with pedagogy and content (Mishra & Koehler, 2006). By acknowledging concerns of scholars after 1990s, Mishra and Koehler suggested a new framework called TPACK that specifically focuses on the interrelationship among pedagogy, content, and technology to build up a common language among scholars and allow systematic research of technology integration to teaching (Mishra & Koehler, 2006). In fact, they did not argue that this approach was completely new. Before Mishra and Koehler (2006), TPACK was articulated as TPCK by Niess (2005) in her article in which she examined TPCK of pre-service teachers in the science and mathematics teacher education program. However, what set apart their approach from what Niess had come up with was the specific articulation of interaction of pedagogy, technology and content both separately and in pairs, as Shulman had done for pedagogy and content. By following Shulman's strategy, they introduced a third component to the PCK construct and created TPACK (Mishra & Koehler, 2006). The name of the new framework was not TPACK but TPCK. Later, the name was changed to TPACK. TPACK meant the "TOTAL PACKage" because it embraced the idea that pedagogy, content, and technology should not be treated separately from each other but should be considered as a whole for good teaching with technology (Thompson & Mishra, 2007).

TPACK was proposed to consist of seven sub-teacher knowledge domains: content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technology knowledge (TK), *technological content knowledge (TCK), technological pedagogical knowledge (TPK),* and *technological pedagogical content knowledge (TPACK)*. TPACK was described as being:

> the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones (Koehler & Mishra, 2009, p.66).

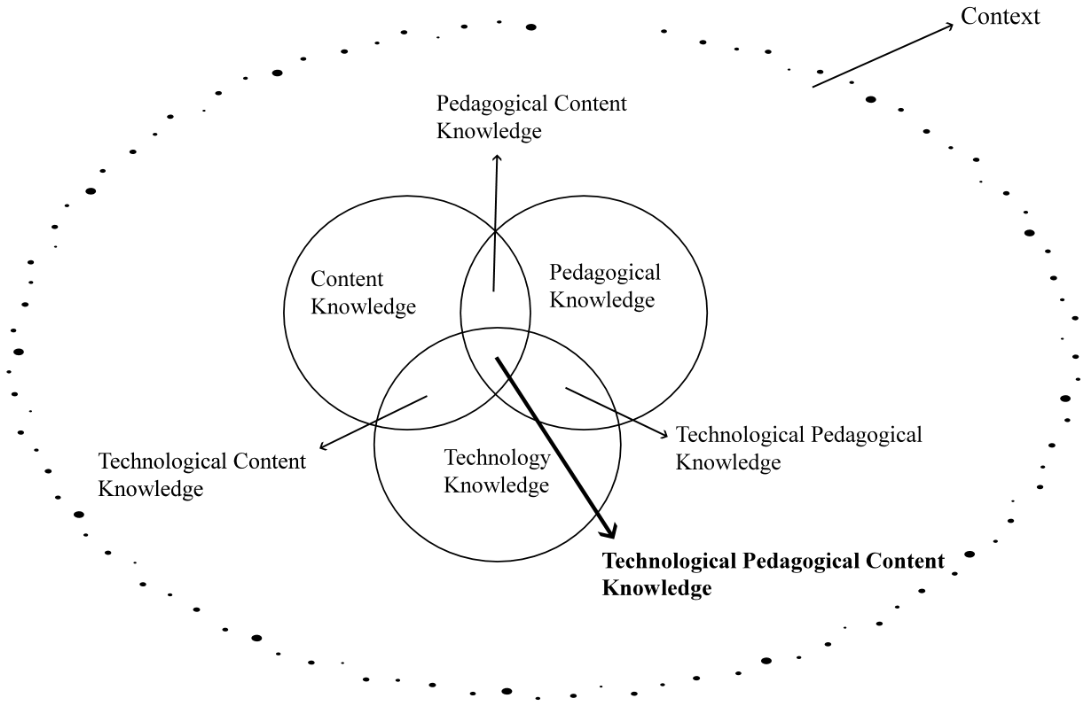


Figure 2.1. The TPACK framework proposed by Mishra and Koehler (2008)

The TPACK knowledge domains and the "context" factor identified by Mishra and Koehler (2006) are explained below:

Content knowledge (CK).

Content knowledge refers to the knowledge about the subject matter (Koehler & Mishra, 2009; Shin et al., 2009). It refers to "what the research chemist understands about the discipline of chemistry" (Baxter & Lederman, 1999, p.148). This type of knowledge is independent of any other pedagogical considerations (Cox, 2008). It includes the knowledge of facts, procedures, principles and theories in one's subject matter area (Mishra & Koehler, 2006).

Pedagogical knowledge (PK).

Pedagogical knowledge refers to "general skills, beliefs, and knowledge related to teaching, independent of a particular subject area. Knowledge and beliefs about learners, basic principles of instruction, classroom management, and the aims and purposes of education are all part of general pedagogical knowledge”(Cox 2008, p. 7).

Technology knowledge (TK).

Technology knowledge refers to having knowledge about generic uses of technologies. Mishra and Koehler (2006) describe technology knowledge as:

> the knowledge about standard technologies, such as books, chalk and blackboard, and more advanced technologies, such as the Internet and digital video. This involves the skills required to operate particular technologies. In the case of digital technologies, this includes knowledge of operating systems and computer hardware, and the ability to use standard sets of software tools such as word processors, spreadsheets, browsers, and e-mail. TK includes knowledge of how to install and remove peripheral devices, install and remove software programs, and create and archive documents (p. 1027).

Pedagogical content knowledge (PCK).

Pedagogical content knowledge refers to the understanding of “the most useful forms of representation of [content], the most powerful analogies, illustrations, examples, explanations, and demonstrations—in a word, the ways of representing and formulating the subject that make it comprehensible to others” (Shulman, 1986b, p. 9). Pedagogical content knowledge differs across different subject areas since it combines both pedagogy and content to lead to better teaching of that content (Schmidt et al., 2009).

Technological content knowledge (TCK).

Technological content knowledge is the knowledge of technologies specific to a content area. Cox (2008) states that:

> technological content knowledge is the knowledge of appropriate technologies that may be utilized in a given discipline and how the use of those technologies transforms the content of that discipline through representation or the generation of new content or how the content of that discipline transforms or influences technology. It is the knowledge of (a) how technology represents content, (b) how technology generates new content, and (c) how content transforms technology (p. 60).

Technological pedagogical knowledge (TPK).

Technological pedagogical knowledge is the knowledge of the pedagogical use of technologies independent of any content. It refers to the knowledge of affordances and constraints of technologies that can be used in general pedagogical context. It includes the knowledge of how those technologies' affordances and constraints affect or are affected by pedagogical choices of a teacher (Cox, 2008; Koehler & Mishra, 2009; Mishra & Koehler, 2006).

Technological pedagogical content knowledge (TPACK).

Technological pedagogical content knowledge is the knowledge of using technology, pedagogy, and content at the same time in the same context. Cox (2008) describes TPACK as:

> the knowledge of the dynamic, transactional negotiation among technology, pedagogy, and content and how that negotiation impacts student learning in a classroom context. The essential features [of TPACK] are (a) the use of appropriate technology (b) in a particular content area (c) as part of a pedagogical strategy (d) within a given educational context (e) to develop students' knowledge of a particular topic or meet an educational objective or student need. This definition acknowledges the presence and interaction of all three components with particular emphasis on the use of content-dependent pedagogy (p. 65).

The context factor.

Context-independent designs offer generic solutions to problems in teaching with technology. While those solutions are valuable, they are not enough for effective technology integration in teaching. Besides, they do not consider the individuality of teachers such as their styles, experiences, and philosophy. In other words, technology integration is contextually bound. It is affected by subject matter to be taught; available technologies used, and characteristics of students and teachers (Mishra & Koehler, 2006). In addition, those factors can bifurcate when role players, tools, and the time change. Thus, they seem to have a considerable impact on TPACK based designs. A TPACK lesson design effective in a situation may not be effective at all in another. That's why custom designs for specific subject matters in a specific classroom context are important for technology integration efforts (Mishra & Koehler, 2008). Cox (2008) stated that an effective TPACK example should also report the context of that example.

By keeping in mind the context factor, TPACK combines technology, pedagogy, and content in one domain as a total teaching package with good quality (Thompson & Mishra, 2007). However, adding an additional component to PCK increases the complexity of TPACK and its development process. To understand TPACK as a construct and examine its development, wide range of research has been conducted in the last seven years.

2.3. Investigating the Development of TPACK

Endeavors of understanding dynamics of TPACK as a complex and multidimensional entity have led to a range of studies. Those studies can be classified as the ones conducted in (1) courses in teacher preparation programs (Fransson & Holmberg, 2012; Pamuk, 2012; Srisawasdi, 2012; Ta Chien et al., 2012) and (2) teacher professional development programs (e.g. Doering et al., 2009; Guzey & Roehrig, 2009; Hofer & Grandgenett, 2012). Participants in these studies ranged from undergraduate students to in-service teachers including graduate students and faculty members. Research on TPACK development included developmental activities such as presentations, explorations, discussions, design projects, and implementations of technology integration in teaching in terms of TPACK framework. Majority of the studies can be classified as LBD studies. The rest included professional development programs (e.g. Doering et al., 2009; Hofer & Grandgenett, 2012) and courses with no LBD approach (e.g. Koçoğlu, 2009; Shin et al. 2008). In addition, an instructional model was designed specifically for developing TPACK has been identified in the literature (e.g. Koh & Divaharan, 2011). Within the TPACK development research, main focus has been on design projects (Koehler & Mishra, 2005a, 2005b; and Koh & Divaharan, 2011). Even studies which did not take LBD approach as a guide allocated space for design activities to contribute to participants' TPACK development (e.g. Hofer & Grandgenett, 2012; Shin et al., 2009).

2.3.1. Design activities as guides for TPACK development.

Several studies conducted a series of activities to examine the development of TPACK in different contexts. Among those activities, participants also experienced technology integrated design activities. To illustrate, Shin et al. (2009) investigated how in-service teachers' self-beliefs changed after attending in a set of educational technology summer courses. 17 in-service teachers with several years of teaching experience participated in the study. It was hypothesized that in-service teachers would show a more integrative understanding about technology, pedagogy, and content at the end of summer courses. In courses, in-service teachers worked on a series of assignments such as preparing digital videos, developing wikis about educational technologies, or designing personal web portfolios while working on web 2.0 technologies in courses. Researchers used the Survey of Teachers' Knowledge of Teaching and Technology (Schmidt et al., 2009) in a pre-test post-test design and reported significant increase in TK (Technological Knowledge), TCK, PCK, TPK, and TPACK knowledge of in-service teachers. In addition, researchers stated that significant improvement in PCK of in-service teachers is an unexpected result of the study although CK and PK showed no significant difference. Researchers emphasize the importance of the study by pointing out the need for quantitative measures for TPACK development because of the effort load of qualitative studies. In addition, they offer triangulated methods to look at instructional practices of in-service teachers in future studies.

In another study, Hofer and Grandgenett (2012) combined graduate students' self-reported data and their lesson plan documents in a longitudinal study to understand the development of pre-service teachers' technology integration knowledge during their teacher preparation program. 8 master students from English, Mathematics, Social Studies, and Science departments attended the study. Data sources were (1) Schmidt et al (2009)'s TPACK survey, (2) pre-service teachers' reflection papers, and (3) pre-service teachers' lesson plan artifacts. Pre-service teachers completed the TPACK survey. Data were collected through reflection papers and lesson plans.

Results revealed that survey results indicated strong growth in TPACK. Furthermore, much gain in each area of knowledge (e.g. PCK, TCK) was identified during the fall of semester when they first met educational technology and teaching methods course. Although survey results showed growth in their expressed level of TPACK, the first lesson plan rubric results were slightly higher than the second lesson plan rubric results. However, researchers also pointed out that both of the results demonstrated adequate TPACK by stating that overall mean of their second lesson plans was 2.91 on a 4 point scale, and the target for each dimension in the rubric was determined as 3.0. This slight decrease in their lesson plan rubric scores was explained as increasing workload of students and decreasing help from their teachers thorough the end of the semester. Finally, researcher reported that in both reflection statements and lesson plans of pre-service teachers, they identified much more TPK related codes than TCK and TPACK related codes meaning that participants mostly focused on TPK. However, when researchers checked survey responses and rubric scores, they could not find any greater difference between TPK, TCK, and TPACK. Thus, this result in number of codes were explained as it might be due to the questions asked in reflection papers since questions in reflection papers were more general than survey questions and content-focused nature of lesson design. Rather, pre-service teachers were asked about the effective use of technologies in their content areas, and when to use and when not to use technology in their teaching. As for limitations, they addressed (1) their small sample size, and (2) their scope of the study. They explained that sample size could be higher but their longitudinal studies generated intensive data even for small sizes of participants. In addition, they addressed the necessity that, the study should be extended to pre-service teachers' first several years of full time teaching experiences.

Differently from the studies above, Koh and Divaharan (2011) followed a *design-based approach* (Lesh, Kelly, & Yoon, 2008) and developed a TPACK developing instructional model by taking the studies of Niess, Suharwoto, Lee and Sadri (2006) and Niess (2007) as their guide. In those studies, TPACK development of teachers was examined as they attended a development program on the use of spreadsheets for Math. It was found that teachers' TPACK development followed some steps, namely:

1. *Recognizing* the utility of spreadsheets,
2. *Accepting* that spreadsheets can be used pedagogically,
3. *Adapting* lesson ideas they have explored in implementing spreadsheets for teaching,

4. *Exploring* new ways of teaching content with spreadsheets,
5. *Advancing* the uses of spreadsheets beyond content teaching.

Koh and Divaharan (2011) posited that different ICT instructional methods were needed to support each stage of teacher's TPACK development as identified by Niess et al. (2006) and Niess (2007), and came up with three phases in their model, namely "foster acceptance", technological proficiency and pedagogical modeling", and "pedagogical application". In the scope of study, 74 pre-service teachers studied on the pedagogical use of Interactive Whiteboard. They were trained about characteristics and pedagogical uses of Interactive Whiteboards thorough faculty modeling and worked in groups to design Interactive Whiteboard integrated lesson plans. Qualitative and quantitative analysis of data indicated that the model proposed was successful at contributing to the growth of participants' confidence in integrating an ICT tool that they were not knowledgeable at all before. During Phase 1, it was identified that participants were more interested in technical capabilities of Interactive Whiteboards (TK). Nevertheless, their TPK was also significant which was interpreted as the effect of faculty modeling (presenting pedagogical affordances of the technology). TPK related comments on their reflection papers were also evident during Phase 2. Their hands-on and shared experiences about pedagogical uses of Interactive Whiteboards took their ideas beyond faculty modeling. Design activities at phase 3 were more effective for contributing their TK and TPK than TCK and TPACK. Researchers thought that it was because participants were in their first semester of teacher education training and they did not attend methods courses. Since they were novice in teaching, they could not establish successful linkages between and among pedagogy, content, and technology. Second, researchers contended that 7 weeks might not be enough for novice pre-service teachers moving from TK and TPK towards TPACK (in fact, participants also were not so much familiar of Interactive Whiteboards before the study) and emphasized the need of longer periods of studies. As for limitations, they stated that different ICT tools should be added and the study should be extended to pre-service and in-service teachers with different subject specializations.

Literature on TPACK development approach in this section indicated significant developments with regard to TPACK constructs of participants. However, scholars (e.g. Doering et al., 2009; Graham et al., 2012; Koehler et al., 2007; Rienties et al., 2013; Shin et al., 2009) also addressed that relying on chiefly self-reported measures limited the scope of their studies calling for triangulation of data, which in fact, is evident in the literature on LBD explained in the next section.

2.3.2. Understanding LBD.

When TPACK was first introduced to the literature as a new teacher knowledge domain, Mishra and Koehler (2006) recommended learners to design technology integrated educational artifacts to not only develop their technology integration skills but also to uncover the complexity of TPACK framework. Design teams were first used by Kolodner (2002). The approach combined case-based reasoning and problem based learning. In design teams, students worked in groups to learn specific science contents by exploring, collaborating, investigating, designing, reflecting, and revising.

The LBD approach was also used in the context of university education (e.g. Alayyar, 2011; Alayyar et al., 2010; Fessakis, Tatsis & Dimitracopoulou, 2008; Fransson & Holmberg, 2012; Kafyulilo, 2010; Pamuk, 2012; Srisawasdi, 2012). where participants were undergraduate students and faculty members (Agyei & Voogt, 2012), and graduate students and faculty members (e.g. Koehler et al., 2004; Koehler et al., 2007; Koehler & Mishra, 2005b). Although design approach first used to study science topics, the components of it also have been applied into technology integration. For instance, participants were provided with an instructional technology problem, and were asked to work in groups to identify possible optimal solutions to that problem (e.g. Alayyar, 2011; Alayyar et al., 2010; Jang & Chen, 2010; Koehler et al., 2004; Koehler et al., 2007; Koehler & Mishra, 2005b). The aim was to develop teachers' technology integration knowledge that can be used in real life classrooms (Johnson, 2012). Thus, LBD approach was used in different contexts in which participants ranged from middle school students to academics with different purposes such as teaching science or developing technology integration competencies.

Koehler and Mishra's "Learning *Technology* by Design" (2005a) approach was one of the technology integration studies that applied the strategies of design approach. In their approach, graduate students and faculty members were provided with ill-structured educational situations that could be confronted in real classroom contexts, such as creating an online course, or creating a technology integrated lesson plan. After the task was identified, they started to engage in exploration, research and design process in order to offer potential meaningful solutions to the problem. In the design process, they started to understand how technology, pedagogy, and content supported and constrained each other when used altogether and how a change in one is compensated by others. Artifacts designed by teams, their discussions, observations and field notes of the researcher were then examined to understand the complex nature of TPACK development (Mishra & Koehler, 2006). In essence, LBD approach offered a hands-on exploration environment in which technology integrated learning tools were designed in the process of TPACK development.

The positive impact of design approach to learn complex and interrelated ideas such as TPACK have been reported in a wide range of studies (Johnson, 2012; Mishra & Koehler, 2006). Unsurprisingly, LBD approach offered by Mishra and Koehler (2006) was reported to lead significant changes in the development of TPACK in an array of studies (e.g. Alayyar, 2011; Alayyar et al., 2010; Jang & Chen, 2010; Koehler et al., 2004; Koehler et al.2007; Koehler & Mishra, 2005a, 2005b). Studies revealed that TPACK developed by doing and thorough the interaction among design teams while working to find an optimal solution to the problems caused by the interactions of technology, pedagogy, and content (Koehler et al., 2007). LBD activities offered participants rich opportunities to deeply understand the relationships between and among content, pedagogy, and technology (Koehler et al., 2004; Koehler & Mishra, 2005a, 2005b). LBD approach was acknowledged by scholars as a beneficial way of understanding the TPACK and examining its development.

In conclusion, LBD approach has been acknowledged as an effective strategy for presenting the complexities of the TPACK constructs. Through the design process of technology integrated lesson environment, designers wrestle with the conflicting forces of technology, pedagogy, and content. In this process, cooperation and communication among design members help them generate, share, and test their ideas/potential solutions to the problems experiences in the design process which are important for becoming successful integrators of technology (Hur, Cullen & Brush, 2010). The advantages of the LBD approach leaded to substantial studies on TPACK development with LBD approach.

2.3.3. LBD as an approach for fostering and examining the development of TPACK.

Research examining TPACK development through LBD activities seem to be common in the literature. Following sections present LBD literature with research that (1) used one or two of measurement techniques and (2) triangulated data by using all three types of data collection methods.

2.3.3.1. LBD research with several measurement techniques.

LBD research which utilized one or two data collection techniques were reported to have a positive impact on the development of TPACK. For instance, Graham et al. (2012) sought to inquire pre-service teachers' TPACK by analyzing their decision-making processes in selecting possible technologies for three LBD tasks. In the study, pre-service teachers were provided three design tasks and a survey consisting of open ended questions about designs prepared by researchers. In the survey, they were asked how they could teach a specific curricular standard using technology. This process was repeated at the end of the semester. Answers of open ended questions were analyzed by content analysis which indicated that the number of codes they derived in TPACK categories significantly increased after design tasks. Qualitatively, they found that overall pre-service teachers' responses were much more detailed in terms of technology integration on course post-assessment than pre-course assessment. Among TPK responses, pre-service teachers interpreted technologies in terms of 1) general teaching strategies, and 2) general understanding of learner characteristics, like student motivation. Among TPACK responses, researchers identified three TPACK categories, namely 1) knowledge of content-specific instructional strategies, 2) knowledge of learner content understanding, and 3) knowledge to transform content representations for teaching. Among them, knowledge to transform content representations for teaching was the most common rationale in their responses in which they emphasized that technology transformed content to make it more visual. In the first category of "knowledge of learner content understanding", they mostly stated that technology had a positive effect on student content learning outcomes, which means that according to pre-service teachers, technology facilitated reaching content objectives identified in design tasks. One interesting result was that, they did not consider technology as a tool that remedies student misconceptions. Researchers explained this situation by stating that pre-service teachers did not confront with student misconceptions intensely because of their limited teaching experiences. As for limitations of the study, they pointed out that their study did not consider classroom realities since pre-service teachers answered questions by imagining about the learning environment depicted in design tasks which calls for the importance of the transfer of TPACK to practice. In addition, they addressed the importance of using multiple sources of data.

In another study, Mishra and Koehler (2005b) conducted a LBD seminar in which 4 faculty members and 14 students worked together to develop online courses. The study consisted of whole group and small group sessions. In whole group sessions, participants read articles and discussed ideas about technology in teaching. In small group sessions, they worked as a group to develop online courses throughout the semester. Each group had only one faculty member. As for data collection procedures, participants attended an online survey 4 times. They analyzed data for pre-post difference and found that participants moved from considering technology, pedagogy, and content as separated constructs to considering them as transactional and co-dependent which was interpreted as indicators of their TPACK development.

In another similar study, Koehler et al. (2007) aimed to understand TPACK development of faculty members and graduate students by examining their discourses (either orally or written) which they called it as *design-talk* in a LBD study. 6 faculty members and 18 Master’s students attended the study. Like Mishra and Koehler’s work (2005b), this study also consisted of a whole-group component in which participants discussed readings and issues, and a small-group component in which design teams worked together to prepare online courses. Researchers collected data from group discussions as the main source, e-mails among participants, notes and other artifacts. The data were quantitatively and qualitatively analyzed using content analysis. Quantitative analyses revealed that design teams moved from considering technology, pedagogy, and content as separated constructs towards understanding the mutual dependencies between and among them interpreted as their TPACK developed overtime. When data were qualitatively analyzed, it was identified that design-talks of the teams have changed throughout the study. Starting points and length of conversations, participants' role in those conversations have changed over time proving that TPACK is a multigenerational process with its complex nature and this nature's components and interactions of those components. Still, the researchers emphasized that qualitative content analysis may expose to subjective judgments which brings the importance of triangulation of data to the fore.

Apart from studies above, teaching experiences has been integrated into the LBD approaches in some of the literature. To illustrate, Rienties et al. (2013) constructed a TPACK questionnaire with three experts in technology enhanced learning and used it in their pretest-posttest design. The study aimed to examine TPACK development of 73 academics from 9 higher education institutions through an online teacher professionalization program. In the study, they were asked to redesign a teaching module and practice it in their classrooms and then share their experiences. The results of the study suggest that after participating in the program, academics' TPACK and its subcomponents named TPK, PCK, and TCK scores on post-test were significantly higher than those on pre-test. The study did not measure PK, CK and TK. They also pointed out the limitation of using measures based on self-reported data and addressed the economic burden of the program they proposed.

In a different study, Agyei and Voogt (2012) examined TPACK development of 4 pre-service mathematics teachers who worked in two design teams to develop spreadsheet-supported lesson plans. Pre-service mathematics teachers first developed spreadsheet integrated lesson plans and then taught them in classroom settings to either colleagues, peers, or the researcher. Later, they revised their plans based on their experiences. Data were collected thorough self-reported data from interviews and questionnaire which were adapted from Schmidt et al. (2009)'s survey, and observation notes of the researcher. The results indicated significant growth in component of TPACK (TK, TPK, TCK, and TPACK) as it was stated by the researchers that they moved from thinking discretely about technology, pedagogy and content to thinking about them as they were almost inseparable constructs. As for transfer of TPACK, researchers pointed out the time management issue of lesson implementation. Errors in estimating time for some activities in their lesson plans caused rush and teacher driven conclusions in their lessons. In addition, teacher-centered roots of pre-service mathematics teachers limited their design being student centered and more interactive. Lastly, pre-service mathematics teachers stated that they needed more time to effectively integrate such a new technology in their design and teaching supporting Koh and Divaharan (2011) who recommended in their study to design longer studies (their study was 7-week-long) for TPACK development.

Ta Chien et al. (2012) also used pre-service science teachers but specifically employed a framework called MAGDAIRE (Modeled Analysis, Guided Development, Articulated Implementation, and Reflected Evaluation) to transform them from being passive users of technology to active designers of technology. 16 pre-service science teachers participated to LBD activities and prepared flash based online science courseware. In the study, they were divided into groups and gone thorough MAGDAIRE steps. To illustrate, at “modeled analysis” phase, they studied about online science course wares by discussing and brainstorming about what features of technology would be powerful to teach specific science content, and how technology could be integrated in their teaching. At “guided development” phase, they prepared open science course wares including learning materials, activities, and assessments of a specific science content that they selected as groups. At “articulated implementation” phase, they experienced a teaching practice with their open science course ware materials in a classroom setting and shared their experiences, thoughts and feedbacks with each other. Finally, at “reflected evaluation” phase, pre-service science teachers evaluated and made comments about other groups’ performances. After that, MAGDAIRE framework recycled and they improved their work thanks to their hypotheses testing, discussing, reflecting, and evaluating by peer coaching.

Quantitative data was collected by using two surveys called Technical Proficiency of Flash Concept and Skill tests. Those tests were administered before and after the study as pretest-posttest format. Qualitative data was collected through (1) online discussions, online submissions of weekly course assignments, and participants’ feedbacks on their open science course wares, (2) video-recordings of participants’ teaching practices, (3) semi-structured interviews. Two tailed t-test was applied to the two surveys and inductive data analysis was handled for qualitative data. Two tailed t-test revealed that post-test scores of the surveys were significantly higher than those of pre-test. In addition, 16 participants (100%) believed their technology competency (TK) increased and 14 participants (87.5) stated that they improved their selves in integrating technology in their teaching (TPACK). Researchers contended that all open science course wares prepared by participants could be used in learning of science topics which was interpreted as those technology skills that participants acquired were transferable into their teaching practice. As for limitations, they took attention to participant's cultural backgrounds, the subjects that they chose for the study, and researcher's inherently subjective qualitative data analysis.

Kafyulilo (2010) used not only science but also mathematics pre-service teachers to understand TPACK development thorough design activities and microteaching practices. 29 pre-service teachers attended the study. In the study, four data collection instruments were preferred. They were an adaptation of Schmidt et al. (2009) survey (it was used in a pretest-posttest format), researcher log book, interview, and observation checklist. Pre-service teachers started to conduct a short microteaching practice. Those practices were video recorded. After that, they attended TPACK training sessions and read about, discussed about, and explored about different ICT tools and TPACK. Furthermore, they evaluated their first microteaching practice and identify weaknesses after their TPACK trainings. Later, as groups, they designed lesson plans incorporating TPACK and presented them to the researcher, four instructors from curriculum and teaching department, and pre-service teachers. Finally, they reflected on their experiences via surveys. Results indicated that participants were not competent at all in technology use (TK) and its integration into pedagogy and content (TPACK) before the study. That incompetency was partly associated with the way they were taught in their university. To put it differently, participants' teachers in the university were not so competent in integrating technology in their teaching which in turn affected their technology related knowledge domains (TK, TCK, TPK, and TPACK) negatively. However, after the study, it was identified that all activities in the study had significant impact on TPACK development of pre-service teachers. In addition, it was found that microteaching, lesson design, and discussions on microteachings were much more beneficial in growth of technology integration knowledge than theoretical TPACK training sessions by means of which combination of theory and practice were announced as more important by the researchers than only theoretical training in TPACK development.

In another different study, Bahçekapılı (2011) used CEIT teacher candidates as technology mentors (henceforth, CEIT mentors) of 5 primary school teacher candidates and they prepared technology-supported lessons with CEIT mentors which they later practiced those lesson plans in their application schools. Data were collected using TPACK survey (adapted from Schmidt et al., 2009), diaries kept by primary school teacher candidates after their teaching experiences, and interviews.

The results of pretest-posttest implementation of the survey revealed that there were significant developments in TK, TCK, TPK, and TPACK of primary school teacher candidates. It was thought by the researcher that the result might be positively affected from their collaborative design process of technology supported learning applications. In addition, it was identified that teaching practice enabled them to develop a vision in integrating in technology in their actual teaching practices. According to another result, CEIT mentors successfully shared their knowledge about technology integration which they acquired from their department (so technology integration can be said one of their expertise of area) which was interpreted by the researcher as that it could be expected from CEIT teachers to take the role of technology integration mentorship in their schools. According to another finding, Bahçekapılı (2012) stated that CEIT mentors reported that they increased their awareness about their role in technology integration in actual schools and had a picture about possible situations that they might have faced with there. A fruitful result indicated that CEIT mentors increased their subject matter and pedagogical knowledge in their mentorship process. It was explained by addressing the collaborative process of mentors and primary school teacher candidates from different subject matter expertise by means of which technological, pedagogical, and content knowledge of both mentors and primary school teacher candidates were communicated to develop their selves.

To conclude, one study reported that pre-service teachers' self-perceived TPACK was transferable into their instructional practices (e.g. Ta Chien et al., 2012). In addition, only one study reported problems in the development of TPACK of pre-service teachers because of their classroom inexperience (e.g. Koh and Divaharan, 2011). The rest of LBD research in that section reported increase in TPACK competency level of participants.

2.3.3.2. Triangulation of data sources in LBD research.

TPACK literature has several research that triangulated data while investigating TPACK development in different contexts. Most LBD research with triangulated data reported increase in TPACK competency of participants. To illustrate, Koehler et al. (2004) reported from a LBD seminar in which faculty members and graduate students worked together to design online courses. The study consisted of reading, exploring technologies, designing online courses, attending discussions, and providing and receiving feedback. Data were collected thorough postings made to the discussion groups, e-mails, artifacts, observations of the researchers, reflection papers, interviews, and a short online survey. At the end of the study, they reported important changes in the faculty members and their students' comprehension of mutual effect among TPACK components.

In another research, Kurt (2012) sought to understand TPACK development of participants by LBD approach in a 12-week-long coursework that specifically focused on developing TPACK of participants. 22 English pre-service teachers all of whom were reported as having lack of training on the educational uses of technology participated in the course.

In the study, English pre-service teachers first discussed on the importance of technology integration in teaching. Second, they reflected on and shared ideas about TPACK and different pedagogical uses of ICT tools thorough readings, discussions, and presentations. Third, they prepared lesson plans and did peer-teaching. After taking feedbacks from their peers and the instructor of the course, they revised their plans and taught in their practicum schools. Throughout the study, data collection sources were determined as Schmidt et al. (2009)'s survey (in a pretest-posttest design), written reflections of English pre-service teachers, interviews, lesson plans, and classroom observations, and field notes of instructor/researcher.

The study seemed to triangulate their findings using all three types of measurement techniques, namely self-reported data, observation, and design artifacts. As for results, the researcher explained that while they treated technology as an isolated construct at the beginning of the treatment, thorough the end of the study they started to consider technology in relation to pedagogy and content. In order to look at how English pre-service teachers ' TPACK reflected in their instructional practices, their lesson plans and observational data from their lesson design and practice activities were analyzed thanks to Technology Integration Observation Instrument prepared by Harris et al. (2010). Those analyses revealed that in both design and practice phases, English pre-service teachers considered the dynamic equilibrium between and among TPACK constructs. However, their original lesson plans before peer feedback indicated that they seemed not to be able to think alternate ways of using technology in line with content considerations. It was associated with the lack of experiences in design and practice of participants which in fact, proves the importance of hands on activities in TPACK development also identified in Kafyulilo's study (2010) in which he emphasized that micro-teaching and lesson plan design activities were much more effective than theoretical TPACK training sessions in contributing to TPACK of participants.

In another study, Timur (2011) researched 30 senior pre-service science teachers' TPACK development thorough TK-based instructions, lesson plan designs and teaching experiences. Data collection methods were (1) two instruments adapted to Turkish, (2) interviews, (3) observations, and (4) artifacts. At the end of the study, technology-supported instructions were understood as effective means of contributing TPACK development of learners. Furthermore, it was identified that TK, PK, and CK was necessary for TPACK development. Another complementary results indicated that developing TPACK requires a long term commitment as it was already stated in studies of Agyei and Voogt (2012), Koh and Divaharan (2011), and Guzey and Roehrig (2009). Another finding addressed that the study was not effective on development of the knowledge of addressing students' misconceptions and difficulties in teaching with technology, which was also evident partly in Graham et al. (2012)'s study in which participants did not consider technology as a tool that remedies student misconceptions. Graham et al. (2012) explained this situation by stating that pre-service teachers did not confront with student misconceptions intensely because of their limited teaching experiences. Likewise, in Timur's study (2011), two of three participants selected for qualitative analyses had no teaching experience, whereas one of them had only six months teaching experience in a private teaching institution (in Turkish, "dershane") which might be associated with the finding.

Likewise, Canbazoğlu Bilici (2012) analyzed the change in TPACK and TPACK self-adequacy levels of science teacher candidates. Her study consisted of three parts. First, 27 pre-service science teachers attended a five week long trainings structured by TPACK constructs. Later, they had microteaching experiences by designing technology enhanced lesson plans in eight weeks period. After, 6 of pre-service science teachers were observed as they taught in primary school classrooms. Data collected via survey, tests, interviews, reflection forms, videotape records, blog comments, and lesson plans and materials. Among findings, she identified that pre-service science teachers had no difficulty in classroom management and classroom communication. However, she stated that it might be the case that teaching experiences were not held in real classroom environment. In fact, Guzey and Roehrig (2009)'s study explained elsewhere above detected several difficulties among their participants in classroom management while teaching with technology, as it was already pointed out in Canbazoğlu Bilici's study (2012) as well. Another finding was that pre-service science teachers were dependent on smart board use in their teaching experience which was attributed to deficiency in their TPK. As a result, she addressed the importance of faculty modeling for effective technology integration which in fact is concurred with one of the results presented by Koh and Divaharan (2012) stating that faculty modeling in their study increased TPK competency of their participants. Similar to the finding in Timur (2011)'s study, the TPACK training provided at the beginning of this study did not work in developing knowledge of pre-service science teachers in identification and remediation of misconceptions and difficulties of learners in a technology supported lesson. Another similar finding with the one in Timur (2012)'s study, pre-service science teachers used educational technologies with teacher-centered instructional actions instead of with student-centered approaches. In fact, in their study, Agyei and Voogt (2012) made an interpretation about their similar finding by reporting that teacher-centered roots of participants limited their design being student centered and more interactive.

Differently from studies above, Fransson and Holmberg (2012) conducted a *self-study research* with LBD approach in a course of which subject matter was the pedagogical use of ICT. 28 preschool teachers and 10 compulsory school and upper secondary school teachers with different subject combinations attended the study. Participants were required to work on course content related with pedagogical use of ICT and then choose topics and objectives to teach them with web 2.0 applications and Open Educational Resources. Participants were expected to develop their

TPACK through the process since researchers stated that participants found opportunities to learn about technological tools and their relationship with content and pedagogy which are regarded as the ways of TPACK development. The researcher noted that observations were the main data collection source. However, artifacts of participants were also analyzed. In addition, a survey at the beginning and at the end of the program was administered for complementary purposes. The study reported considerable indicators about participants' growth on TPACK and its subdomains. Being a self-study research, they also came up with some understanding about their TPACK development. They stated that the teacher who had more expertise in ICT teaching found it easier to integrate theory and practice comparing the one who was mostly academically oriented.

Unlike research above, several studies reported problems in development of TPACK of participants. To illustrate, Pamuk (2012) conducted a LBD research in one of the CEIT department in Turkey offering a course called Principles of Distance Education. 78 pre-service teachers participated in the study. In the course, pre-service teachers were required to develop educational materials specific to distance education. As for data collection procedures, the researcher used multiple data sources and tools, namely open - ended questionnaires, teaching products, and formal and informal observations which were later undertaken coding procedures for data analysis. His study reported that although pre-service teachers' self-perceptions about their PK was found to be high, they showed limited competence when their project reports were examined. Issues such as interactions, assessment strategies, collaboration, and others were not implemented satisfactorily in their projects. In addition, in spite of the fact that pre-service teachers seemed to have enough competence in TK and CK, their inadequacy in pedagogical experience limited their PCK and TPK. Unsurprisingly, students were found to be capable in transformation of representation of content using technology, that is, in TCK. Another interesting result was that pre-service teachers were found to be in favor of using technology to visualize the content. This finding is consistent with Graham et al. (2012) in which participants in that study emphasized that technology transformed content to make it more visual. However, it is also found in Pamuk (2012)'s study that visualization attempts were not successful at all because of pedagogical inexperience of pre-service teachers. To illustrate, a participant prepared a flash animation for static scenes which can be displayed with pictures only. It showed that without pedagogical considerations, transformation of content with technology seem to be ineffective for learning (Pamuk, 2012). Finally, their TPACK development seemed to be problematic. The biggest barrier about TPACK development was found to be their pedagogical inexperience. This pedagogical inexperience was explained by their lack of teaching practice. Due to the same reason, while they have a certain level of TK, PK, and CK, they have problems to generate new knowledge bases such as TPK.

Guzey and Roehrig (2009) found a supporting data for Pamuk (2012)'s study and identified that pedagogical reasoning skills was important for TPACK development. They investigated the TPACK development of 4 in-service secondary science teachers in a yearlong professional development program. Data included interviews, surveys, classroom observations, teachers' technology integration plans, and study reports. In the study, several science-related instructional technologies were presented first to in-service science teachers. After learning about technology tools, they designed lesson plans that integrated those tools and technology integration plans which would be used in their next semester to integrate those tools in their actual teaching. During the next school year, science teachers and university educators met online and face to face and discussed their experiences and difficulties about the integration of those tools in their teaching. After that, they conducted action research and reflected on their own practices with their own research questions.

One of the findings of the study addressed the management issues in in-service science teachers' classroom practices. Issues like troubleshooting or technology engagement of learners (make students use the technology offered by the teacher) caused hardship for teachers and decreased their classroom control. Another finding was that teachers' pedagogical reasoning skills influence teachers' use of knowledge bases necessary for TPACK development. To put it differently, it was thought that there might have been a relationship with their development of TPACK and their pedagogical reasoning skills which concurred with results of Pamuk (2012) who stated that the biggest barrier to TPACK development of participants were found to be their pedagogical inexperience, which in fact might have affected their pedagogical reasoning skills. As for future research, they emphasized the importance of long term studies to better understand the nature of TPACK development (their study was one-year-long) which was also stated in the studies of Agyei and Voogt (2012) and Koh and Divaharan (2011).

To conclude, most LBD research with triangulation of data reported significant increase on the development of TPACK of undergraduates, graduates and faculty members. The ones which reported problems in the development of TPACK addressed pedagogical problems such as pedagogical inexperience and insufficiency of pedagogical reasoning skills of pre-service and in-service teachers.

2.3.4. Summary of the literature review.

The literature pointed out that TPACK development is a complex process which should be examined thorough more than one measurement technique and using multiple interrelated data. In addition, researchers stated that TPACK development needed a long term commitment to take satisfactory results. It seems that one of the reason of emphasis on learning by design approach is that it allows not only long term inquiry process for participants but also different data sources to be collected such as participants' self-perceptions, observations of design and practice process, and analysis of designed artifacts. In addition, it was identified that hands on activities such as designing lesson plans or online courses was more effective than theoretical training for TPACK development. The research on LBD reported the development in TPACK of participants (See Appendix C for tabular format of the literature review).

CHAPTER 3

METHODOLOGY

The purpose of this study was to understand how students' TPACK develops. In that sense, the study investigated the following research questions:

- What pathways students followed while reaching TPACK in the Research and Practice on Technology in Teacher Education course?
- What is the interaction between students' self-perceived TPACK and their instructional practices?
- What is the impact of the LBD module on students' development of TPACK?

3.1. Overall Design of the Study

This study followed the case study methodology. Case study is "used to study an individual, an institution, or any unique unit in a setting in as intense and as detailed a manner as possible" (Salkind, 2008, p.127). According to Hitchcock and Hughes (1995), a typical case study has some specific characteristics:

- It is concerned with a rich and vivid description of events relevant to the case.
- It provides a chronological narrative of events relevant to the case.
- It blends a description of events with the analysis of them.
- It focuses on individual actors or groups of actors, and seeks to understand their perceptions of events.
- It highlights specific events that are relevant to the case.
- The researcher is integrally involved in the case.
- An attempt is made to portray the richness of the case in writing up the report (p. 317).

The study followed a case study methodology since it allowed for triangulation of data which was important to investigate the complex nature of TPACK. Case study provided rich and detailed data whereby research questions were meaningfully answered. Case study provided close examination of the case selected with detailed data. Using more than one data collection techniques and a more varied data helped to derive from different sources for the same research question/s and increased the trustworthiness of findings (Salkind, 2008). Hence, case study methodology provided a sense of “being there” and enabled the researcher to deeply represent students’ TPACK development.

3.2. Context of the Study

3.2.1. The setting.

This research took place in the 3-credit Research and Practice on Technology in Teacher Education graduate course offered in the department of Curriculum and Instruction at a public university in Turkey in Spring 2013. The course aimed to present and discuss major concepts, theories, models, approaches, and research and practice on technology integration in teacher education. Students were expected (1) to analyze contemporary issues surrounding technology in teacher education, (2) investigate approaches, models, and theories of teachers’ knowledge of effective technology integration, (3) analyze research methods conducted to examine teachers’ knowledge of technology integration, (4) develop capacity to deal with difficulties that they might encounter while integrating technology in their teaching, and (5) prepare projects about teacher education practice via technology (Baran, 2013). In addition to the review and critique of ICT tools and related research, students also used various learning technologies in a supportive manner for their learning and teaching tasks such as Moodle, Diigo, Twitter, and Wikibooks after reviewing their affordances and limitations considering the course content, objectives, and instructional strategies.

The course assignments included: (1) technology in teacher education news, (2) preparation, attendance, participation, discussion, facilitation, (3) technology demonstration, (4) technology in teacher education project (TPACK module), and (5) wikibook chapter. The details about assignments are presented in Table 3.1 below:

Table 3.1

Research and Practice on Technology in Teacher Education Course Assignments

Assignments	**Activities**
Technology in teacher education news	Students shared and discussed the news related with technology integration in teaching using Diigo platform before each class.
Preparation, attendance, participation, discussion, facilitation	Students were expected to be prepared to each class by completing assigned readings and other homework. In addition, they were encouraged to actively participate in classroom activities. Furthermore, each student was assigned on of the groups, and each group presented weekly topics and facilitated discussions.
Technology demonstration	Students conducted demonstrations on a technology that could be integrated in teaching.
Technology in teacher education project (TPACK module)	Students designed, implemented, and evaluated "technology in teacher education" module in workshops. Those workshops included activities to present content based technology integrated lesson examples to their participants and to contribute their understanding on TPACK.
Wikibook chapter	Students completed a chapter for a book about a course related topic. Later, the book was published on the website: http://www.wikibooks.org.

The course offered a wide range of topics about ICTs, pedagogical use of those ICTs in a student-centered context in which participants actively involved in readings, discussions, presentations, and assignments. LBD activities of the current study were held thorough the end of the each class time. Some of them were assigned as homework. The flow of the class topics and the current research activities are presented at Table 3.2.

Table 3.2

General Flow of Course and Research Activities

Week	**Date**	**Class Topics** *(From Syllabus)*	**LBD Activities**
1	20.02.2013	Course Introduction	*No activity*
2	27.02.2013	Rationale for use of technology in learning and teaching	*No activity*
3	06.03.2013	Rationale for integrating technology into teacher education	*Course activity:* Introduction to study *Home assignment:* 1) TPACK-deep survey, 2) TPACK Game pool completion
4	13.03.2013	Introduction to Technological Pedagogical Content Knowledge framework	*Course activity:* TPACK Game I
5	20.03.2013	TPACK within disciplines	*Course activity:* TPACK Game I (Continued)
6	27.03.2013	Measuring and developing TPACK	*Course activity:* TPACK Game I (Continued)
7	03.04.2013	Distance education and teacher education (e.g. Virtual schools)	*Course activity:* TPACK Game I (Continued)
8	10.04.2013	Online communities of practice, social networking, open education in teacher education	*Course activity:* TPACK Game II
9	17.04.2013	Simulations, virtual reality and games in teacher education (e.g. Simschool)	*Course activity:* TPACK Game II (Continued)

Table 3.2 (continued)

General Flow of Course and Research Activities

Week	Date	Class Topics (From Syllabus)	LBD Activities
10	24.04.2013	Emerging technologies in teacher education (e.g. Mobile platforms, open courseware, cloud computing, learning analytics, and game based learning, web 2.0)	*Course activity:* TPACK Game II (Continued)
11	01.05.2013	The analysis of "technology in teacher education" projects and initiatives in the contexts of Turkey, Europe, and North America.	*Home assignment:* 1) TPACK-deep survey, 2) Reflection papers
12	08.05.2013	Looking forward to the future	*No Activity*
13	15.05.2013	Workshop week	*No Activity*
14	22.05.2013	Wikibooks presentations	*No Activity*

3.2.2. The participants.

Considering Mishra and Koehler's identification of TPACK as being a situated, multifaceted, and therefore complex teacher knowledge domain (2006), participants from various backgrounds were preferable in order to have a more detailed data about the development of TPACK. Students were from different teaching experiences with different subject matter expertise. Students' demographic information is presented at Table 3.3.

Table 3.3 *Demographic Information about Participants*

Pseudonyms	**Age**	**Gender**	**Graduate level**	**Undergraduate education**	**Teaching Experience**	**Technology Courses taken**
Selim	23	Male	Master	English Education	1 year and 6 months	None
Hale	26	Female	Master	Primary School Education	Field Experience	None
Gizem	27	Female	PhD	Science Education	Field Experience	None
Mutlu	36	Male	Master	Math Education	12 years	2
Buket	28	Female	PhD	Computer Education	3 months	14
Tuğçe	27	Female	Master	Computer Education	3 years and 6 months	25
Kaan	27	Male	Master	Computer Education	6 months	30
Hakan	25	Male	PhD	Computer Education	1 year	17
Mehmet	28	Male	Master	Computer Education	Field Experience	10
Yağmur	29	Female	PhD	Computer Education	1 year 3 months	More than 15

Students' age ranged between 23 and 36 (N = 10). Among 10 students, 5 were male and 5 were female. Among them, 6 were CEIT students, and 1 a piece was Science Education, Primary School Education, Math Education, and English Education students. In addition, 4 were PhD whereas 6 were Master's students. Students' teaching experiences changed from none to 12 years. Unsurprisingly, CEIT students have taken many technology related courses before Research and Practice on Technology in Teacher Education Course. Among them; Selim, Hale and Gizem have never taken a technology related course before. Nevertheless, descriptive analysis of the first administration of the TPACK-deep survey (Kabakçı Yurdakul et al., 2012) before study begins revealed that participants generally felt secure about their competence in technology integration in teaching (M = 4.18, SD = .89, see Table 3.8 for the assessment criteria).

3.2.3. The role of the researcher.

I am a Master's student in Curriculum and Instruction department at Middle East Technical University (METU). I received my undergraduate degree from the CEIT department at the same university. Currently, I am working as an instructional designer at Education Information Network, a unit under Innovation and Education Technologies Directorate General in which online educational content has been designed for FATIH Project initiated by the Turkish Ministry of National Education. Throughout the study, I took the designer and observer role. I guided the process by designing the TPACK game, introducing the TPACK Game and the rules to the students, and answering their questions while they were playing the game. During the TPACK game activities, I prevented myself from asking leading questions or stating leading thoughts while students attended to the LBD activities. Sometimes, I asked clarifying questions where I felt that I did not understand completely what was going on in the activity. Furthermore, when I found something unclear while examining data out of the class, I also talked to participants to get a deeper and clearer data at the next class time. During the TPACK Game activities, I was involved in the activities as an observer and took notes and audio records.

3.2.4. The role of the instructor.

The course instructor attended to the TPACK Game sessions as an observer. She was also involved in the design of the TPACK game and the organization of the integration of the game to the course flow. After each game session, we conducted debriefs discussing the observations, emerging themes, and necessary revisions to the TPACK game activities.

3.2.5. The TPACK game.

The TPACK Game was developed at the National Technology Leadership Summit’s annual gathering in 2007 (Richardson, 2010). The main rule in the game was to discuss on possible lesson designs using items derived from TPACK Game pools prepared before the game by considering affordances and limitations of those items. After small modifications, TPACK game was integrated to the LBD activities in this study.

In TPACK game, students were divided into four groups. There were 6 Computer Education students, and 1 Math Education, 1 Science Education, 1 English Education, and 1 Primary School Education students. Since the aim was to generate design groups that focused on different content areas, students from the Science Education, Math Education, Computer Education and English Education disciplinary backgrounds were placed into each group as content experts. Final design groups were: Science Education Group (SEG), Math Education Group (MEG), English Language Education Group (EEG), and Computer Education Group (CEG). The distribution of members to groups is reflected at Table 3.4 below:

Table 3.4

The Distribution of the Group Members to the Design Teams

Group Names	**Group Members and Their Disciplinary Background**
Science Education Group (SEG)	Gizem (Science Education) and Yağmur (Computer Education)
Math Education Group (MEG)	Mutlu (Math Education), Hakan (Computer Education), and Mehmet (Computer Education)
English Language Education Group (EEG)	Selim (English Language Education), Hale (Primary School Education), and Kaan (Computer Education)

Table 3.4 (continued)

The Distribution of the Group Members to the Design Teams

Group Names	**Group Members and Their Disciplinary Background**
Computer Education Group (CEG)	Buket (Computer Education) and Tuğçe (Computer Education)

Since the number of Computer Education students was high, they were distributed to MEG, SEG, and EEG. Since Hale-P graduated from Primary School Education, which does not have a specific content area, she was not included in a new group but was included in EEG. Hence, groups consisted of students who were content experts and students who were not content experts. In that way, possible differences in the development of TPACK between content experts and others could have been examined. Only CEG consisted of merely content experts. Both CEG members were from Computer Education. The reason of generating CEG with only content experts was to examine the development of Computer Education students' TPACK since their content area was also technology.

TPACK game was played with the help of a wiki page on http://tpackinaction.wikispaces.com/. A screenshot of the wikipage is presented in Figure 3.1 below:

Figure 3.1. A screenshot from the wiki page

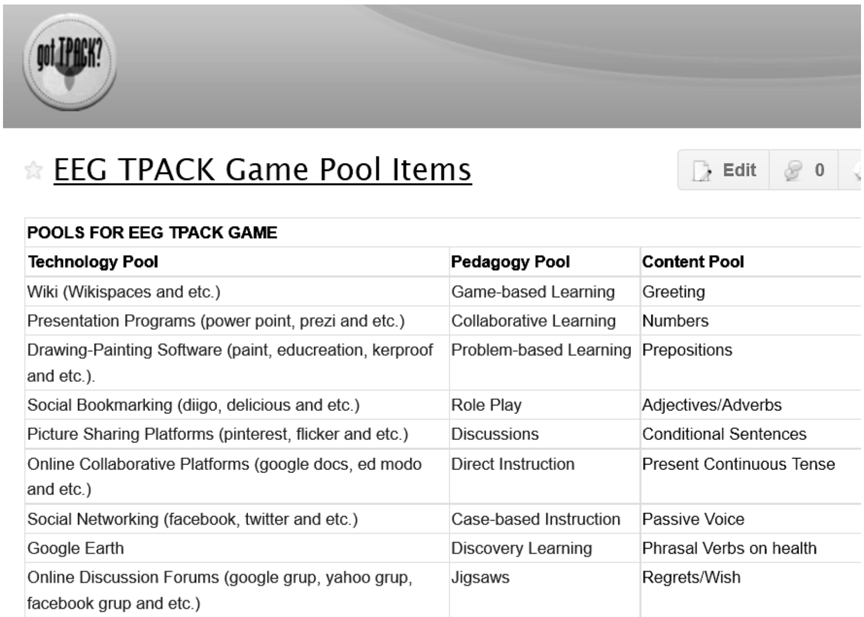
In that wiki page, each group had three pages: TPACK Game pool items page, TPACK Game I questions page, and TPACK Game II questions page.

3.2.5.1. TPACK game pool items page.

Each group had a page that included the list of several technologies, pedagogies and topics presented in pools. In each TPACK Game Pool page, a table was presented with three columns. The columns were named as the “Technology Pool”, “Pedagogy Pool”, and “Content Pool”, respectively. An array of predefined digital technologies and pedagogies were listed in these pools. Those lists were the same for each group. Then, groups were asked to visit their pages and finalize the pools by adding or removing items from predefined lists. Finally, each group had their own modified set of technology and pedagogy pool items.

The third column which was named as the Content Pool was intentionally left blank. Groups were asked to determine their own content items and fill in the Content Pool columns. At the end of that process, each group had a finalized set of technology, pedagogy, and content pool. A screenshot from EEG TPACK Game

Pool Items page illustrates the final shape of EEG's technology, pedagogy and content pool items in Figure 3.2.



EEG TPACK Game Pool Items

POOLS FOR EEG TPACK GAME		
Technology Pool	**Pedagogy Pool**	**Content Pool**
Wiki (Wikispaces and etc.)	Game-based Learning	Greeting
Presentation Programs (power point, prezi and etc.)	Collaborative Learning	Numbers
Drawing-Painting Software (paint, educreation, kerproof and etc.).	Problem-based Learning	Prepositions
Social Bookmarking (diigo, delicious and etc.)	Role Play	Adjectives/Adverbs
Picture Sharing Platforms (pinterest, flicker and etc.)	Discussions	Conditional Sentences
Online Collaborative Platforms (google docs, ed modo and etc.)	Direct Instruction	Present Continuous Tense
Social Networking (facebook, twitter and etc.)	Case-based Instruction	Passive Voice
Google Earth	Discovery Learning	Phrasal Verbs on health
Online Discussion Forums (google grup, yahoo grup, facebook grup and etc.)	Jigsaws	Regrets/Wish

Figure 3.2. An example pool items page screenshot from EEG

After all the pools items were finalized by each group, the items from the pools were written in small piece of papers which were then placed in three plastic cups for each group. Figure 3.3 shows the plastic cups prepared for the CEG.

Figure 3.3. Plastic cups prepared for CEG

Once the plastic cups were prepared for each group, they were distributed to the groups within the first session.

The TPACK game consisted of four sub games: (1) TPACK Game I – Technology Non-random, (2) TPACK Game I – Content Non-random, TPACK Game I – Pedagogy Non-random, and TPACK Game II. The main aim of the games was to design lesson plans by using technology, pedagogy and content drawn from the pools.

In the first game session, the groups started the game by playing the TPACK Game I – Technology Non-random first. This first combination included choosing a piece of paper from the content and pedagogy pools randomly, and then based on the items drawn from the pedagogy and content pool cups, non-randomly selecting a technology item from the technology pool presented on the wiki page. Students were asked to decide on technology/ies that could be used in the environment in which randomly chosen pedagogy and content were used.

TPACK Game I- Content Non-random and TPACK Game I- Pedagogy Non-random was played following the same fashion. In the TPACK Game I- Content Non-random groups randomly selected a technology and pedagogy from their plastic cups and a topic from their groups' content list on wiki. In the TPACK Game I- Pedagogy Non-random, groups randomly selected a content and technology from their plastic cups and a pedagogy from their groups' pedagogy list on wiki. Once these three TPACK game combinations were completed students played the TPACK Game II that included choosing technology, pedagogy and content randomly from the pools. After each game students completed the corresponding wiki page answering the guiding questions. The aim of playing four different TPACK games including different selection criteria was twofold. First, those different games attempted to show students how TPACK components afford and constraint each other in different circumstances contributing to their TPACK development. Second, the researcher investigated if selection criteria in those games generated some patterns in pathways in reaching TPACK.

3.2.5.2. TPACK game I questions page.

As it was stated above, each group had three pages. One of them was pages of pool items explained above. Apart from the pages for pool items, each group also had a page including questions about TPACK Game I Technology Non-random, TPACK Game I Content Non-random, and TPACK Game I Pedagogy Non-random. In those pages, there were open-ended guiding questions to be answered while designing the TPACK lesson plans. The wiki page included questions about characteristics, affordances and limitations of items selected, rationale in determining non-random items, strategies designing a TPACK integrated learning environment by combining all items determined, and articulation of lesson plans designed. Students were given questions such as: Why did you choose that technology/those technologies? Why do you think that the technology/ies you selected can be effective in a context where the randomly selected pedagogy and content is used? Considering the pedagogy and the content that you randomly selected, how would you use that technology/those technologies in an effective way in your classroom? Which technology/ies would also be effective in the same context apart from the one/s that you have already selected? Why? An example of the pages including TPACK Game I questions is presented in the Figure 3.4 below.

SEG TPACK GAME I - Technology Non-random

Please fill in the table considering the pedagogy, the content and the technology/ies that you have.

Questions	**Answers**
Randomly selected pedagogy	Problem based learning
Randomly selected content	Mirrors
Level of the content (e.g. 8th grade)	8th grade
Selected technology/ies by yourselves	Blogging,paint
Why you chose that technology/those technologies *(In one or two paragraph, please explain why you chosed that one/those ones, but not the others)*	Because the students may work for days or eve and studying process.
Why do you think that the technology/ies you selected can be effective in a context where the randomly selected pedagogy and content is used? *(In one or two paragraph, please explain your drives and assumptions about the effectiveness of technology/ies that you selected in a framework including the randomly selected pedagogy and the content.)*	Problem based learning is a time consuming st particular problem for a long time. Therefore, b of their own work and follow others' work. While studying mirrors students are needed to useful tool to draw basic shapes like rectangula

Figure 3.4. An example screenshot from pages of TPACK Game I questions of SEG

Questions for the three TPACK game combinations were placed at separate tables.

3.2.5.3. TPACK game II questions page.

The last game combination was the TPACK game II. After each group randomly chose pedagogy, technology, and content from plastic cups, they answered questions in TPACK Game II pages. An example of the pages including TPACK Game II questions was presented in Figure 3.5 below.

CEG TPACK GAME II

Please fill in the table below considering the pedagogy, the content and the technology that you have, USED AT THE SAME TIME IN THE SAME CONTEXT.

Questions	**Answers**
Randomly selected pedagogy	Project Based Learning
Randomly selected content	Computer Networks
Level of the content (e.g. 8th grade)	4th grade
Randomly selected technology	Blogs
Why the three components that you have randomly selected can not be used together in a classroom? *(Please explain IN DETAIL, how affordances and limitations of all three components that you have selected would interact in a way leading to an ineffective instruction?)*	Project-based learning is appl require more time and hands- computer networks is briefly e project-based learning activity
How would you remedy those issues that you have identified while examining the interaction among the pedagogy, the content, and the technology that you have randomly selected? *(Please explain which component/s (among technology, pedagogy, and the content randomly selected) do you think make you be unable to use all three components in a coherent and effective way in your instruction? Which component/components would you change with another? Why? Please state the new component that you use to be replaced with the old one. To illustrate, "I would replace direct instruction with anchored instruction since..", or "I would use Prezi instead of Edmodo since..")*	We can use collaborative Lea instead of project based learn Educational Software(kidsprat the computer networks. By the teacher together can create tl the class teacher can introduc students into groups. Student this point our technology is co end, teacher can conclude inf networks and the network of tl

Figure 3.5. An example screenshot from pages of TPACK game II questions of CEG

To conclude, each group has played four different games: (1) TPACK Game I-Content Non-random, (2) TPACK Game I-Pedagogy Non-random, (3) TPACK Game I-Technology Non-random and (4) TPACK Game II. The sequence of games and the selection criteria were depicted at Table 3.5 below.

Table 3.5

The Selection Rules in TPACK Game

Sub Games	**Technology Selection Rule**	**Pedagogy Selection Rule**	**Content Selection Rule**
TPACK Game I – Technology Non-random	Non-randomly	Randomly	Randomly
TPACK Game I – Content Non-random	Randomly	Randomly	Non-randomly

Table 3.5 (continued)

The Selection Rules in TPACK Game

Sub Games	**Technology Selection Rule**	**Pedagogy Selection Rule**	**Content Selection Rule**
TPACK Game I - Pedagogy Non-random	Randomly	Non-randomly	Randomly
TPACK Game II	Randomly	Randomly	Randomly

Four combinations were played in 7 weeks during the last hour of each lesson in the course. In the first 4 weeks, students played TPACK Game I combinations. In the last 3 weeks, they played TPACK Game II.

3.3. Data Sources and Data Collection Procedures

Data sources for understanding the TPACK development were: (1) students' wiki entries, (2) transcribed discussions during the TPACK Game sessions, (3) students' self-perceptions about their TPACK collected with the TPACK-deep survey (Kabakçı Yurdakul et al., 2012), (4) students' self-perceptions about their TPACK collected with reflection papers, and (5) researcher and the instructor observations during the game sessions. Data sources and analysis strategies are presented below at Table 3.6.

Table 3.6

The Relation between Data Sources and Data Analysis

Data Sources	**Data Analysis**
Wiki entries	Game by game and whole data analysis
Transcribed discussions	Game by game and whole data analysis
TPACK-deep survey (Kabakçı Yurdakul et al., 2012)	Descriptive analysis
Reflection papers	Descriptive analysis
Observations of the researcher and the course instructor	Used for triangulation purposes

3.3.1. TPACK-deep survey.

TPACK-deep survey was implemented before and after the study to descriptively analyze students' self-perceptions about their technology integration competencies (See Appendix D for the survey).

The instrument was developed to measure specifically the TPACK construct. It consisted of 4 factors, namely "design", "exertion", "ethics", and "proficiency". The distribution of questions related with factors was presented at Table 3.7 below:

Table 3.7

Distribution of Questions According to Factors

Factors	Questions
Design	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Exertion	11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22
Ethics	23, 24, 25, 26, 27, 28
Proficiency	29, 30, 31, 32, 33

Note. From "The Development, Validity, and Reliability of TPACK-deep: A Technological Pedagogical Content Knowledge Scale," by Kabakçı Yurdakul et al., 2012, *Computers and Education, 58,* p. 964-977, Copyright 2012 by Elsevier Ltd. Reprinted with permission.

As it is seen at Table 3.7, the questions between 1 and 10 were related with the "design" factor; between 11-22 were related with "exertion" factor; between 23-28 were related with "ethics" factor, and between 29-33 were related with "proficiency" factor.

The survey is a 5 point agreement rating scale consisting of statements such as "Strongly Disagree", "Disagree", "Neither Agree nor Disagree", "Agree", "Strongly Agree". The reliability and validity check process was conducted with 995 pre-service teachers. The internal consistency value (Cronbach's alpha coefficient) was calculated as .95. (Kabakçı Yurdakul et al., 2012). The internal consistency of factors (design, exertion, ethics, and proficiency) ranged from .85 to .92. The scale is considered as valid and reliable for measuring the TPACK competency (Kabakçı Yurdakul et al., 2012).

The instrument consisted of positive statements. Thus, reversing procedure was not applied. Agreement statements of the scale were numbered by 1, 2, 3, 4, and 5 for analytical analysis. Accordingly, "Strongly Disagree" was coded with 1; "Disagree" was coded with 2, and so on. When those values were calculated, the minimum and maximum scores were found to be 33 and 165, respectively. Scores closer to 165 were determined as “high level of TPACK competency” whereas scores closer to 33 referred to “low level of TPACK competency”. Total scores with mean value equivalents were depicted at Table 3.8 below:

Table 3.8

Assessment Criteria of the TPACK-deep Survey

Total Scale Scores	Total Mean Scores	Assessment Criteria
$\overline{X} \leq 95$	1.00 – 2.33	Low Level
$95 < \overline{X} \leq 130$	2.34 – 3.67	Intermediate Level
$\overline{X} > 130$	3.68 – 5.00	High Level

Note. From “The Development, Validity, and Reliability of TPACK-deep: A Technological Pedagogical Content Knowledge Scale,” by Kabakçı Yurdakul et al., 2012, *Computers and Education, 58,* p. 964-977, Copyright 2012 by Elsevier Ltd. Reprinted with permission.

3.3.2. Reflection papers.

At the end of the research, students were asked to evaluate the LBD module that they engaged in. They were asked how the module impacted their TPACK development via online. They were asked such as “How do you evaluate your development of TPACK throughout the LBD module? What contributed the most to your TPACK development? What contradicted with what you have already known?”. Their answers were collected and interpreted in conjunction with survey and artifact results.

3.3.3. Wiki entries and transcribed discussions.

During TPACK game, two sets of data have been collected. One of them was groups’ wiki entries. Groups answered questions placed on the wiki while playing the game. Those answers were collected. The other set of data was groups’ discussions in the game. Their discussions in every phase of the game were audio recorded and transcribed. In total, 720 minute long audio recording were collected.

3.3.4. Observations.

At the end of each TPACK Game activity, the researcher and the course instructor gathered together and talked about the process of the study and their observations. In line with experiences of the researcher and those negotiations with the course instructor, the researcher took field notes about each session's climate and session based findings. At the end of each field note, the researcher wrote a synthesis paragraph with an endeavor of building up relationships between notes taken.

In line with data sources and collection procedures above, the study included three stages as shown in Figure 3.6.

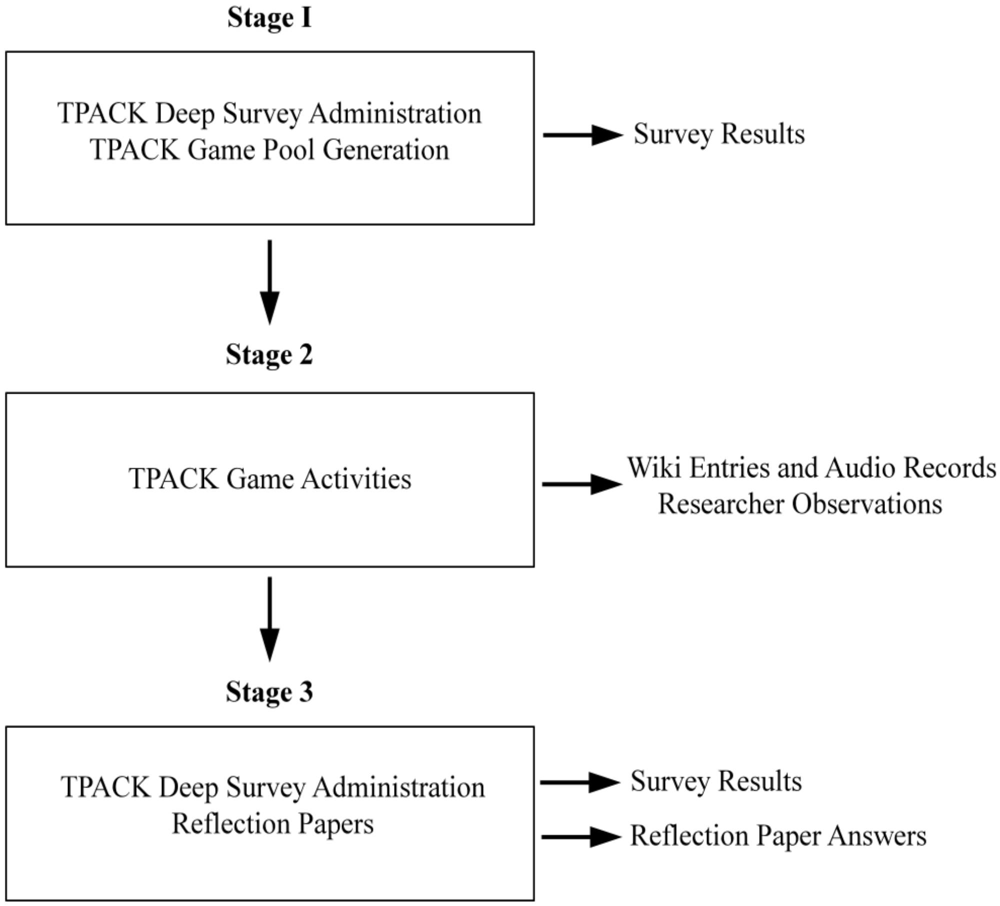


Figure 3.6. Overall design of the study

3.4. Data Analysis

Data collected through the study were analyzed both quantitatively and qualitatively. Data from the TPACK-deep survey was examined quantitatively whereas wiki answers and transcriptions were examined qualitatively.

3.4.1. The quantitative data.

TPACK-deep survey and lesson plans were descriptively analyzed by utilizing IBM SPSS Statistics 20 software. For each data set, mean and standard deviation scores were calculated.

As for TPACK-deep survey, participants' answers to five point likert scale prepared by Kabakçı Yurdakul et al. (2012) were entered into SPSS software. Later, (1) all data set, and (2) individual data set of each graduate were calculated in terms of their means and standard deviations to descriptively understand students' self-perceptions about their TPACK competence. The same steps were repeated for the second data set derived from the second implementation of the survey to examine changes in scores of students for the sake of understanding developmental patterns of TPACK in their self-perceptions.

3.4.2. The qualitative data.

As for the data analysis of qualitative data, case analysis procedures were applied. As for case analysis, the data set was analyzed first game by game. Later, the same set of data was examined as a whole.

3.4.2.1. Game by game analysis.

In game by game analysis, transcriptions and wiki entries of students were examined game by game. Each game was analyzed in its own context. To illustrate, the data set coming from TPACK Game I-Pedagogy Non-random games were examined under the folder "TPACK Game I-Pedagogy Non-random Games" whereas data set coming from TPACK Game II games was examined under the folder of "TPACK Game II Games".

One of the aims of game by game analysis was to investigate the possible pathways that groups followed to develop TPACK which referred to the first research question of the study. Since TPACK literature does not have sufficient research about the nature of those pathways, firstly an inductive approach was preferred (Berg, 2001). In other words, a predefined codebook was not used first but let "the data lead to emergence of concepts" (Yin, 2011, p.94). The investigation of data led to four emergent themes: (1) orientation, (2) focus, (3) component transformation, and (4) context which were presented in Table 3.9.

Table 3.9

Emergent Themes of Game by Game Analysis

Emergent Themes	**Explanations**
Orientation	The situation that a component dictates others and makes them being selected or being adjusted so that they fit into the characteristics and requirements of dictating component
Focus	The situation that a component was talked and discussed more than others
Component transformation	A special situation in CEG. It indicates the instances in which the content becomes also the technology, or technology becomes also the content.
Context	Instances in which students talked about contextual factors such as time, curriculum, grade level, etc.

After the emergence of orientation and component transformation themes, it was identified that students' statements revealed clues about those components. Hence, while reporting them, quotations from students were used.

Focus theme was seen to be best determined by applying coding procedure. In that process, statements in transcriptions and wiki entries of students were coded as "tech" and/or "ped" and/or "cont". The aim was to detect and code any phrase about technology, pedagogy or content in groups' each game. Later, game by game, frequencies of those codes were calculated, and focused component/s of each game was/were identified. Before the coding procedure, "phrases" were selected as the units of analysis. It means that a single statement could be coded as more than one different code. For example, one of wiki entries of CEG students were coded as both tech and ped presented below:

> The Scratch programme allows students to study with hands-on activities so project-based learning is more appropriate than other pedagogies. In this process students can study collaboratively to complete the task. While they have a task on preparing computer hardware model via using Scratch, they

need to help each other in terms of how to use stratch and how to model the computer *(TPACK Game I- Pedagogy Non-random wiki entries).*

Underlined phrases indicated that CEG students talked about not only technology but also pedagogy in that paragraph. That's why this paragraph was coded as both tech and ped. Hence, while determining focus component/s, a whole sentence or a paragraph could be coded as more than one code if it had phrases referring to more than one code.

In the coding process, any phrase related with technology, pedagogy, and content was coded as tech, ped, and cont, respectively. To illustrate, in TPACK Game I-Pedagogy Non-random of SEG students, they had randomly chosen nervous system and presentation programs as their content and technology, and they had non-randomly selected collaborative learning as their pedagogy. The phrases in their wiki entries and transcriptions were coded as tech, ped, or cont and those phrases were Presented in Table 3.10 below.

Table 3.10

Phrases Coded as Either Tech, Ped, or Cont

Phrases coded as tech	**Phrases coded as ped**	**Phrases coded as cont**
Presentation	Collearning	Nervous
Power Point	Multiple Intelligences	Body System
Technology	Discussion	It (Subject)
Present (verb)	Groups	Brain
Thing	Together	Content
	Direct Instruction	Science Education
		Specific Topic
		Cells

After the coding procedure, frequencies of those codes were calculated. Finally, based on those frequencies; focus components were determined and reported.

In game by game analysis, the same set of data was also examined deductively to investigate patterns among students' discussions which could provide valuable insights for the second and third research questions of the study. In deductive approach, "researchers use some categorical scheme suggested by a theoretical perspective, and the documents provide a means for assessing the hypothesis" (Berg, 2011, p. 246). In line with deductive approach, a codebook, which was based on TPACK literature, was prepared before coding the data set. All codes used in game by game analysis were presented at Table 3.11 below.

Table 3.11

Codes Used in Game by Game Analysis

Codes Used in Game by Game Analysis	**Short Descriptions of Codes**
TK-(Name)	Technology knowledge of a student
TKD-(Name)	Technology knowledge deficiency of a student
PK-(Name)	Pedagogical knowledge of a student
PKD-(Name)	Pedagogical knowledge deficiency of a student
CK-(Name)	Content knowledge of a student
CKD-(Name)	Content knowledge deficiency of a student
PCK-(Name)	Pedagogical content knowledge of a student
TCK-(Name)	Technological content knowledge of a student
TPK-(Name)	Technological pedagogical knowledge of a student
TPACK-(Name)	Technological pedagogical content knowledge of a student

The Name part in parenthesis refers the pseudonym name of the student who is the owner of the statement. In the study, students' names were pseudonym. No actual name was reported. While mentioning about a student, his/her pseudonym name and first letter of his/her area of expertise were always provided in the study. To illustrate, since Gizem is a science education graduate, she was always mentioned in the study as Gizem-S. Accordingly, while coding one of Gizem-S's statements as TPK code, her statement was coded as TPK-(Gizem-S). However, sometimes, a sentence or a statement was a group sentence or statement. In those situations, the related code was coded with its group name, such as TK-(MATHGr).

3.4.2.2. Whole data analysis.

Whole data analysis was handled to examine the second and the third research questions. In whole data analysis, all transcriptions and wiki entries of students were examined together. In that process, among the codes used in game by game analysis, codes related with TPACK constructs were also used in whole data analysis. All codes used in whole data analysis were presented at Table 3.12 below.

Table 3.12

Codes Used in Whole Data Analysis

Codes Used in Whole Data Analysis	**Short Descriptions of Codes**
TK	Technology knowledge of all students
PK	Pedagogical knowledge of all students
CK	Content knowledge of all students
PCK	Pedagogical content knowledge of all students
TCK	Technological content knowledge of all students
TPK	Technological pedagogical knowledge of all students
TPACK	Technological pedagogical content knowledge of all students

In whole data analysis process, (Name) part was omitted so that an overall frequency can be derived for each code. In that sense, the same codes with different names were summed and written without (Name) part. To illustrate, in order to derive a total frequency of TK based statements coming from all students, all TK codes with different names were summed with the formula below:

TK = TK-(Hakan-C) + TK-(Mehmet-C) + TK- (Tuğçe-C) + TK-(Buket-C) + TK-(SCIGr) + TK-(MATHGr) + TK-(Selim-E)

As it is seen from the example formula, all TK codes with different names, which was used in within case analyses, were summed and written as a single TK to show the overall frequency of the code in whole data analysis. The same strategy was followed for PK-(Name), CK-(Name), PCK-(Name), TCK-(Name), TPK-(Name), TPACK-(Name). Furthermore, an additional code named CONTEXT, which was not used in game by game analysis, was used in whole data analysis. Students' talks about the contextual factors of their designs were coded as CONTEXT (See Appendix F for detailed explanations of codes).

In conclusion, the same sets of qualitative data were analyzed both game by game and as a whole. In those processes, both inductive and deductive approaches were preferred in order to find meaningful answers to the research questions of the study. In inductive processes, no codebook was used but let the data generate its own codes. In deductive phases of the qualitative data analysis, predefined codes were used and their frequencies were calculated and interpreted.

3.5. Trustworthiness of the Study

Trustworthiness of a research was described by Savin-Baden and Major (2010) as “the process of checking with participants both the validity of data collected, and that data interpretations are agreed upon a shared truth. It is evidence of research accountability, and involves both integrity and rigour” (p. 178). Guba and Lincoln (1981) identified four major criteria to determine trustworthiness of a qualitative research. They are credibility, transferability, dependability, and confirmability. The trustworthiness of current research was discussed in terms of those criteria in subsequent paragraphs.

Lodico, Spaulding, and Voegtle (2010) describe credibility as the question of “has the researcher accurately represented what the participants think, feel, and do and the processes that influence their thoughts, feelings, and actions?” (p.169). Guba and Lincoln (1981) explained that in order for a study to be credible, its analyses, interpretations, and formulations should be believable. In order to increase the credibility of a research, they offered prolonged engagement at a site, persistent observation, peers debriefing, triangulation, referential adequacy materials, and member checks. In the study, the researcher was engaged in the process by being in the classroom with students throughout the study. It was the researcher who managed all TPACK game sessions, audio recorded students, and closely observed discussions during games. Besides, peer debriefing was implemented. Each week, the researcher and the course instructor came together and discussed about each weeks’ current progression. In those meetings, the researcher also asked the course instructor for discussing analyses and emergent findings. Those processes helped the researcher to realize if he overemphasized a point, or missed an important dimension that may change the direction of the study, or in general, if he carefully read data and wrote the final report (Ritzer, 2007). In addition to peer debriefing, the collected data were triangulated by different quantitative and qualitative measures, namely survey, observations, and artifacts. As for referential adequacy material, Guba and Lincoln

(1981) explained it as storing data derived from research site free from analysis in a raw form in order to enable the researcher or others to utilize them again. In the current research, all raw materials are backed up for later use.

Guba and Lincoln (1981)'s second criteria was the transferability referring to generalizability of data across context. Since the study is a case study, findings were unique to the case. However, the aim of the research was not reaching general results but deepening and extending TPACK literature with in-depth analysis of the case with thick description. In that sense, the study provided valuable insight for people who are interested in research about TPACK development. Accordingly, findings can be transferred into another context and interpreted in line with that context.

Guba and Lincoln (1981)'s third criteria was dependability. Dependability was described as referring to whether the study can be conducted again "under the same circumstances in another place and time" (Guba & Lincoln, 1981, p.377). The current research had clear steps to be followed. Besides, all materials used in the study are easy to prepare. Pools and wiki questions were also placed as Appendix at the end of the study. In that sense, the study can be applied in different contexts. However, case differences inherently might lead to different results.

Finally, Guba and Lincoln (1981) emphasized the importance of confirmability referring that whether findings were reported objectively without any bias. In the current research, the data was triangulated with self-reports, observations, and learning artifacts. Besides, peer debriefing sessions were implemented with the course instructor. In those meetings, the researcher and the course instructor, (1) discussed on the code generation process and validity and accuracy of codes, (2) discussed on the implementation process of the research and weekly observations, (3) discussed on the findings. Still, in qualitative research, the effect of the implementers could not be ignored. In that sense, both the researcher's and the course instructor's background and information and possible influence on students were presented in Chapter 3 at the methodology section.

3.6. Limitations of the Study

Answers to research questions in this study were expected to provide valuable insights for TPACK literature. Nonetheless, several limitations of the study could be discussed.

In the first two weeks when groups were playing TPACK Game I-Technology Non-random, audio recording tools could not be provided to groups. Hence, their discussions could not be recorded. That's why focus codes of TPACK Game I-Technology Non-random of groups could not be identified. However, it was revealed that, throughout the end of the study, findings started to generate some patterns. To put it differently, similar patterns in data were started to be identified. It indicated that data collected was sufficient for reaching saturation in findings. Results of the focus theme were also found as a saturated data. As a result, those findings were reported.

Researcher involvement in the study and his influence on interpreting results were unavoidable because of the nature of qualitative research. However, the researcher's influence on the study was reflected at the methodology section in the current research with an aim of enabling readers to interpret findings by also paying regard to the researcher involvement. With the same considerations, the role of the course instructor was also presented at the same section.

Since 10 students were attended to the study, findings might not be representable for a specific population. Nonetheless, the current research was a case study research and that case included 10 students. Besides, the aim of the study was not to come up with generalizable findings but in depth analysis of the case for deepening and extending literature on TPACK development. The main drive of that aim was the identification of TPACK as complex, multifaceted and situated construct (Mishra & Koehler, 2006) which requires in-depth analyses.

Students were engaged in TPACK game activities in a technology area course. While they were playing TPACK game each week, they were also attending to technology-related lessons. Their gaining from those lessons might also have affected the findings of the research.

3.7. Ethical Considerations

This research followed the ethical procedures required by the Human Subjects Ethic Committee at METU. The information collected from the participants remained confidential. Participants' names were not revealed in the study. Participants had right not to participate in the study, or withdraw from the study anytime they wanted. The aim and procedures of the study were clearly described to participants and any questions were answered by the researcher to avoid misconceptions. The results were announced to participants.

CHAPTER 4

FINDINGS

This section presents the results under the research questions investigated in this research.

4.1. What Pathways Students Followed while Reaching TPACK in the Research and Practice on Technology in Teacher Education Course?

The first research question investigated possible pathways that students followed in their TPACK Game design processes. Four themes emerged that illustrated the paths students took to reach their TPACK: (1) orientation, (2) focus, (3) context, and (4) component transformation.

4.1.1. Orientation.

Orientation theme emerged when it was realized that in the design process of students, among TPACK components randomly chosen, a component was dictating others and made them being selected or being adjusted so that they fit into the characteristics and requirements of dictating component. To illustrate, in one of the conversations among CEG students Buket-C and Tuğçe-C and the course instructor during the TPACK Game I –Content Non-random, they said that:

Tuğçe-C: It seems that pedagogy predominates in our situation.

The course instructor: Do you think that each has different dominations?

Buket-C: In my opinion, yes they have. Sometimes, one of them may be dominant; it may direct you *(TPACK Game I- Content Non-random transcriptions).*

In the conversation, CEG students explained that in their designs, one of the TPACK components may direct their design. It was identified that, in all designs, one of the component that was chosen randomly directed the component selections and utilizations of students. In other words, students put one of the random components (i.e. technology) at the center of their design, and selected and/or used other components (i.e. pedagogy and content) according to the demands of that component (i.e. technology). The important part at those processes was that always one of the randomly chosen components oriented the designs, not non-randomly selected ones. The orienting component was identified to have two different impacts on designs such as “impact on selection” and “impact on utilization”.

4.1.1.1. Impact on selection.

It was identified that when students were required to select a component non-randomly from pools, students selected a component which was regarded as suitable for the orienting component. To put it differently, students selected a component which they thought that it could be used at the same context in which the orienting component existed. In brief, it was identified that non-random components were selected based on the orienting component.

4.1.1.2. Impact on utilization.

It was identified that one of the random components oriented designs. Besides, it was identified that students did some adjustments or modifications on the random components that did not oriented the designs. The aim of those adjustments or modifications was to make them suitable to be used in the same context with the orienting component. To put it differently, where necessary, students made some changes on other items that were randomly chosen so that they could fit into the characteristics of the orienting component.

It was identified that adjustments and modifications were not peculiar to random components that did not orient designs. When three components came together, students did some changes on all components regardless of their orienting status since all components afforded and constrained each other when they were used in the same context. However, it was found that the orienting component had always the least change in its usage but dictated others’ utilization at the same context. To conclude, the components, which did not have so many changes but dictated others so that students built their designs by considering those dictations, leaded to a new emergent theme named orientation.

Based on orientation components, students designed technology oriented, pedagogy oriented, and content oriented designs. To illustrate, in TPACK Game I – Pedagogy Non-random, SEG students randomly chose presentation programs and nervous system as their technology and content. Later, they non-randomly selected collaborative learning as their pedagogy. In that game, SEG students' wiki entries and discussions showed that they created a technology oriented design. For instance, they answered the question "why did you choose that pedagogy/those pedagogies?" as *"because students will prepare a presentation in a class time and it would be difficult to prepare it individually. By working in groups they will be quicker and more successful"* (SEG TPACK Game I – Pedagogy Non-random wiki entries). In addition, while discussing about possible pedagogies that can be selected Gizem-S stated that:

> ...but all of them cannot express their selves in presentation, I thought if we prepare groups suitable for multiple intelligences and ask each of them to do [presentation] according to those, but each of them cannot express [him/herself] with presentation, how will you express bodily kinesthetic in presentation? *(SEG TPACK Game I – Pedagogy Non-random transcriptions).*

Wiki entries and discussions indicated that the presentation programs made SEG students select collaborative learning considering limited time scope of the course. In other words, the technology affected pedagogy selection of students. In addition, they assigned different subtopics of nervous system to each group and asked them to prepare a presentation. To put it differently, it seems that content was arranged in line with planned interaction between technology and pedagogy (preparing presentations as groups). It seemed to naturally fit into pedagogy and technology. However, since the technology affects pedagogical preferences of SEG students, it can be concluded that this design was a technology oriented design.

In another design, EEG students created a content oriented design in their TPACK Game I – Pedagogy Non-random. In that game, they randomly chose Educational Simulations and Numbers as technology and content respectively, and they non-randomly selected Role Play as pedagogy. In that design, it was identified that EEG students built their design over the content, that is, the content oriented their design. For instance, they wrote in the wiki *"this content is learned best by active participation and this activity (role play) gives enough chance to practice the topic by using their real life experience and helps them connect to real life"*(EEG TPACK Game I-Pedagogy Non-random wiki entries). In another one, they wrote *"greeting takes parts in interactive situations that are why role play meets this demand. Students can have different experiences from different situations"* (EEG

TPACK Game I-Pedagogy Non-random wiki entries). It seems from their wiki entries that they selected the pedagogy according to the demands of the content. They also wrote *"blog has opportunity to create different situations for greeting to make role play. Also blog allow embedding videos, photos, illustrations, to create different atmospheres to compare register differences"* (EEG TPACK Game I-Pedagogy Non-random wiki entries). It seems that blog was decided to be used to create a rich environment so that greeting can be efficiently taught with role play. The content also affected the usage of the technology. Thus, it can be concluded that in that game, EEG students' design was a content oriented design.

To conclude, game by game analyses of wiki entries and transcriptions revealed that a component in students' designs dictated other components by influencing their selections or utilizations. The orienting component was found to be either technology, pedagogy, or content in designs.

4.1.2. Focus.

Focus theme was identified when it was seen that students talked more about a component or components than others in their designs. To illustrate, it was identified that, in a game, students talked more about pedagogy than technology and content. This situation was interpreted as students focused on pedagogy in that game.

Investigations of possible reasons that caused focusing on a component revealed that students focused on a component when (1) it caused more problems when attempting to use it with other components, and (2) students do not have enough knowledge about that component. To illustrate, in TPACK Game II, CEG students focused on the content. When frequency of focus codes were examined, it was found that 152 statements were coded as technology, pedagogy, and/or content (N = 152). Among them, 32.2% were coded as pedagogy (n = 49), 24.3% were coded as technology (n = 37), and 43.4% were coded as content (n = 60). The distribution of focus codes in CEG's TPACK Game II is presented in Figure 4.1 below.

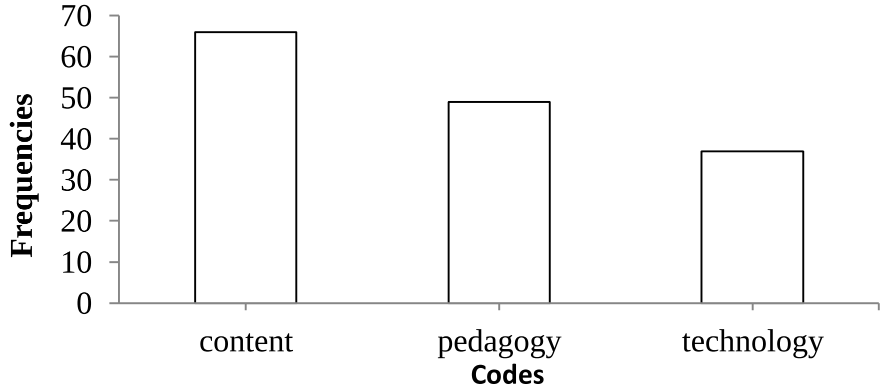


Figure 4.1. The distribution of focus codes in CEG's TPACK game II

Frequencies of focus codes suggested that their discussions were about the content most of the time. They talked about objectives of the content, time needed to cover those objectives, and possible pedagogies which can be used to teach the topic. It was revealed that CEG students talked more about the content since it caused more problems than others when all three components were used together. Specifically, they talked more about content which did not fit randomly selected technology and pedagogy. Thus, they discussed more on the content in order to decide on modifications that would help making the content fit into the context in which randomly chosen technology and pedagogy were used. In conclusion, it was identified that CEG students focused on the component causing more problems than others in the same environment.

In another example, SEG students focused on technology and pedagogy at the same time in TPACK Game I- Content Non-random. Students' statements were coded 76 times as pedagogy, technology, and/or content (N = 76). Among them, 36.8% were coded as pedagogy (n = 28), 27.6% were coded as content (n = 21), 35.5% were coded as technology (n = 27). The distribution of focus codes is presented in Figure 4.2 below:

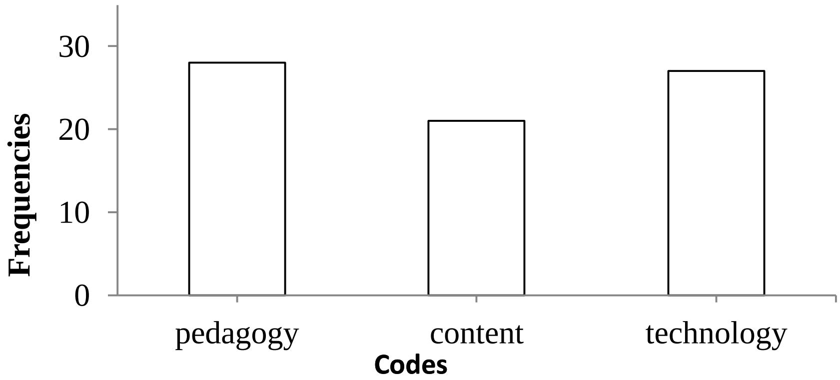


Figure 4.2. The distribution of focus codes in SEG's TPACK game I-content non-random

Frequencies of focus codes revealed that SEG students talked more about pedagogy and technology than content. It means that they focused on pedagogy and technology while creating their design. In their talks, as the content expert, firstly Gizem-S talked about what the learning cycle was since Yağmur-C was not knowledgeable about this science specific pedagogy. That situation indicated that knowledge deficiency in a component caused focus on that component. Later, they talked about the mismatch between technology and pedagogy since learning cycle was needed to be conducted in classroom whereas Facebook was an online platform. This mismatch made students focus more on pedagogy and technology. In other words, since the interaction between pedagogy and technology caused problems, students spent more time to find an optimal solution for using them together effectively with the content that they selected.

In conclusion, it was identified in game by game analysis that students focused on one or more components either when they caused more problems or when students did not have sufficient knowledge about them.

4.1.3. Naming designs of students in terms of orientation and focus.

When TPACK Game designs of students were named in terms of their orientation and focus, a variety was identified. All designs with their orientation and focus were presented at Table 4.1 below.

Table 4.1

TPACK Game Designs in terms of Orientation and Focus

Designs	**Games**	**Groups**
Pedagogy Oriented-Equally Focused Design	TPACK Game I-Content Non-random	SEG
Pedagogy Oriented-Pedagogy and Content Focused Design	TPACK Game I-Content Non-random	CEG
Technology Oriented-Technology Focused Design	TPACK Game I-Pedagogy Non-random	CEG
Technology Oriented-Technology Focused Design	TPACK Game I-Content Non-random	MEG
Technology Oriented-Technology Focused Design	TPACK Game I-Pedagogy Non-random	MEG
Technology Oriented-Technology Focused Design	TPACK Game II	EEG
Technology Oriented-Pedagogy and Content Focused Design	TPACK Game I-Content Non-random	EEG
Technology Oriented-Pedagogy Focused Design	TPACK Game II	MEG
Technology Oriented-Equally Focused Design	TPACK Game I-Pedagogy Non-random	SEG
Content Oriented-Equally Focused Design	TPACK Game I-Pedagogy Non-random	EEG
Content Oriented-Content Focused Design	TPACK Game II	CEG
Content Oriented-Technology and Content Focused Design	TPACK Game II	SEG

According to Table 4.1, several findings were identified. First, the type of the game did not generate a specific pathway in reaching TPACK. Regardless of the game played (e.g. TPACK Game I-Technology Non-random or TPACK Game I-Pedagogy Non-random), students created different designs with different orientations and focuses. Second, content area differences did not result in a specific pathway in reaching TPACK. Each group indicated variety in their designs in terms of orientation and focus. Third, the number of technology oriented designs was much in number. However, since students' discussions could not be recorded in TPACK Game I-Technology Non-random, designs in TPACK Game I-Technology Non-random were not placed on the table which might have influenced the number of different orientations. Besides, there were pedagogy and content oriented designs in addition to technology oriented designs. In line with those considerations, despite the high number of technology oriented designs, it was identified that there were multiple pathways of reaching TPACK.

Another finding revealed that a considerable number of designs were technology oriented-technology focused design. In those designs, the technology dictated other components. In addition, it was talked more than others since either it caused more problems than others or students did not have sufficient knowledge about that technology. However, when those designs were closely examined, no patterns were identified. One of the reasons was that orientation emerged from the interaction between and among components. To put it differently, a technology oriented design might become a pedagogy oriented design when one or more components have changed. Thus, it can be concluded that technology orientation in those designs emerged from the dynamic relationship of components. Coincidentally, technologies in those designs caused more problems or students did not know enough about them. This situation made those technologies focused by students. In conclusion, no specific pattern was identified in technology oriented-technology focused designs proving that there were multiple pathways in reaching TPACK.

4.1.4. Context.

Qualitative data analysis revealed that students took into account several contextual factors in their designs which had influence on selection or utilization of components. To illustrate, Gizem-S stated in one of their design process the following:

> But it is not something that they can do in the classroom or, you remind the course in a place like computer laboratory, I mean you instruct lesson there, each student has a computer,…you ask them for preparing presentation there. In that sense, you ensure that they search for the content. Meanwhile you do observation… *(TPACK Game-I Pedagogy Non-random transcriptions).*

In another discussion Tuğçe-C stated that *"Maybe we can use extra topics, about computer networks, I mean maybe slightly higher level and by taking grade level as 7, I mean taking grade level high and we can extend the content that we cover"* (TPACK Game II Transcriptions).

Analyses of qualitative data showed that contextual factors affected students' design process. When components changed as game changed (e.g. from TPACK Game I Technology-Non-random to TPACK Game I-Pedagogy Non-random), selected or chosen components inherently changed. When those components changed, contextual factors also changed since each technology-pedagogy-content combination created its own unique context. To illustrate, topic supposed to be taught changed, grade level changed and interactions between and among TPACK components also changed. Those changes indicated the effect of contextual factors in designs. In summary, it was found that existence of different designs in the study was affected by the contextual factors.

4.1.5. Component transformation.

Component transformation theme was special to CEG. In CEG, it was identified that sometimes content and technology were transformed into each other. In other words, sometimes content became technology, and sometimes technology became content. Since CEG students tried to teach several technologies, they filled their content pools with technology items such as keyboard, word processors, and computer networks. In that sense, their component combinations consisted of pedagogy, a technology, and a technology that was supposed to be taught (content). This special situation led to content to be used as technology or technology to be used as content.

4.1.5.1. Content to technology.

CEG used content as technology in their two designs such as TPACK Game I-Technology Non-random and TPACK Game II.

In TPACK Game I-Technology Non-random, they chose role play as their pedagogy, and Using Keyboard and Word Processors as their content. In addition, they non-randomly selected google docs and word processors as technologies. In one of their conversations, Buket-C said that *"...technology was word processor, the content was also using word processors, I even had read an article but I could not find it, it was said that both of them coincides in technology education"* (CEG TPACK Game I – Technology Non-random transcriptions). Students used word processors to teach the subject "using keyboard and word processors". Inherently, they needed to use keyboards to use word processors. Hence, the content in that design was also used as the technology.

In TPACK Game II, they chose project based learning, blog, and computer networks as pedagogy, technology, and content, respectively. Later they added an additional technology, that is, Kidspiration. They decided to use the content as the technology just like they did in TPACK Game I-Technology Non-random. To put it differently, the content again became also the technology. A conversation between group students indicates the situation:

> Buket-C: ... [the teacher] will group children, then s/he will ask them for writing to each other for example, ... or s/he will ask [a student] for sending a thing to his/her group member via the network for example, ok s/he will do this by means of the computer...a special technology is not used here, that is, computers are used.
>
> Tuğçe-C: In other words, the content and the technology becomes the same thing there, not only network technologies but also the the topic is the network.
>
> Buket-C: ...at the end of the course, they can do things by using Kidspiration, that is, which computer communicated with which computer in the activity that s/he completed, how those computers are linked each other...a mind map will be prepared to tell it *(CEG's TPACK Game II wiki entries).*

Considering thoughts of CEG students about technology selection, it seems that they planned to teach computer networks by using computers and computer networks. The chosen technology, the blog was ignored and not used. Instead, they set up a network connection and taught the lesson on that connection. Thus, it can be concluded that, since the topic was about a technology, they did not need to use the technology chosen from the game. However, it did not mean that when the topic was about a technology, it would be always enough to use that technology while teaching it. The reason was that students in that design also chose a different kind of technology called Kidspiration to generate a network map of the classroom to concretize the topic. It means that, according to students, the technology itself seemed not to be enough to teach itself. Thus, even if the technology may become the content; the interaction among characteristics, affordances and limitations of current components (blogs, computer networks) may necessitate additional components. In that case, it was the Kidspiration software.

In brief, CEG designs were identified having a special situation in which students used the content also as the technology to teach them. In that process, they did not rely on those transformed technologies but also selected additional separate technologies meaning that transforming content into technology might not always be enough for effective teaching with technology.

4.1.5.2. Technology to content.

In TPACK Game I - Pedagogy Non-random, CEG students used the technology as the content. In that game, they randomly chose scratch as the content, and computer and peripheral devices as the technology. They non-randomly selected project based learning as the pedagogy.

In the game, technology became also the content. To put it differently, the Scratch became one of the content of their design. To illustrate, in one of the conversations among the researcher and Tuğçe-C, she said that:

> For instance, Scratch and computer and peripheral devices came from the pool, now he/she learns Scratch and programming there, s/he also learns computer and peripheral devices, the students, two different contents have emerged for example, but of course the Scratch will be at background… *(CEG TPACK Game I – Pedagogy Non-random transcriptions)*

In another conversation, Buket-C stated that:

> We are asking them for using Scratch for preparing their own models but firstly we will teach Scratch since do students know about Scratch? At first related with it, at project based learning, we need to introduce Scratch to them in one session *(CEG TPACK Game I – Pedagogy Non-random transcriptions).*

Hence, it seems that students in CEG struggled with the issue that students might not have enough knowledge about the technology chosen non-randomly from the pool. According to students, their lack of technology knowledge about Scratch would hinder the effectiveness of its usage to teach the topic computer and peripheral devices. Thus, technology in the design was mentioned at the beginning of the course. Students planned to teach with essential characteristics of the software which would be enough to use it to learn the topic. In that sense, the technology also became the content in the process which brought extra burden to students, as Buket-C stated that:

> In addition, you teach technology with technology and it causes problems sometimes...Scratch becomes a limitation there, would it be too many load for the child if he/she does not know programming and if we teach the other with it, such problems may emerge because of the technology area *(CEG TPACK Game I – Pedagogy Non-random transcriptions).*

In short, CEG students had to plan to teach how to use the technology before teaching the actual topic chosen from the pool, that is, the technology became also content which was regarded by CEG students as an extra load sometimes for both teachers and students.

CEG students had a special situation in their design considering other groups. In their designs, content and technology was sometimes transformed to each other. That situation is called as component transformation. Sometimes they used content as technology, and sometimes they used technology as content. It was identified that CEG students benefited from using content as technology. However, they thought that when technology transformed to content, it brought extra load on teachers and students since there became two content at the same context.

4.2. What is the Interaction between Students' Self Perceived TPACK and Their Instructional Practices

The second research question investigated if students self-perceived TPACK was reflected in their instructional practices. Their initial survey results and learning artifacts were examined together to answer the research question. The aim was to see if there was consistency between their self-reported TPACK competencies and the frequencies of their TPACK based statements in wiki entries and transcriptions. It was identified that when data was analyzed as a whole, students reflected their self-perceived TPACK in their instructional practices. When data was analyzed student by student, it was identified that there were students who could not reflect their self-perceived TPACK in their instructional practices.

4.2.1. Reflection of TPACK on instructional practices with whole data analysis.

Whole data analysis revealed that students' self-perceived TPACK was reflected in their instructional practices. Before the study, students filled out the TPACK-deep survey. The result revealed that students indicated high level of TPACK competency before the study (M = 4.18, SD = .89) according to Kabakçı and Yurdakul (2012)'s scale criteria (See Table 3.8). In addition, their wiki entries and transcriptions were coded according to TPACK constructs. The results presented at Figure 4.3 below.

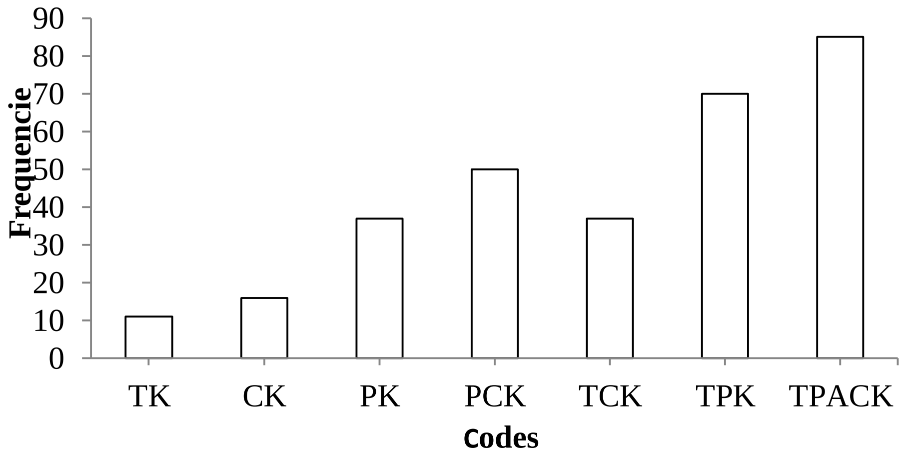


Figure 4.3. Distribution of TPACK constructs in statements of students

Findings presented in Figure 4.3 indicated that the frequency of students' TPACK based statements was more than other TPACK constructs. It means that students indicated a high level of TPACK in their learning artifacts. Both results derived from first implementation of the TPACK-deep survey and from learning artifacts were presented at Table 4.2 below.

Table 4.2

Interaction between Survey Results and Artifact Results based on All Students

Students	**Survey Results**	**Learning Artifact Results**
All Students	High TPACK	High TPACK

According to Table 4.2, a consistency was identified between survey results and learning artifact results of students. Both of them reported high TPACK competency of students. Hence, the result revealed that students could reflect their self-perceived TPACK in their instructional practices.

4.2.2. Reflection of TPACK on instructional practices on individual student level.

Investigations on individual student levels revealed that some students could not reflect their self-perceived TPACK in their instructional practices. Survey and artifact results were examined individually and presented at Table 4.3 below.

Table 4.3

Interaction between Survey Results and Artifact Results based on Individuals

Students	**Survey Results**	**Learning Artifact Results**
Tuğçe-C[a]	High TPACK	High TPACK
Buket-C[a]	High TPACK	High TPACK
Selim-E[a]	High TPACK	High TPACK
Mutlu-M[a]	High TPACK	High TPACK
Gizem-S[a]	High TPACK	High TPACK

Table 4.3 (continued)

Interaction between Survey Results and Artifact Results based on Individuals

Students	Survey Results	Learning Artifact Results
Kaan-C	High TPACK	Low TPACK
Hale-P	Intermediate TPACK	Low TPACK
Hakan-C	High TPACK	Low TPACK
Mehmet-C	Intermediate TPACK	Low TPACK
Yağmur-C	High TPACK	High TPACK

[a]Students who were the content experts in their groups

When quantitative and qualitative data were analyzed based on individuals, it was found that while content experts' both survey results and artifact results indicated high TPACK, those of others indicated inconsistency except for Yağmur-C. Besides, except for Yağmur-C, they indicated low TPACK in their learning artifact designs. When examined closely, it was identified that Gizem-S, who was the content expert, always gave small information about the content or the content-based pedagogy. Those actions might have affected Yağmur-C's TPACK positively in the design processes. However, generally, it was identified that mostly content experts were able to transfer their self-perceived TPACK into their instructional practices since their both survey results and artifact results indicated similar level of TPACK competency.

In artifact design process, students' low TPACK who were not content experts indicated that content knowledge deficiency affected students' developing TPACK in their learning artifact design processes. This situation was examined with follow up analysis below.

4.2.2.1. The effect of knowledge deficiencies in developing TPACK.

Data analyses based on individuals revealed that students who were not the content experts in their groups' subject domain indicated low TPACK in their design processes. When examined closely, analyses showed that they also had pedagogical knowledge deficiencies. Some statements of students were coded as either TKD (technological knowledge deficiency), PKD (pedagogical knowledge deficiency), and CKD (content knowledge deficiency). Those statements indicated that students knew little about those components. They either asked each other to get information about the component that they know little about or collaboratively searched the internet to collect information before using them in their designs. To illustrate, when a student stated that he/she did not have enough information about a pedagogy, that statement were coded as PKD.

In order to see in which knowledge domain area students might have had knowledge deficiency, CKD, PKD, and TKD of students were examined. For that aim, frequencies of CKD, PKD, and TKD were calculated. Results were presented at Figure 4.4, Figure 4.5, and Figure 4.6 below.

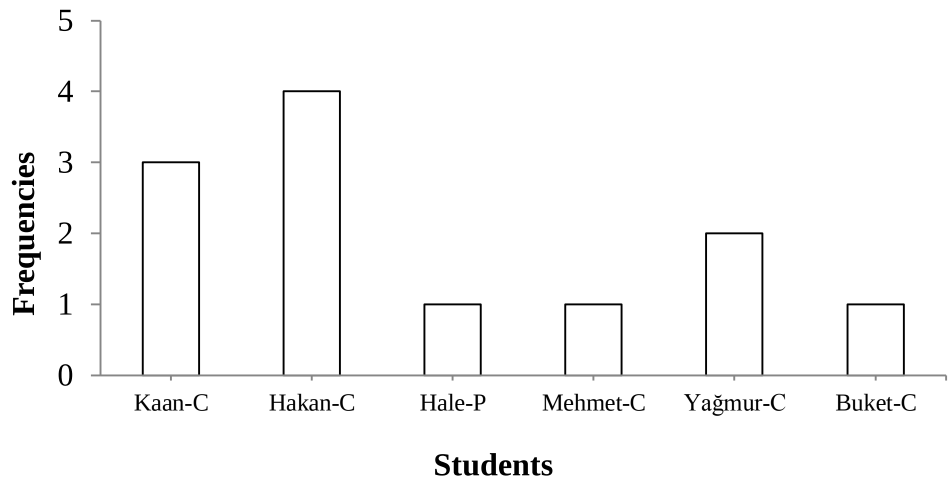


Figure 4.4. Distribution of CKD codes among students

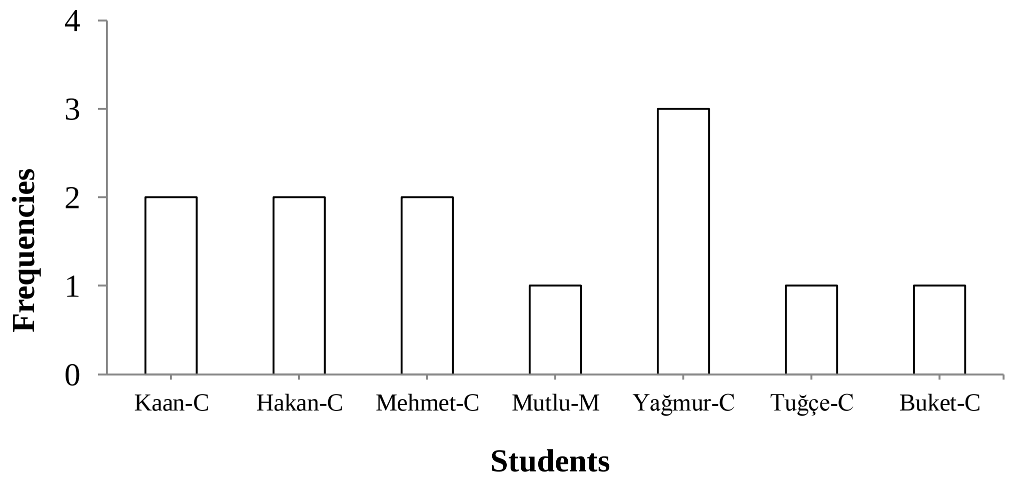


Figure 4.5. Distribution of PKD codes among students

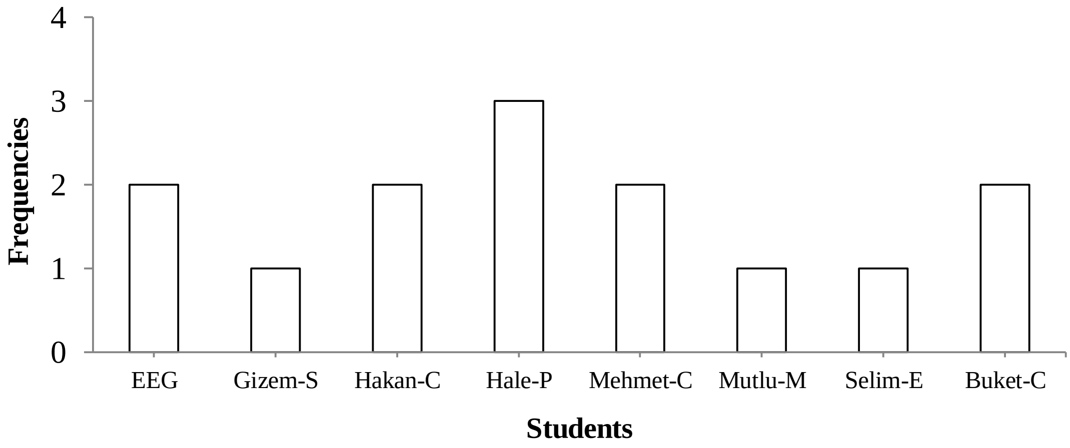


Figure 4.6. Distribution of TKD codes among students

Among students who were not the content experts in their group content domains, all were Computer Education students except Hale-P. When Hale-P's deficiencies in knowledge domains were examined, Figure 4.4, Figure 4.5, and Figure 4.6 indicated that Hale-P did not have PKD and CKD. It had been expected before the study that Hale-P could show CKD since she was not a content expert. However, Hale-P was in EEG, the English group. Furthermore, Hale-P knew English since she was a research assistant in the university, which gave courses in English, in which this study was conducted. Those situations might have led to no CKD in Hale-P's results since she was knowledgeable about English language, that is, CK. However, Hale-P mostly had TKD. Hence, it was concluded that Hale-P showed low TPACK in learning artifacts since she had TKD.

When PKD and CKD codes were examined, it was identified that mostly Computer Education students who were not the content experts used PKD and CKD based statements. CKD was natural since they were in groups that they did not have content expertise. However, it was found that PKD also affected their TPACK negatively. Hence, it was concluded that Computer Education students who were not content experts showed low TPACK in their learning artifacts since they had both CKD and PKD.

Low TPACK competency of students' who were not content experts in learning artifact designs was attributed to their knowledge deficiency in separate TPACK knowledge domain areas (CK, PK, and TK). It was found that Hale-P had TKD based statements more than other students indicated that she sometimes did not have enough information about technologies that they used in EEG designs.

Computer Education students who were not content experts did not show TKD as expected. However, they had CKD and PKD based statements in their talks meaning that they sometimes did not know enough about topic and pedagogies coming from pools. It was identified that, in learning artifact design processes, students who were not content experts indicated low TPACK competency because of those knowledge deficiencies.

4.3. What is the Impact of the LBD Module on Students' Development of TPACK?

The third research question investigated the impact of LBD module in the study on students' development of TPACK. Survey results, learning artifact results and reflections of students indicated that LBD module in the study had positive impact on students' development of TPACK.

A positive change was identified between results of TPACK deep survey implemented before and after study. The results were presented in Table 4.4 below.

Table 4.4

Survey Results Before and After Study

Implementation Stages	**Results**	**TPACK Level**
Before Study	M = 4.18, SD = .89	High TPACK
After Study	M = 4.47, SD = .71	High TPACK

Both the first and the second implementation of TPACK deep survey indicated High TPACK according to Kabakçı and Yurdakul (2012)'s scale criteria (See Table 3.8). However, when mean scores were compared, it was revealed that the mean score of the second implementation of survey was higher than that of the first implementation. It indicated that the LBD module in the study had positive impact on students' development of TPACK.

Furthermore, for triangulation purposes, wiki entries and transcriptions of all students were also examined in terms of TPACK development. For that aim, the frequencies of all statements coded as TPACK were calculated and analyzed game by game to see whether there were a positive difference in number of TPACK based statements from the beginning to the end of LBD activities (See Appendix F to see what kind of statements were coded as TPACK). The result indicated that the number of students' TPACK based statements increased through the end of the LBD module activities. Changes in frequencies of TPACK based statements of students over time were given at Table 4.5 below.

Table 4.5

Change in Frequencies of TPACK Based Statements over Time

TPACK Game Stages	**Percentage of TPACK Based Statements**
TPACK Game I-Content Non-random	%22.2 of statements were TPACK based
TPACK Game I-Pedagogy Non-random	%30 of statements were TPACK based
TPACK Game II	%36 of statements were TPACK based

Table 4.5 revealed that there was a positive change in the frequencies of TPACK based statements of students from the beginning to the end of the study. The increase in the number of TPACK based statements meant that, while designing their lessons, students considered pedagogy, technology, and content together as a whole more and more through the end of the study. This positive change showed that data derived from learning artifacts also supported the finding derived from the TPACK deep survey. To conclude, both survey results and learning artifact results indicated that LBD module in the study positively affected students' development of TPACK.

Increase in TPACK competency of students reported by survey and artifact results could have been affected by course activities in addition to LBD module activities. Throughout the research, students had technology related assignments such as readings, discussions, presentations and projects in addition to TPACK game activities offered in LBD module. Those activities could also have an impact on TPACK competency of participants. In order to have a clear picture of the impact of LBD module, students' reflection papers were also examined. Students reported that TPACK game activities were beneficial to see the complex interaction between and among TPACK components. They reported that LBD module used in the current research had positive impact on their TPACK development. To illustrate, when she was asked for the activities that she engaged in the course, Yağmur-C stated that:

> … TPACK game was the most beneficial activity for me. Especially "randomly selected" option made me to think deeper about TPACK and it was very helpful to understand TPACK *(Reflection paper answers).*

In another reflection paper, Selim-E stated that:

> TPACK game helped me to see the variables of a teaching situation. While intending to use technology in a lesson is a choice, I understood that from the moment on you decide to choose it; it is a part of your lesson, not an addition. Even though I didn't work with ELT [English Language Teaching] teachers, I learned still a great deal from my group members. TPACK game … helped us in that we were able to see possible dilemmas and challenges when creating a lesson plan with different T P & C [technology, pedagogy, and content] with first-hand experience… *(Reflection paper answers).*

Buket-C also agreed that TPACK game was beneficial for her TPACK development by saying that:

> TPACK game helps us to understand the domains in TPACK framework and their interactions. By playing the TPACK game … we almost act as a teacher and plan our lessons by taking into consideration of the nature of the content, constraints and affordances of pedagogy and technology, and also how we can put them together. By the way, we experience this preparation process and try to solve problems that we encountered *(Reflection paper answers).*

Students' comments revealed that TPACK game activities used in LBD module positively affected students' TPACK development. It was found that, with the LBD module in the study, they better understood how separate TPACK components (technology, pedagogy, and content) afforded and constrained each other when used at the same context and what were the possible ways to find an optimal balance among them so that they could be used at the same context at the same time. Hence, based on the survey results, artifact results, and reflections of students, the current study identified that LBD module used in the study had positive impact on students' TPACK development.

4.4. Summary of the Findings

The study identified two major themes from students' TPACK designs: Orientation and focus. Orientation was used for the component which students built their design by putting it on the center of the design. Orienting component dictated others by having little changes but affected others' selection and utilization (with modification according to dictations of the orienting component). Focus was used for the component which was talked more than others in TPACK design process. Focused component caused more problems than others in the same context and/or making students search for it since they did not have much information about. When TPACK designs were classified in terms of their orientation and focuses, it was revealed that students created different designs with different orientation and focuses. This finding indicated that there were multiple pathways in reaching TPACK.

The study also indicated that in CEG, students sometimes used content as technology, and sometimes technology as content. This situation was called as component transformation. Furthermore, CEG students reported that content to technology transformation was acceptable since it could facilitate teaching. However, they pointed out that technology to content transformation brought extra load to teachers since they had to teach two different contents (content which was supposed to be taught with the technology, and technology which was transformed into content) in the same context.

In another analyses, it was found that content experts' self-perceived TPACK was aligned with their instructional practices whereas others' was not. It was found that students who were not content experts could not reflect their self-perceived TPACK into their instructional practices since they indicated low TPACK in their TPACK lesson plan design process. The reason was that Hale-P indicated TKD whereas Computer Education students indicated both CKD and PKD.

In another finding, it was revealed that LBD module implemented in the study had positive impact on students' development of TPACK.

The findings as a whole addressed the benefit of triangulation in examining the development of TPACK. Analyses in the second research question reported that when data was analyzed as a whole, students could reflect their self-perceived TPACK into their instructional practices. However, when data was analyzed at individual student level, it was found that students who were not content experts could not reflect their self-perceived TPACK into their instructional practices. Inconsistency in different analyses showed the importance of collecting data from different sources. Furthermore, in the third research question, in order to check the reliability of findings, the LBD module's impact on the development of TPACK was investigated not only with survey but also with learning artifacts and reflection papers. This triangulation strategy allowed for checking accuracy of the findings.

CHAPTER 5

DISCUSSION, CONCLUSION, IMPLEMENTATION

In this chapter, discussion, conclusion, and implementation of the research were discussed. First, discussion and conclusion of findings were provided. Second, implications for the research and the practice were presented.

5.1. Discussion and Conclusion

The main purpose of this study was to examine the development of TPACK with 10 graduate students in the context of Research and Practice on Technology in Teacher Education course offered in the department of Curriculum and Instruction at a public university in Turkey in Spring 2013. The research site was purposefully selected since students in the course, who were from different area of expertise, could provide rich data for investigating the complex nature of TPACK. Variety in data was utilized by following a case study methodology and LBD approach by means of which in depth analysis of the research site with triangulation could be conducted.

The advent of technology has changed the way that we use information, and education is not an exception. Integration of technology in education has increasingly become an important concern among scholars (Agyei & Voogt, 2012; Mishra & Koehler, 2006). However, those studies lacked a theoretical base which prevented literature on instructional technology from having a unity (Mishra & Koehler, 2006). Accordingly, Mishra and Koehler (2006) offered TPACK as a new theoretical knowledge framework in teacher education. Since then, extensive research on understanding the nature of TPACK was conducted. However, the research indicated that the definitions of TPACK constructs were still fuzzy (Graham, 2011). Scholars have not reached a consensus on the precise definitions of TPACK constructs, yet. Furthermore, research so far was descriptive rather than prescriptive. In other words, TPACK literature articulated the existence of TPACK domains without offering hypotheses about how those domains affected each other, what were the possible pathways in TPACK designs, or how TPACK affected students' learning (Graham, 2011). Furthermore, while Mishra and Koehler (2006) articulated the complex, multifaceted, and situated nature of TPACK, there is still limited research that triangulated the data with self-reports, learning artifacts, and observations (e.g. Koehler et al., 2004; Koehler et al., 2007; Pamuk, 2012). Hence, investigating how TPACK develops in line with considerations mentioned so far was critical to deepen and extend the literature on the development of TPACK.

The current study sought for the development of TPACK in line with several perspectives. First, the study investigated the possible pathways that students followed in their TPACK lesson plan design process. It was found that students created different designs with different orientations and focuses. The analysis revealed that there were multiple pathways in developing TPACK. The findings are in line with Bull et al. (2007)'s study. Bull (2007) stated:

> For instance, one could focus on Pedagogy and see how it interacts with Technology and Content. Alternatively, one could focus on one content area, and see how Pedagogy and Technology can be best utilized to develop student understanding of core content ideas. A third possibility is "considering the affordances (and constraints) imposed by one particular technology and its interaction with content areas and pedagogical goals (p. 131).

Kafyulilo (2010) identified that in their design processes, groups in his study also followed different routes while designing their courses. One started from pedagogy, one started from technology, etc. Thus, while research on possible pathways of developing TPACK is not extensive, it also supported that there might be different routes in developing TPACK similar to the finding in the current study.

Orientation and focus elements in TPACK designs leading to different pathways found in the current study support the complexity of TPACK. The finding was in line with the literature. To illustrate, Koehler et al. (2007) stated that "developing TPCK[TPACK] is a multigenerational process, involving the development of deeper understandings of the complex web of relationships between content, pedagogy and technology and the contexts in which they function" (p.758). In another study, Harris et al. (2010) wrote that "TPACK, like all types of teacher knowledge, is expressed in different ways and to different extents at different times, with different students, and in differing contextual conditions" (p.324). Hence, the findings of the current study supported the complexity of the TPACK framework articulated in the TPACK literature.

Identified pathways in TPACK designs in the current study indicated that designing a technology integrated material depended on contextual factors such as components used in TPACK designs (technology, pedagogy, and content), grade level, curriculum, time, etc. Context factor was also widely acknowledged and taken into consideration in TPACK research (e.g. Cox & Graham, 2009; Graham et al., 2012; Mishra & Koehler, 2006; Pamuk, 2012; Srisawasdi, 2012). However, endeavors on preparing context-neutral software tools were common so far among stakeholders in educational technology. Mishra and Koehler (2006) depicted those endeavors in their study as following:

> Policy makers, teacher educators, and technology enthusiasts, we see a wide range of workshops and teacher education courses about general software tools that have application across content and pedagogical contexts. This content-neutral emphasis on generic software tools assumes that knowing a technology automatically leads to good teaching with technology (p.1031).

Mishra and Koehler (2006) criticized those generic tools in terms of two aspects. One of them was the assumption that a generic software tool can enhance learning in so many contexts. The other one was the assumption that training teachers about how to use those general tools (giving TK only) would be enough to use them in their own classroom environment (most probably they were different form each other) successfully for a good teaching with technology.

The findings of the current study support the first criticism. The current study addresses that generic tools might not be effective in every context since each context need different technology integration solutions. That's why students in the current study did not prepare generic designs but created different custom designs. The findings indicated that custom designs were required for good teaching with technology.

The findings of the study also supported the second criticism. Custom designs took teachers beyond having only technology knowledge. It was found in the current study that students needed to think on the affordances and limitations of components that they wanted to use in the same context. This context was produced by the

TPACK components selected and was diversified by other contextual factors such as curriculum, time, students' characteristics, etc. Those situations made students not only use their technology knowledge but use their TPACK. To conclude, the current study found that custom designs with TPACK were more effective than generic designs with TK for good quality teaching with technology (Mishra & Koehler, 2006; Mishra & Koehler, 2008).

Looking at how students reflected their self-perceived TPACK into their instructional practices, the result indicated an alignment between self-perceived TPACK and TPACK in instructional practices of content experts in groups. In line with the finding, Ta Chien et al. (2012) found that their participants' TPACK was found to be transferable into their teaching practice. Furthermore, Suharwoto (2006) showed that pre-service teachers' TPACK in his study was reflected in their practices during student teaching. While literature on reflection of self-perceived TPACK into instructional practices is not extensive, the findings of the current study supported Suharwoto (2006)'s and Ta Chien et al. (2012)'s studies.

Individual analysis of the current study showed that students who were not content experts indicated low TPACK in their TPACK lesson plan design processes. Among them, Hale-P indicated TKD while Computer Education students indicated CKD and PKD. Those deficiencies were interpreted as the factors leading to low TPACK. TPACK literature also reported that deficiency in separate knowledge bases were important for TPACK development. To illustrate, Timur (2011) found that TK, PK, and CK were necessary for TPACK development of his participants in his study. Altan (2011) found that teachers should have essential PK to use technology in educational settings. Pamuk (2012) found that "lack of experience or knowledge in one area in the [TPACK] model has resulted in failure or unexpected outcomes" (p. 433). Thus, the finding of the current study supported the TPACK literature by reporting that technological, pedagogical, and content knowledge deficiencies of participants negatively affected students' TPACK development.

Investigating the impact of LBD module used in the study, the results indicated that LBD activities had positive impact on students' development of TPACK. The findings of the current research were aligned with the literature. Researchers who used LBD reported increase in TPACK competencies of participants (e.g. Agyei & Voogt, 2012; Bahçekapılı, 2011; Fransson & Holmberg, 2012; Graham et al., 2012; Hofer & Grandgenett, 2012; Kafyulilo, 2012; Koehler et al., 2004; Koehler et al., 2007; Koehler & Mishra, 2005b; Kurt, 2012; Rienties et al., 2012; Shin et al., 2009; Ta Chien et al., 2012; Timur, 2011). Findings suggested that LBD activities provide advantages for participants to become successful technology integrators. When design teams work together for seeking for solutions to some real-world problems, they come up with several potential solutions. Among them, their task is to identify optimal solutions, not perfect solutions, through the process of "satisficing" (Simon, 1969). This satisficing process serves for increasing their knowledge about the interrelations between and among technology, pedagogy and content (Koehler et al., 2004). Koehler et al. (2004) found that initial brainstorming process in their design teams allowed participants identify potential steps and solutions to real-world problems determined through discussions on the components of TPACK. As teams started to work on those potential solutions' strengths and weaknesses, they started to discover how components of TPACK interacted by constraining and supporting each other in the same environment. Mishra and Koehler (2005a) reported that TPACK develops when students are confronted with the conflicting forces of specific content, characteristics and requirements of pedagogies and affordances and constraints of technologies. Through those confrontations, they start to understand nuances of ensuring dynamic equilibrium of TPACK components for good teaching with technology in real-life contexts (Kariuki & Duran, 2004; Mishra & Koehler, 2006). Activities in LBD approach serve as a kind of tools that directly show the dynamic relations of TPACK constructs with each other and the ways of building equilibrium between and among those constructs for good teaching with technology.

The findings of the study supported the importance of triangulation in TPACK research addressed by scholars (e.g. Doering et al., 2009; Graham et al., 2012; Koehler et al., 2007; Rienties et al., 2013; Schmidt et al., 2009; Shin et al., 2009). Triangulation allowed for in-depth analysis of data in answering research questions. By providing more than one different source of data, in-depth analyses could be implemented which was needed to investigate the complex nature of the TPACK. To conclude, the study showed that triangulation was an important technique for the TPACK research.

This study contributes to the body of knowledge in TPACK research by investigating the development of TPACK in terms of different perspectives. Specifically, the study investigated pathways in TPACK designs, the reflection of self-reported TPACK in instructional practices, special situations of Computer Education teachers in teaching technology with technology, and impact of LBD module used in the research on the development of TPACK. The study aims to contribute to the prescriptive demands of TPACK research. TPACK literature so far was descriptive rather than prescriptive (Graham, 2011). The need for prescriptive research was articulated among scholars. The current study went beyond to descriptively explain TPACK constructs but came up with some new themes such as orientation and focus elements which could serve as guides in designing TPACK lesson plans, the interaction between content and technology in CEG, and possible reasons of alignment problems in self-perceived TPACK and instructional practices of students. Thus, the findings of this research will extend and deepen TPACK research and give insights to the interest groups in educational technology and teacher education.

5.2. Implications for Research

The current study has implications for future research. To begin with, the findings of the current research found that there were multiple pathways in designing TPACK designs. Based on the context, different components oriented designs. Furthermore, students focused on different components in those processes. However, those findings need saturation since the scarcity of studies (e.g. Bull et al., 2007; Kafyulilo, 2010). Findings of those multiple pathways are unique to the case investigated in the study. More research could be conducted in different settings to deepen the body of knowledge about custom-TPACK designs.

The study investigated reflection of self-perceived TPACK into instructional practices. Similar to findings about custom-TPACK designs, literature lack sufficient studies to reach saturation about the reflection issue (e.g. Suharwoto, 2006; Ta Chien et al., 2012). Thus, future research could continue to look at the reflection of self-perceived TPACK in the instructional practices in different contexts to contribute to endeavors of filling that gap in TPACK research.

LBD module used in the study was found to have positive impact on students' development of TPACK. However, that positive impact was unique to the context of the case. Hence, the module could be applied in different contexts and the development of different participants' TPACK could be examined to check its impact on TPACK development. Furthermore, since the module has clear steps to implement, similar sets of data could be collected from different contexts which could be used to deepen the knowledge about the complex nature of the TPACK.

5.3. Implications for Practice

The findings of the current study indicated that LBD module had positive impact on TPACK. Hence, at faculty level, that module could be used in technology integration courses to contribute to the development of pre-service teachers TPACK. Furthermore, the module could be utilized in-service training sessions for developing in-service teachers' TPACK.

The results indicated that students followed different routes while designing TPACK based lesson plans with different orientations and focuses. Furthermore, it was found that Computer Education students used technology and content interchangeably from time to time. Those findings served as valuable findings in custom TPACK designs. Benefiting from those findings, TPACK guides could be prepared. Those guides could aid in-service teachers in their technology integration process in their classrooms and could provide benefit to the development of pre-service and in-service teachers' TPACK when used in technology integration courses and in-service trainings.

Computer education students in the current study had graduated from Computer Education and Instructional Technology (CEIT) department in Turkey. Graduates from that department are entitled as "Information Technologies Teacher". Graduates of CEIT are inherently expected to be successful technology integrators with leadership skills in technology utilization in teaching. However, findings indicated that Computer Education students indicated PKD which affected their TPACK negatively. Pedagogical knowledge was regarded as one of the building block of TPACK development (Guzey & Roehrig, 2009; Pamuk; 2012). Hence, at faculty level, CEIT students could be provided with a stronger pedagogical knowledge base.

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APPENDICES

APPENDIX A

CONSENT FORM

Bu çalışma, ODTÜ Sosyal Bilimler Enstitüsü Eğitim Programları ve Öğretim Bölümü yüksek lisans öğrencisi Erdem Uygun tarafından yürütülen nitel bir çalışmadır. Çalışmanın amacı, katılımcıların teknolojik pedagojik alan bilgilerinin gelişimlerinin doğasını, “tasarım yoluyla öğrenme” (learning by design) yaklaşımını kullanarak oluşturulan aktiviteler yoluyla izlemektir. Çalışmaya katılımınız gönüllülük esasına dayalıdır. Çalışmanın fiziksel ve ruhsal sağlığınız için herhangi bir riski bulunmamaktadır. Ayrıca, araştırma için kullanılacak olan anket, görüşme ve raporlarda sizden kimliğinizle ilgili hiçbir bilgi istenmemektedir. Cevaplarınız tamamen bilimsel amaçlı değerlendirilecek olup, araştırma dışında kullanılmayacaktır. Anket, görüşme ve raporlarda kişisel anlamda rahatsızlık verici sorular bulunmamaktadır. Ancak, herhangi bir nedenden ötürü kendinizi rahatsız hissederseniz, soruları yanıtlamayı bırakabilir ve neden yarım bıraktığınız konusunda herhangi bir gerekçe belirtmeden ayrılabilirsiniz. Çalışmaya katılma, çalışmaya katılmama ya da çalışmayı yarım bırakma durumları herhangi bir olumsuzluk yaratmayacak ve ders notlarınıza etki etmeyecektir.

Çalışmada sizden beklenen aktivitelere aktif katılım sağlamanız ve sorulara içtenlikle yanıt vermenizdir. Katılımınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Eğitim Bilimleri Bölümü öğretim üyelerinden Yrd. Doç. Evrim BARAN (Oda: 418; Tel: 2104017; E-posta: ebaran@metu.edu.tr) ile iletişim kurabilirsiniz.

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

İsim Soyad	Tarih	İmza	Alınan Ders
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APPENDIX B

POST-PARTICIPATION DISCLOSURE FORM

Bu çalışma ODTÜ Sosyal Bilimler Enstitüsü Eğitim Programları ve Öğretim Bölümü yüksek lisans öğrencisi Erdem Uygun tarafından yürütülen nitel bir çalışmadır. Çalışma katılımcıların TPAB gelişimlerini gözlemek amacıyla başlatılmıştır.

TPAB ile ilgili yapılan çalışmalar çok eskiye dayanmamaktadır. TPAB literatürü TPAB'nin yeni, karmaşık ve çok yüzlü bir bilgi çeşidi olduğu konusunda hemfikirdir. Böyle bir bilgi türünün doğası, nasıl geliştiği ve bu gelişimin nasıl ölçüleceği ile ilgili yapılan araştırmaların sayısı her geçen gün artmaktadır. Bu çalışmalar içerisinde tasarım yoluyla öğrenme çalışmaları uzun süreli araştırma ortamı sunmasından ve katılımcıların aktif katılımını sağlayarak ürettikleri eğitim materyallerinin analizlerini birden fazla ölçekle destekleme olanağı sağladığından dolayı yaygın bir biçimde tercih edilmeye başlamıştır. Bu çalışmada tasarım yoluyla öğrenme yaklaşımını temel alarak bir modül tasarlanmıştır. Bu modül TPAB oyunu oynayarak katılımcıların sürece aktif bir biçimde katkıda bulunmalarını sağlayacaktır. Modülde yer alan TPAB oyunundan elde edilecek veriler TPAB gelişiminin doğasına ışık tutacakken, hazırlanacak olan kılavuzlarla öğretmenlerin kendi sınıflarında da teknolojiyi, pedagojiyi ve içeriği doğru ve etkili bir biçimde kullanmaları sağlanacaktır.

Bu çalışmadan alınacak ilk verilerin Mart 2013 başında elde edilmesi planlanmaktadır. Elde edilen bilgiler sadece bilimsel araştırma ve yazılarda kullanılacaktır. Çalışmanın sonuçlarını öğrenmek ya da bu araştırma hakkında daha fazla bilgi almak için aşağıdaki isimlere başvurabilirsiniz. Bu araştırmaya katıldığınız için tekrar çok teşekkür ederiz.

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APPENDIX C

LITERATURE TABLE

Studies with Design Activities				
Author	**Purpose**	**Activities**	**Instruments**	**Results**
Shin et al. (2009)	To investigate how 17 in-service teachers' self-beliefs about their TPACK changed after attending in a set of educational technology summer courses.	Preparing digital videos Developing wikis about educational technologies Designing personal web portfolios	Survey	Significant increase in TK (Technological Knowledge), TCK, PCK, TPK, and TPACK. Significant improvement in PCK. No significant difference in CK and PK.
Hofer and Grandgenett (2012)	To understand the development of technology integration knowledge of 8	Reflection about technology integration	Survey Reflection papers	Strong growth in TPACK according to survey. Adequate TPACK according to the first and second lesson plans.

	master students during their teacher preparation program.	Preparing lesson plans Teaching practice	Lesson plan artifacts	
LBD Research with Several Measurement Techniques				
Author	**Purpose**	**Activities**	**Instruments**	**Results**
Graham et al. (2012)	To inquire 133 pre-service teachers' TPACK by analyzing their decision-making processes in selecting possible technologies for three LBD tasks.	Design tasks	Survey	Number of codes derived in TPACK categories significantly increased after design tasks according to open-ended questions. Overall participants' responses were much more detailed in terms of technology integration on course post-assessment than pre-course assessment. Technology transformed content to make it more visual. Technology facilitated reaching content objectives identified in design tasks. Participants did not consider technology as a tool that remedies student misconceptions *(Similar partly to Timur, 2011)*. Researchers explained this situation by stating that pre-service teachers did not confront with student misconceptions intensely because of their limited teaching experiences.

Mishra and Koehler (2005b)	To investigate how TPACK develops thorough LBD activities.	Developing online courses	Survey	Participants moved from considering technology, pedagogy, and content as separated constructs to considering them as transactional and co-dependent which was interpreted as indicators of their TPACK development.
Koehler et al. (2007)	To understand TPACK development of 6 faculty members and 18 Master's students by examining their discourses (either orally or written) which they called it as "design-talk" in a LBD study.	Developing online courses	Discussions E-mails Notes and other artifacts	Design teams moved from considering technology, pedagogy, and content as separated constructs towards understanding the mutual dependencies between and among them interpreted as their TPACK developed overtime. Design-talks of the teams have changed throughout the study. Starting points and length of conversations, participants' role in those conversations have changed over time.
Rienties et al. (2013)	To examine TPACK development of 73 academics from 9 higher education	Redesigning a teaching module Teaching practice	Learning artifacts	Academics' TPACK and its subcomponents named TPK, PCK, and TCK scores on post-test were significantly higher than those on pre-test.

	institutions through an online teacher professionalization program.			
Agyei and Voogt (2012)	To examine TPACK development of 4 pre-service mathematics teachers who worked in two design teams to develop spreadsheet-supported lessons plans.	Developing spreadsheet integrated lesson plans Teaching practice	Survey Observations	Significant growth in component of TPACK (TK, TPK, TCK, and TPACK). Teacher-centered roots of participants limited their design being student centered and more interactive *(Similar partly to Canbazoğlu Bilici, 2012).* More time is needed to effectively integrate technology in design and teaching *(Similar to Koh & Divaharan, 2011; Guzey & Roehrig, 2009; and Timur, 2011).*
Ta Chien et al. (2012)	To transform pre-service science teachers from passive users of technology to active designers of technology using MAGDAIRE	Prepared flash based online science course ware Teaching practice	Survey Discussions Course Assignments Feedbacks Video	Significant increase in TK and TPACK. Technology skills that participants acquired were transferable into their teaching practice.

	framework.		recordings Interviews	
Kafyulilo (2010)	To understand TPACK development of 29 pre-service science and mathematics teachers.	Micro-teaching practices TPACK training sessions Designing lesson plans	Survey Interviews Observations	Participants were not competent at all in technology use (TK) and its integration into pedagogy and content (TPACK) before the study. After the study, it was identified that all activities in the study had significant impact on TPACK development of pre-service teachers. Microteaching, lesson design, and discussions on microteachings were much more beneficial in growth of technology integration knowledge than theoretical TPACK training sessions *(Similar to Kurt, 2012)*.
Bahçekapılı (2011)	To develop TPACK of primary school candidates under the mentorship of CEIT teacher candidates.	Preparing technology-supported lessons with CEIT mentors Teaching practices	Survey Diaries Interviews	Significant developments in TK, TCK, TPK, and TPACK of participants. Teaching practice enabled participants to develop a vision in integrating in technology in actual teaching practices. CEIT mentors successfully shared their knowledge about technology integration which they acquired from their department (so technology integration can be said one of their expertise of area). It can be

				expected from CEIT teachers to take the role of technology integration mentorship in their schools.
				CEIT mentors increased their awareness about their role in technology integration in actual schools and had a picture about possible situations that they might have faced with there.
				CEIT mentors increased their subject matter and pedagogical knowledge in their mentorship process.

Triangulation of Data Sources in LBD Research

Author	**Purpose**	**Activities**	**Instruments**	**Results**
Koehler et al. (2004)	To investigate how TPACK develops thorough LBD activities.	Developing online courses	Postings E-mails Artifacts Observations Reflection papers Interviews	Important changes in the faculty members and their students' comprehension of mutual effect among TPACK components.

			Survey	
Fransson and Holmberg (2012)	To report on their experiences when planning, teaching, and evaluating a course in line with TPACK framework.	Designing lessons with web 2.0 applications and Open Educational Resources.	Observations Artifacts Survey	Considerable indicators about participants' growth on TPACK and its subdomains. The teacher who had more expertise in ICT teaching found it easier to integrate theory and practice comparing the one who was mostly academically oriented.
Koh and Divaharan (2011)	To analyze TPACK development of 74 pre-service teachers in the context of a TPACK developing instructional model.	Designing Interactive Whiteboard integrated lesson plans.	Survey Reflection papers	The model proposed was successful at contributing to the growth of participants' confidence in integrating an ICT tool that they were not knowledgeable at all before. Their TPK was significant among codes which were interpreted as the effect of faculty modeling (presenting pedagogical affordances of the technology) *(Similar to Canbazoğlu Bilici, 2012)*. 7 weeks might not be enough for novice pre-service teachers moving from TK and TPK towards TPACK. There is a need of longer periods of studies *(Similar to Agyei & Voogt, 2012; Guzey & Roehrig, 2009; and Timur, 2011)*.

Pamuk (2012)	To understand 78 pre-service teachers' technology use through TPACK framework.	Designing technology integrated educational materials specific to distance education.	Open ended questions Teaching products Formal & informal observations	Although participants' self-perceptions about their PK was found to be high, they showed limited competence when their project reports were examined. In spite of the fact that students seemed to have enough competence in TK and CK, their inadequacy in pedagogical experience limited their PCK and TPK. Students were found to be capable in transformation of representation of content using technology, that is, in TCK. Participants were found to be in favor of using technology to visualize the content. *(Similar to Graham et al., 2012).* However, visualization attempts were not successful at all because of pedagogical inexperience of participants. Without pedagogical considerations, transformation of content with technology seems to be ineffective for learning. The biggest barrier about TPACK development was found to be participants' pedagogical

				inexperience *(Similar to Guzey & Roehrig, 2009)*. This pedagogical inexperience was explained by their lack of teaching practice. Due to the same reason, while participants have a certain level of TK, PK, and CK, they have problems to generate new knowledge bases such as TPK.
Guzey and Roehrig (2009)	To investigate the TPACK development of 4 in-service secondary science teachers in a yearlong professional development program.	Designing lesson plans Teaching practice	Interviews Surveys Classroom observations Teachers' technology integration plans Study reports	The study addressed the management issues in participants' classroom practices. Issues like troubleshooting or technology engagement of learners (make students use the technology offered by the teacher) caused hardship for teachers and decreased their classroom control *(Contrasts with Canbazoğlu Bilici, 2012)*. Teachers' pedagogical reasoning skills influence teachers' use of knowledge bases necessary for TPACK development *(Similar to Pamuk, 2012)* Long term studies are needed to better understand the nature of TPACK development was emphasized *(Similar to Agyei & Voogt, 2012; Koh & Divaharan, 2011; and Timur, 2011)*.
Kurt (2012)	To understand TPACK development of 22 English pre-service teachers by LBD approach in a	Preparing lesson plans Teaching practice	Survey Reflection papers Interviews	Significant increase in their self-perception about their TK, TCK, TPK, and TPACK. In both design and practice phases, pre-service teachers considered the dynamic equilibrium between and among TPACK constructs.

	12-week-long coursework that specifically focused on developing TPACK of participants.		Lesson plans Observations Field notes	Their first lesson plans before peer feedback indicated that they seemed not to be able to think alternate ways of using technology in line with content considerations. It was associated with the lack of experiences in design and practice of participants which in fact, proves the importance of hands on activities in TPACK development *(Similar to Kafyulilo, 2010).*
Timur (2011)	To study 30 senior pre-service science teachers' TPACK development.	TK-based instructions Designing lesson plans Teaching practices	Survey Interviews Observations Artifacts	Technology-supported instructions were understood as effective means of contributing TPACK development of learners. Adequate TK, PK, and CK were necessary for TPACK development. Developing TPACK requires a long term commitment. *(Similar to Agyei & Voogt, 2012; Koh & Divaharan, 201; and Guzey & Roehrig, 2009).* The study was not effective on development of the knowledge of addressing students' misconceptions and difficulties in teaching with technology. *(Similar partly to Graham et al., 2012, and similar to Timur, 2011).*

Canbazoğlu Bilici (2012)	To analyze the change in TPACK and TPACK self-adequacy levels of science teacher candidates.	Trainings Designing technology enhanced lesson plans Teaching experience	Survey Tests Interviews Reflection forms Videotape records Blog comments Lesson plans and materials	Participants had no difficulty in classroom management and classroom communication. However, it might be the case that teaching experiences were not held in real classroom environment *(Contrasts with Guzey & Roehrig, 2009)*. Participants were dependent on smart board use in their teaching experience which was attributed to deficiency in their TPK. Faculty modeling was addressed for effective technology integration *(Similar to Koh & Divaharan, 2012)*. TPACK training provided at the beginning of the study did not work in developing knowledge of participants in identification and remediation of misconceptions and difficulties of learners in a technology supported lesson *(Similar to Timur, 2011)*. Participants used educational technologies with teacher-centered instructional actions instead of with student-centered approaches *(Similar partly to Agyei & Voogt, 2012)*.

APPENDIX D

TPACK-DEEP SURVEY

Background

Age:	**Gender:** Male ☐ Female ☐	**State of Education:** Msc ☐ Doctorate ☐
Undergraduate Department (e.g. English Language Teaching):		
Teaching Experience (e.g. 1 year 8 months):		
The Number of Technology Related Courses That Have Been Taken So Far:		

TPACK Questions

The purpose of this section is to gather information about combining technology, pedagogy and content knowledge in the teaching and learning process. For each item, choose **only one option** (Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree) that best describes you. Please answer all of the questions and if you are uncertain of or neutral about your response you may always select "Neither Agree nor Disagree"	**Strongly Disagree**	**Disagree**	**Neither Agree Nor Disagree**	**Agree**	**Strongly Agree**
1. I can update an instructional material (paper based, electronic or multimedia materials, and etc.) based on the needs (students, environment, duration, and etc.) by using technology.					
2. I can use technology to determine students' needs to a content area in the pre-teaching process.					
3. I can use technology to develop activities based on students' needs to enrich the teaching the teaching and learning process.					
4. I can plan the teaching and learning process according to available technological resources.					
5. I can conduct a needs analysis for Technologies to be used in the teaching and learning process to increase the quality of teaching.					
6. I can optimize the duration of the lesson by using technologies (educational software, virtual labs, and etc.)					
7. I can develop appropriate assessment tools by using technology.					

8. I can combine appropriate methods, techniques and Technologies by evaluating their attributes in order to present the content effectively.					
9. I can use technology to appropriately design materials to the needs for and effective teaching and learning process.					
10. I can organize the educational environment in an appropriate way to use technology.					
11. I can implement effective classroom management in the teaching and learning process in which technology is used.					
12. I can assess whether students have the appropriate content knowledge by using technology.					
13. I can apply instructional approaches and methods appropriate to individual differences with the help of technology.					
14. I can use technology for implementing educational activities such as homework, projects, and etc.					
15. I can use technology for evaluating students' achievement in related content areas.					
16. I can use technology for evaluating students' achievement in related content areas.					
17. I can be an appropriate model for the students in following codes of ethics for the use of technology in my teaching.					
18. I can guide students in the process of designing technology based products (presentations, games, films, and etc.)					
19. I can use innovative technologies (Facebook, blogs, twitter, podcasting, and etc.) to support the teaching and learning process.					
20. I can use technology to update my knowledge and skills in the area that I will teach.					
21. I can update my technological knowledge for the teaching process.					
22. I can use technology to keep my content knowledge updated.					
23. I can provide each student equal access to technology.					
24. I can behave ethically in acquiring and using special/private information – which will be used in teaching a subject area – via technology (auido records, video records, documents, and etc.)					
25. I can use technology in every phase of the teaching and learning process by considering the copyright issues (e.g. licence)					
26. I can follow the teaching profession's codes of ethics in online educational environments (WebCT, Moodle, etc.)					

27. I can provide guidance to students by leading them to valid and reliable digital sources.					
28. I can behave ethically regarding the appropriate use of technology in educational environments.					
29. I can troubleshoot problems that could be encountered with online educational environments (WebCT, Moodle, etc.)					
30. I can troubleshoot any kind of problem that may occur while using technology in any phase of the teaching and learning process.					
31. I can use technology to find solutions to problems (structuring, updating and relating the content to real life, etc.)					
32. I can become a leader in spreading the use of technological innovations in my future teaching community.					
33. I can cooperate with other disciplines regarding the use of technology to solve problems encountered in the process of presenting content.					

APPENDIX E

TPACK GAME QUESTIONS

TPACK Game I Technology Non-random

Please randomly select a pedagogy from the Pedagogy Pool	Write here.
Please randomly select a content from the Content Pool	Write here.

Please fill in the table below considering the pedagogy and the content that you have randomly selected from Pedagogy and Content Pools.

Initial Information About the Pedagogy Randomly Selected	
Randomly Selected Pedagogy	Write here.
Characteristics of the Randomly Selected Pedagogy	Write here.
Affordances of the Randomly Selected Pedagogy	Write here.
Limitations of the Randomly Selected Pedagogy:	Write here.
Initial Information About the Content Randomly Selected	
Randomly Selected Content:	Write here.
General Summary of Randomly Selected Content:	Write here.

Please select one or more technology/ies from "Technology Pool" by yourselves (not randomly) considering the randomly selected pedagogy and content.	Write here.

Please fill in the table below considering technology/ies selected.

Initial Information about Technology/ies Selected	
Technology/ies Chosen	Write here.
Characteristics of Technology/ies Chosen	Write here.
Affordances of Technology/ies Chosen	Write here.
Limitations of Technology/ies Chosen	Write here.

Please fill in the table considering the pedagogy, the content and the technology/ies that you have.

Questions	**Answers**
Randomly selected pedagogy	Write here.
Randomly selected content	Write here.
Level of the content (e.g. 8th grade)	Write here.
Selected technology/ies by yourselves	Write here.
Why you chose that technology/those technologies *(In one or two paragraph, please explain why you chosed that one/those ones, but not the others)*	Write here.
Why do you think that the technology/ies you selected can be effective in a context where the randomly selected pedagogy and content is used? *(In one or two paragraph, please explain your drives and assumptions about the effectiveness of technology/ies that you selected in a framework including the randomly selected pedagogy and the content.*)	Write here.
Considering the pedagogy and the content that you randomly selected, how would you use that technology/those technologies in an effective way in your classroom? *(Please explain in detail, how the content, the pedagogy and the technology/ies that you have can be used*	Write here.

at the same time in a coherent and effective way in your instruction. Please think on the affordances and limitations of each component; namely pedagogy, content and technology/ies selected).	
Which technology/ies would also be effective in the same context apart from the one/s that you have already selected? Why? *(In one or more paragraph, please explain how would you ensure that a different technology/different technologies became successful as well in the same context?(with the same pedagogy and the content))*	Write here.

TPACK Game I Content Non-random

Please <u>randomly</u> select a pedagogy from the Pedagogy Pool	Write here.
Please <u>randomly</u> select a technology from the Technology Pool	Write here.

Please fill in the table below considering the pedagogy and the technology that you have <u>randomly</u> selected from Pedagogy and Technology Pools.

Initial Information About the Pedagogy Randomly Selected	
Randomly Selected Pedagogy	Write here.
Characteristics of the Randomly Selected Pedagogy	Write here.
Affordances of the Randomly Selected Pedagogy	Write here.
Limitations of the Randomly Selected Pedagogy:	Write here.
Initial Information About Technology Randomly Selected	

Randomly Selected Technology	Write here.
Characteristics of Randomly Technology	Write here.
Affordances of Randomly Selected Technology	Write here.
Limitations of Randomly Selected Technology	Write here.
Randomly Selected Technology	Write here.

Please select one content from "Content Pool" by yourselves (not randomly) considering the randomly selected pedagogy and technology.	Write here.

Please fill in the table below considering the content selected

Initial Information About the Content Selected	
Selected Content:	Write here.
General Summary of Selected Content:	Write here.

Please fill in the table considering the pedagogy, the content and the technology that you have.

Questions	**Answers**
Randomly selected pedagogy	Write here.
Randomly selected technology	Write here.
Selected content by yourselves	Write here.
Level of the content (e.g. 8th grade)	Write here.
Why you chose that content? *(In one or two paragraph, please explain why you chosed that one, but not the others)*	Write here.
Why do you think that the content you selected can be effectively taught in a context where the randomly selected pedagogy and technology is used? *(In*	Write here.

one or two paragraph, please explain your drives and assumptions about the suitability of the content that you selected in a framework including the randomly selected pedagogy and the technology.)	
Considering the pedagogy and the technology that you randomly selected, how would you instruct the content you select in an effective way in your classroom? *(Please explain in detail, how the content, the pedagogy and the technology that you have can be used at the same time in a coherent and effective way in your instruction. Please think on the affordances and limitations of each component; namely pedagogy, content and technology/ies selected).*	Write here.
Which content/s would also be effectively taught in the same context apart from the one that you have already selected? Why? *(In one or more paragraph, please explain how would you ensure that different contents were successfully taught as well in the same context?(with the same pedagogy and the technology))*	Write here.

TPACK Game I Pedagogy Non-random

Please <u>randomly</u> select a content from the Content Pool	Write here.
Please <u>randomly</u> select a technology from the Technology Pool	Write here.

Please fill in the table below considering the content and the technology that you have randomly selected from Content and Technology Pools.

Initial Information About Technology Randomly Selected	
Randomly Selected Technology	Write here.
Characteristics of Randomly Technology	Write here.
Affordances of Randomly Selected Technology	Write here.
Limitations of Randomly Selected Technology	Write here.
Initial Information About the Content Randomly Selected	
Randomly Selected Content:	Write here.
General Summary of Randomly Selected Content:	Write here.

Please select one or more pedagogy/ies from "Pedagogy Pool" by yourselves (not randomly) considering the randomly selected content and technology.	Write here.

Please fill in the table below considering the pedagogy/ies selected.

Initial Information About the Pedagogy/ies Selected	
Selected Pedagogies	Write here.
Characteristics of Selected Pedagogy/ies	Write here.
Affordances of Selected Pedagogy/ies	Write here.
Limitations of Selected Pedagogy/ies	Write here.

Please fill in the table considering the pedagogy, the content and the technology that you have.

Questions	**Answers**
Randomly selected content	Write here.
Level of the content (e.g. 8th grade)	Write here.
Randomly selected technology	Write here.

Selected pedagogy/ies by yourselves	Write here.
Why you chose that pedagogy/those pedagogies? *(In one or two paragraph, please explain why you chosed that one/those ones, but not the others)*	Write here.
Why do you think that the pedagogy/ies you selected can be effective in a context where the randomly selected technology and content is used? *(In one or two paragraph, please explain your drives and assumptions about the effectiveness of pedagogy/ies that you selected in a framework including the randomly selected technology and the content.*)	Write here.
Considering the technology and the content that you randomly selected, how would you use that pedagogy/those pedagogies in an effective way in your classroom? *(Please explain in detail, how the content, the pedagogy/ies and the technology that you have can be used at the same time in a coherent and effective way in your instruction. Please think on the affordances and limitations of each component; namely pedagogy/ies, content and technology selected).*	Write here.
Which pedagogy/ies would also be effective in the same context apart from the one/s that you have already selected? Why? *(In one or more paragraph, please explain how would you ensure that a different pedagogy/different pedagogies became successful as well in the same*	Write here.

context?(with the same technology and the content))	

TPACK Game II

Please randomly select a pedagogy from the Pedagogy Pool	Write here.
Please randomly select a content from the Content Pool	Write here.
Please randomly select a technology from the Technology Pool	Write here.

Please fill in the table below considering the pedagogy, the content, and the technology that you have randomly selected from Pedagogy, Content, and Technology Pools.

Initial Information About the Pedagogy Randomly Selected	
Randomly Selected Pedagogy:	Write here.
Characteristics of the Randomly Selected Pedagogy:	Write here.
Affordances of the Randomly Selected Pedagogy:	Write here.
Limitations of the Randomly Selected Pedagogy:	Write here.

Initial Information About the Content Randomly Selected	
Randomly Selected Content:	Write here.
General Summary of Randomly Selected Content:	Write here.

Initial Information About the Technology Randomly Selected	
Randomly Selected Technology:	Write here.
Characteristics of Randomly Selected	Write here.

Technology:	
Affordances of Randomly Selected Technology:	Write here.
Limitations of Randomly Selected Technology:	Write here.

Please fill in the table below considering the pedagogy, the content and the technology that you have, IF YOU THINK THAT THEY CAN BE USED AT THE SAME TIME IN THE SAME CONTEXT.

Questions	**Answers**
Randomly selected pedagogy	Write here.
Randomly selected content	Write here.
Level of the content (e.g. 8th grade)	Write here.
Randomly selected technology	Write here.
Considering the pedagogy, the content, and the technology that you have randomly selected, how would you prepare an effective learning environment? *(Please explain IN DETAIL, how the content, the pedagogy and the technology that you have can be used at the same time in a coherent and effective way in your instruction. Please think on the affordances and limitations of each component; namely pedagogy, content, and technology selected).*	Write here.
Which pedagogy/ies would also be effective in the same context apart from the one that you have already selected? Why? *(In one or more paragraph, please explain how would you ensure that a different pedagogy/different pedagogies became successful as well in the same*	Write here.

context?(with the same technology and the content))	
Which content/s would also be effective in the same context apart from the one that you have already selected? Why? *(In one or more paragraph, please explain how would you ensure that a different content/different contents became successful as well in the same context?(with the same technology and the pedagogy))*	Write here.
Which technology/ies would also be effective in the same context apart from the one that you have already selected? Why? *(In one or more paragraph, please explain how would you ensure that a different technology/different technologies became successful as well in the same context?(with the same pedagogy and the content))*	Write here.
Additional thoughts:	Write here.

Please fill in the table below considering the pedagogy, the content and the technology that you have, IF YOU THINK THAT THEY CAN NOT BE USED AT THE SAME TIME IN THE SAME CONTEXT.

Questions	**Answers**
Randomly selected pedagogy	Write here.
Randomly selected content	Write here.
Level of the content (e.g. 8th grade)	Write here.
Randomly selected technology	Write here.
Why the three components that you have randomly selected cannot be used together	Write here.

in a classroom? *(Please explain <u>IN DETAIL</u>, how affordances and limitations of all three components that you have selected would interact in a way leading to an ineffective instruction?)*	
How would you remedy those issues that you have identified while examining the interaction among the pedagogy, the content, and the technology that you have randomly selected? *(Please explain which component/s (among technology, pedagogy, and the content randomly selected) do you think make you be unable to use all three components in a coherent and effective way in your instruction? Which component/components would you change with another? Why? <u>Please state the new component that you use to be replaced with the old one. To illustrate, "I would replace direct instruction with anchored instruction since...", or "I would use Prezi instead of Edmodo since..."</u>)*	Write here.
Additional thoughts:	Write here.

APPENDIX F

CODE BOOK

Separate Components of TPACK: Describes instances mentioning components of TPACK separately. TK-(Name)s will be counted to calculate how many times each group has talked about technology and this sum will be coded as "TK". Similarly, sums of CK-(Name)s and PK-(Name)s will be coded as "CK" and "PK", respectively.			
Code	**Description**	**Keywords**	**Example**
TK-(Name)	Instances in which a student proves that he/she knows about the technology that they had randomly chosen or nonrandomly selected.	Is used for, is for, requires, is, aims, etc.	Because presentation programs require someone to manage, someone will prepare, present, etc. I mean even if you prepare the animation on your own... (03.04.2013, SEG Transcriptions)
TKD-(Name)	Instances in which a student proves that he/she does not know/little knows about the technology *(D stands for "deficiency").*	what is, I do not know if, exactly what	There is a thing called educreation, I do not know what educreation is. (20.03.2013, SEG Transcriptions)
PK-(Name)	Instances in which a student proves that he/she knows about the	Is used for, is for, requires, is, aims, etc.	But then it will not be jigsaw. At jigsaw, there are roles of two people; I mean of different people, when everyone comes to a place, one thing emerges. (03.04.2013, EEG Transcriptions)

	pedagogy		
PKD-(Name)	Instances in which a student proves that he/she does not know/little knows about the pedagogy *(D stands for "deficiency").*	what is, I do not know if, exactly what	What was learning cycle? (20.03.2013, SEG Transcriptions)
CK-(Name)	Instances of a student's talks about only content.	Names, affordances, constraints, definitions, summaries, etc. of a specific content.	In fact information security, I mean technology and security, things such as what should be done in order not to caught electricity. (20.03.2013, CEG Transcriptions)

Interacted Components of TPACK: Describes instances of each group mentioning components of TPACK in interaction with each other. PCK-(Name)s will be counted to calculate how many times each group has talked about content and pedagogy together and this sum will be coded as "PCK". Similarly, sums of TCK-(Name)s, TPK-(Name)s, and TPACK-(Name)s will be coded as "TCK", "TPK", and "TPACK", respectively.

Code	**Description**	**Keywords**	**Example**
PCK-(Name)	Instances of a student's talks about teaching content with pedagogical considerations.	*No specific keyword*	Discrepant event is an activity that has an unanticipated outcome, suddenly makes student confused and curious about it, for example you expect there is no difference between coke and diet coke but when you throw them into the water diet coke floats, ordinary coke

			sinks. (27.03.2013, SEG Transcriptions)
TCK-(Name)	Instances of a student's talks about digital technologies in his/her group's subject area without influence of pedagogical considerations.	*No specific keyword*	This software is only related with graphs of equations (17.04.2013, MEG Transcriptions).
TPK-(Name)	Instances of a student's talks about pedagogical uses of technologies or how a technology influences pedagogical actions.	*No specific keyword*	…since you cannot do the entire role plays in presentation. (03.04.2013, SEG Transcriptions)
TPACK-(Name)	Instances of a student's talks about mutual interaction between and among pedagogy, technology, and content.	*No specific keyword*	Since wikispace has been elected there would be an exercise needing writing, and conjunctions are best taught with writing rather than speaking (20.03.2013, EEG Transcriptions)

Special Codes: This category includes statements related with the code CONTEXT.

Code	**Description**	**Keywords**	**Example**
CONTEXT	Statements related with conditions that might be effective in TPACK design	Students, struggle, confused,	It can be at 6th grade, or 8th grades…mainboard, etc., since they already know those, those may not be interesting to them (27.03.2013, CEG Transcriptions).

	process such as student, teacher, infrastructure, etc.	difficulty, needs, challenged, motivation, level, grade, curriculum, teacher, instructor	…technical education faculties, a teacher of technical departments, their content is also completely technical, won't they use blog, won't they use Diigo for example? (10.04.2013, CEG Transcriptions)

APPENDIX G

TPACK GAME POOLS

EEG TPACK GAME POOLS

Technology Pool	Pedagogy Pool	Content Pool
Wiki (Wikispaces, etc.)	Game-based Learning	Greeting
Presentation Programs (power point, prezi, etc.)	Collaborative Learning	Numbers
Drawing-Painting Software (paint, educreation, kerproof, etc.).	Problem-based Learning	Prepositions
Social Bookmarking (diigo, delicious, etc.)	Role Play	Adjectives/Adverbs
Picture Sharing Platforms (pinterest, flicker, etc.)	Discussions	Conditional Sentences
Online Collaborative Platforms (google docs, ed modo, etc.)	Direct Instruction	Present Continuous Tense
Social Networking (facebook, twitter, etc.)	Case-based Instruction	Passive Voice
Google Earth	Discovery Learning	Phrasal Verbs on health
Online Discussion Forums (google grup, yahoo grup, facebook grup , etc.)	Jigsaws	Regrets/Wish
Educational Simulations	Anchored Instruction	Conjunctions
Educational Games	Suggestopedia	Form & Register
Digital Story Telling (kerproof, microsoft photo story, etc.)	Audio-Lingual Method	Causative

Voice Recording-Editing Platforms (audacity, wavepad, wavosaur, etc.)	Lexical Approach	Reported Speech
Video Recording-Editing Platforms (microsoft movie maker, corel video studio, etc.)	Debates	Comparatives/Superlatives
Blogs (blogger, blogspot, etc.)	Gagne's 9 Steps of Instruction	Giving Advice / Making Suggestions
Podcasts (podomatic, etc.)	5E Model	Expressing preference

CEG TPACK GAME POOLS

Technology Pool	Pedagogy Pool	Content Pool
Wiki (Wikispaces, etc.)	Game-based Learning	Bilgi ve Teknoloji
Presentation Programs (power point, prezi, etc.)	Collaborative Learning	Bilgisayar ve Çevre Birimleri
Drawing-Painting Software (paint, educreation, kerproof, etc.).	Problem-based Learning	Teknoloji ve Güvenlik
Social Bookmarking (diigo, delicious, etc.)	Role Play	Klavye Kullanımı ve Kelime İşlemci Programı
Picture Sharing Platforms (pinterest, flicker, etc.)	Discussions	Elektronik Çizelge Programı
Online Collaborative Platforms (google docs, ed modo, etc.)	Direct Instruction	Sunu Programı
Social Networking (facebook, twitter, etc.)	Case-based Instruction	Çizim Programı (Paint vs.)
Google Earth	Discovery Learning	Bilgisayar Ağları
Animations	Jigsaws	İnternet nedir ve İnternet Araçları (E-posta, arama

		motorları, forumlar, Sosyal ağlar, bloglar, wikiler, vs.)
Online Discussion Forums (google grup, yahoo grup, facebook grup, etc.)	Anchored Instruction	Bilgi Güvenliği
Educational Simulations	Demonstration	Veri Tabanı
Educational Software (kidspration, inspration)	Situated Learning	Bilgisayar Programlama
Educational Games	Inquiry based learning	Web Tasarım
Digital Story Telling (kerproof, microsoft photo story, etc.)	Project-based learning	
Voice Recording-Editing Platforms (audacity, wavepad, wavosaur, etc.)	Learning by doing	
Video Recording-Editing Platforms (microsoft movie maker, corel video studio, etc.)	Experiential Learning	
Blogs (blogger, blogspot, etc.		
Podcasts (podomatic, etc.)		
Robots		
Smart Toys		
Touch screens		
Virtual Worlds		
Scratch		

MEG TPACK GAME POOLS

Technology Pool	**Pedagogy Pool**	**Content Pool**
Wiki (Wikispaces, etc.)	Game-based Learning	Concept of Function
Presentation Programs (power point, prezi, etc.)	Collaborative Learning	Graphs of Functions

Drawing-Painting Software (paint, educreation, kerproof, etc.).	Problem-based Learning	Types of Functions
Social Bookmarking (diigo, delicious, etc.)	Role Play	Inverse Functions
Picture Sharing Platforms (pinterest, flicker, etc.)	Discussions	Transformation of Functions
Online Collaborative Platforms (google docs, ed modo, etc.)	Direct Instruction	Linear Inequalities
Social Networking (facebook, twitter, etc.)	Case-based Instruction	Solving Systems of Linear Equations
Google Earth	Discovery Learning	Concept of Triangle
Online Discussion Forums (google grup, yahoo grup, facebook grup, etc.)	Jigsaws	Operations on Fractions
Educational Simulations	Anchored Instruction	Irrational numbers
Educational Games	Demonstration	Graphs of Quadratic Functions
Digital Story Telling (kerproof, microsoft photo story, etc.)		Elements of a triangle
Voice Recording-Editing Platforms (audacity, wavepad, wavosaur, etc.)		Probability
Video Recording-Editing Platforms (microsoft movie maker, corel video studio, etc.)		
Blogs (blogger, blogspot, etc.)		
Podcasts (podomatic, etc.)		
Dynamic Geometry Softwares		

CAS (Computer Algebra Systems)		

SEG TPACK GAME POOLS

Technology Pool	**Pedagogy Pool**	**Content Pool**
Wiki (Wikispaces, etc.)	Game-based Learning	Five senses
Presentation Programs (power point, prezi, etc.)	Collaborative Learning	Properties of Matter
Drawing-Painting Software (paint, educreation, kerproof, etc.).	Problem-based Learning	States of Matter
Social Bookmarking (diigo, delicious, etc.)	Role Play	Electricity
Picture Sharing Platforms (pinterest, flicker, etc.)	Discussions	Light
Online Collaborative Platforms (google docs, ed modo, etc.)	Direct Instruction	Earth and Universe
Social Networking (facebook, twitter, etc.)	Case-based Instruction	Force
Google Earth	Discovery Learning	Motion
Online Discussion Forums (google grup, yahoo grup, facebook grup, etc.)	Jigsaws	Body systems
Educational Simulations	Anchored Instruction	Magnetism
Educational Games	Concept Cartoons	Heat
Digital Story Telling (kerproof, microsoft photo story, etc.)	Learning Cycle	Solutions
Voice Recording-Editing Platforms (audacity, wavepad, wavosaur, etc.)	Demonstration	Mixtures
Video Recording-Editing Platforms (microsoft movie maker,	Project-based Learning	Energy

corel video studio, etc.)	
Blogs (blogger, blogspot, etc.)	Density
Podcasts (podomatic, etc)	Mirrors

APPENDIX H

APPROVAL OF ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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23Temmuz 2013

Gönderilen: Yrd. Doç. Dr. Evrim Baran
Eğitim Programları ve Öğretim Bölümü

Gönderen : Prof. Dr. Canan Sümer
IAK Başkan Vekili

İlgi : Etik Onayı

Danışmanlığını yapmış olduğunuz Eğitim Programları ve Öğretim Bölümü Yüksek Lisans öğrencisi Erdem Uygun'un "Tasarım ve Öğretim Yoluyla Öğrenme: Teknoloji Pedagoji Alan Bilgisine Bütünleşik Yaklaşım" isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

23/07/2013

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

APPENDIX I

THESIS PHOTOCOPY PERMISSION FORM

ENSTİTÜ

Fen Bilimleri Enstitüsü □

Sosyal Bilimler Enstitüsü ■

Uygulamalı Matematik Enstitüsü □

Enformatik Enstitüsü □

Deniz Bilimleri Enstitüsü □

YAZARIN

Soyadı: Uygun
Adı : Erdem
Bölümü: Eğitim Programları ve Öğretim

TEZİN ADI (İngilizce): Learning By Design: An Integrated Approach for Technological Pedagogical Content Knowledge Development

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 bir (1) yıl süreyle fotokopi alınamaz. □

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: 11.10.2013