# A COLLECTIVE CASE STUDY TO UNDERSTAND THE WHYS AND WHEREFORES OF NOT USING TECHNOLOGY IN MATHEMATICS EDUCATION

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2014

# A COLLECTIVE CASE STUDY TO UNDERSTAND THE WHYS AND WHEREFORES OF NOT USING TECHNOLOGY IN MATHEMATICS EDUCATION

Thesis submitted to the

Institute for Graduate Studies in the Social Sciences

in partial fulfillment of the requirements for the degree of

Master of Arts

in

Primary Education

by

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Boğaziçi University

2014

A Collective Case Study to Understand the Whys and Wherefores of Not Using Technology in Mathematics Education

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December 2014

# ABSTRACT

Mehmet Eren, "A Collective Case Study to Understand the Whys and Wherefores of Not Using Technology in Mathematics Education"

The purpose of this study was to investigate the barriers of technology integration in primary mathematics education. To determine the barriers, three different themes were used: (a) teachers' definition of self in integration efforts, (b) the relationship between technology and pedagogy in teachers' perspectives, and (c) teachers' understanding of the nature of technology in today's world. Convenience sampling method was used to select six primary mathematics teachers. A multiple case study design consisting of six distinct cases was used as the methodology. An adapted semi-structured interview was used as the instrument. To make comparisons within and across cases, results were stated under two main headings: Within case analysis and cross case analysis. The data, first of all, revealed that the access barrier to the available sources is prominent in all cases. Secondly, considering pedagogical concerns, the motivation of the students and the pace of the lessons are the points on which technology integration has the greatest impact. Professional development was another barrier participants had a consensus on. In this respect, the participants proposed a ten-stage plan to educate teachers in terms of technology integration. Lastly, but most importantly, it was proposed that technology itself in today's world can appear as the next barrier.

# TEZ ÖZETİ

Mehmet Eren, "Matematik Eğitiminde Teknoloji Kullanılmamasının Nedenleri Üzerine Çoklu Betimsel Bir Çalışma"

Bu çalışmada ilköğretim matematik öğretmenlerinin teknolojisi kullanmalarının önündeki engeller araştırılmıştır. Bu engellerin belirlenmesinde, üç farklı yaklaşım kullanılmıştır. Bunlar; (1) öğretmenlerin teknoloji kullanımında kendi rol tanımları, (2) öğretmenlerin teknoloji kullanımı ve bunun pedagojik çıktıları hakkındaki görüşleri, (3) öğretmenlerin günümüz teknoloji olgusuna karşı bakış açıları, şeklinde tanımlanmıştır. Çalışmaya altı ilköğretim matematik öğretmeni katılmıştır. Altı tane durumdan oluşan çoklu betimsel model kullanılmıştır. Veriler bir başka çalışmadan adapte edilen yarı yapılandırılmış görüşme formu kullanılarak toplanmıştır. Altı durum hem kendi içinde değerlendirilmiş hem de birbirleriyle karşılaştırma yapılarak sonuçlar ortaya konmuştur. Sonuçlar incelendiğinde, öncelikle okuldaki teknolojik donanıma ulaşım ve kullanımında karşılaşılan problemlere yer verilmiştir. Pedagojik unsurlar göz önüne alındığında öğrenci motivasyonu ve ders işleniş hızı öne çıkan unsurlar olmuştur. Öğretmen eğitimi açısından, katılımcılar on adımlı bir model önermişlerdir. Son olarak, günümüzdeki teknoloji olgusu düşünüldüğünde, teknolojinin kendisinin eğitimde teknoloji kullanımında bir engel olarak yer alabileceği öngörülmüştür.

# ACKNOWLEDGEMENTS

I firstly would like to convey my deep gratitude and respect for my thesis advisor, Assoc. Prof. Dr. Serkan Özel. He has inspired me to realize the power of critical reasoning in this process. With his guidance and endless support, I had a chance to complete this study.

My sincere thanks must also go to the members of my thesis committee: Assoc. Prof. Dr. Mehmet Bulut, Assist. Prof. Dr. Engin Ader, Prof. Dr. Emine Erktin, and Assist. Prof. Dr. M. Sencer Çorlu. They kindly spent their time to offer me invaluable comments to improve my work. In particular, Assist. Prof. Dr. Engin Ader showed a great guidance with his reflective comments. Also, I would like to express my deepest thank to Assoc. Prof. Dr. Mehmet Bulut since he created time and place for me to focus and study on my thesis. I extend special thanks to Peggy Alptekin for editing my thesis both in language and formatting.

I would like to thank all my friends, specifically Burak, Gökhan, and Özkan, for their support and endless friendship during my study. Besides, I would like to thank my colleagues Dr. Ahmet Gökmen and Serhat İnan in the department for their guidance and understanding during my graduate study.

Finally, I owe gratitude to my parents, Fatime and Mustafa, for their love and support. Also, there are no proper words to state my gratitude to my brother Doğan for his priceless support and guidance.

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# CHAPTER 1

# INTRODUCTION

When the chalkboard was first introduced in 1890s, it was hard to imagine what the second innovation would be like. Approximately, a hundred years later interactive whiteboards were introduced in the educational world. Teachers were amazed by the features provided with interactive whiteboards. However, no one can guess what tools educators will be using a decade from now. Educational researchers, rather than guessing about the invention of the next tool, mostly pay attention to determining the ways to use available tools to reach the ideal pedagogical outcome. In the following part, the journey of the efforts to use technology more efficiently will be stated.

At first, it made sense to the researchers to study the obstacles in this journey. The usual term used to define those obstacles appeared as "barriers" in the literature. This term was first used in detail as a categorization like first-order barriers and second-order barriers by Brickner in 1995 (as cited in Ertmer, 1999). This categorization can be seen as a milestone for the following body of research because it has determined the flow of the research trends for the 'technology integration' issue. In this respect, the first assumption was that if teachers could have been provided with enough technological sources such as hardware, time, and knowledge about how to integrate, then the integration would automatically follow (Ertmer, 1999). However, afterwards, it was underlined that the results of many studies were just far away from proving this assumption (e.g., Cuban, Kirkpatrick, & Peck, 2001; Ertmer, 2005). Chronologically, teachers' beliefs as second-order barriers have

become the second phase for the efforts of technology integration. Therefore, following the first assumption, the second provoking question was introduced by Ertmer (2005) in the exact words with which she entitled her study "Teachers' technological pedagogical beliefs: The final frontier in our quest for technology integration?" However, approximately three years later, the literature started to give a place for the studies that questions the final point. That is to say, teachers may not act according to their' beliefs when it comes to using technology (e.g., Chen, 2008; Lowther, Strahl, Inan, & Ross, 2008). Afterwards, the possibility of the fact that beliefs may not be the final barrier to overcome has just appeared, researchers have canalized their whole interest in determining the new barrier (Belland, 2009; Chen, 2008; Kim & Keller, 2011; Tsai & Chai, 2012).

While the international literature can be perceived in such a position trying to detect the new barrier which is thought to be beyond beliefs, it would be overly optimistic to claim that the case in Turkey is at the same level. The studies in Turkey mostly concentrated on professional development and teachers' attitudes (e.g., Uslu & Bümen, 2012), the perspectives of teachers and school administrators (e.g., Akbaba-Altun, 2006; Karal, Aydın, & Ursavaş, 2009; Yalın, Karadeniz, & Şahin, 2007; Yılmaz, 2011). From this perspective, this study gains its originality by catching the international up-to-date trends and putting an effort to fill the current gap in the related literature in Turkey.

This study, in general, tries to detect the current gaps in the related literature. To detect the gaps about not using technology for mathematics education in Turkey, the following three perspectives are used for this study:

1) Teachers' definition of self in integration efforts on technology integration.
2) Teachers' perspectives on the technology-pedagogy relationship and the role of this relationship on technology integration.
3) The effect of teachers' understanding of the nature of technology in today's world on technology integration.

Through the lens of those literature-driven themes, the aim of this study is to develop an original perspective in understanding the barriers in technology integration into mathematics education. More specifically, it aims to go beyond belief-grounded explanations for the barriers to technology integration and try to derive a standing point concerning these three new perspectives.

# CHAPTER 2

# LITERATURE REVIEW

## Technology Integration in the General Picture

Prior to drawing a general picture about the technology, it can be more beneficial to mention briefly about the question "what makes technology important in education". In this respect, the National Council of Mathematics Teachers' (NCTM) technology principle gives one of the most comprehensive answers, yet still vague in various aspects which will be touched upon through the following pages. According to this principle, technology is an inseparable part of mathematics education. Via the proper use of technology, students can learn mathematics through the process of decision making, reflection reasoning and problem solving (NCTM, n.d.). Based on this definition, the whole body of research about technology use in education has so far tried to clarify the word "proper" and to reach an agreement about its scope. Therefore, the question in the beginning evolves to a new one "What is the proper use of technology?"

There is a confusing array of answers about the proper use of technology in the literature. For some researchers, the proper use of technology can be achieved through the stimulation of student-centered learning (Becker, 2000b; Bigatel, 2004; Ottenbreit-Leftwich, Glasewski, Newby, & Ertmer, 2010). According to Ertmer (2005), if technology is formulated as an instrument to foster student-centered curricula, the teachers with teacher-centered beliefs are discouraged by such a definition. Therefore, they are less likely to integrate technology unless the

integration process occurs within a traditional activity. Consequently, student-centered approach in the core of desired definition eventually causes more conflict than it solves.

Some researchers foresee the dead end in the abovementioned definition. Thence, they take a more general stance without providing more details. In this respect, they emphasize the subject of the integration process, namely, teachers or students. Among these researchers, some consider that technology integration is specific to teachers' use of technology during instruction (Babell, Russell, & O'Dwyer, 2004). Hennessy, Ruthven and Brindley (2005) elaborate teachers use by focusing on several headings such as "improving production by the fast pace of instruction, enhancing the variety and appeal of classroom activity" (p. 20). On the contrary, some scholars try to derive a definition dominantly from the perspective of students (Belland, 2009; Cuban et al., 2001; Ertmer, 2005; Lim et al., 2003). Cuban et al. (2001) take this perspective one step further and make an ordinal categorization in which there are two main headings: low-level use such as "typing assignments, working on reports, and doing internet searches" (p. 823), and high-level use such as multimedia presentations, database analysis, and collection and interpretation of original data for a project. While Ertmer (2005) also mentions high and low-levels of using technology, Lim et al. (2003) touch upon the issue by highlighting the classroom management issues. Consequently, besides determining the level of use by teachers and/or students as high or low, or the perspective of student-centered or traditional teacher-centered approach, the Achilles Heel of defining technology integration is the lack of an operational definition which offsets the imbalances mentioned previously. The National Center for Educational Statistics (NCES) reveals

a comprehensive definition in which the responsibilities of all the stakeholders are clearly stated. The definition is as follows:

> Technology integration is the incorporation of technology resources and technology-based practices into the daily routines, work, and management of schools. Technology resources are computers and specialized software, network-based communication systems, and other equipment and infrastructure. Practices include collaborative work and communication, internet-based research, remote access to instrumentation, network-based transmission and retrieval of data, and other methods. This definition is not itself sufficient to describe successful integration: it is important that integration be routine, seamless, and both efficient and effective in supporting school goals and purposes. (NCES, 2003, para.3)

## The Barriers on the Track of Technology Integration Process

After having an understanding about the place of technology in education, researchers seek for efficient ways to integrate it into education. In this respect, the subject of a heated debate in the last two decades has been the obstacles to integration of technology (e.g., Bauer & Kenton, 2005; Ertmer, 1999; Ertmer, 2005; Hew & Brush, 2007; Kim, Kim, Lee, Spector, & DeMeester, 2013; Lowther, Strahl, Inan, & Ross, 2008; Norris, Sullivan, Poirot, & Soloway, 2003; Pelgrum, 2001; Pelgrum & Law, 2003).

In the first years of the technology integration, the pioneers mostly focused on the access issue. In the zeitgeist of that period, most researchers believe that the access stands as one of the most compelling and of the first priority obstacle in the whole process (e.g., Bauer & Kenton, 2005; Norris, Sullivan, & Poirot, 2003; Pelgrum, 2001). One of the first attempts to pass this obstacle is to study and underline the importance of having enough number of computers, software and the internet access (Karagiorgi, 2005; O'Mahony, 2003). For example, the study

conducted by Pelgrum (2001) highlights that the most frequently cited problem by school principals and technology experts in schools from twenty six countries is the insufficient number of computers. Also, parallel with the findings with Pelgrum (2001), in a study conducted with 3,665 teachers, the researchers find a significant relationship between technology access and use, claiming that the strongest factor explaining teachers' use of technology is the access (Norris, Sullivan, & Poirot, 2003).

Then, the understanding of access is subject to evolution. In the exact words, "even the cases where technology is abundant, there is no guarantee that teachers have easy access to those resources" (Hew & Brush, 2007, p. 226). Zhao, Pugh, Sheldon, and Byers (2002) overemphasized the "dependence on technological sources" (p. 500) in their technology integration model. According to this study, the most successful integration experiences are the ones which are less dependent on the sources beyond the control of the teachers. One of the most grounded arguments put forward about the "access to the available technology" is stated in a research in which the authors discusses the results of 1998 national survey of Teaching, Learning, and Computing (TLC) with more than four thousand teachers in the U.S. (Becker, 2000a). In the section where the researchers compare having computers in the classroom and using computers labs, he touches upon a critical point: "However despite such settings having so many more computers than in most classrooms (the typical number of computers in classrooms that have any at all is still only two), the teachers with a reasonable number of computers available in their own classrooms are more likely to provide frequent opportunities for students to use computers than when they have to make use of a computer lab" (p. 6). Then, sharing a computer lab,

namely the sources, inevitably highlights the timing problems such as scheduling or searching available materials.

In addition to having access to the available technology, the "time" issue becomes another topic for researchers to explore. In a study conducted for this purpose, it is found that, according to the participants of the study, one of the most major obstacles, as well as having insufficient number of hardware, is a time related problem (Bauer & Kenton, 2005). Consequently, so far, all pieces seem to fit together. If one teacher has access to the technology and has enough time to plan to use technology, the integration will be fully in hand. However, the teachers as one of the sides of the stakeholders in technology integration efforts, is also in need of being studied to reach the ideal integration. Therefore, the literature points out a new kind of area to question for technology integration: teacher-related problems.

When Shulman reorganized "content knowledge" and "pedagogical knowledge", and termed a new area born from the reorganization of these knowledge types as "pedagogical content knowledge" in 1986, no one could have foreseen that approximately two decades later a new element to this conceptualization would be integrated: Technological Pedagogical Content Knowledge (TPACK). This term was first introduced by Mishra and Koehler (2006). According to their framework, a new element called "technology knowledge" should be integrated into the whole picture. Therefore, besides the one named as "technological pedagogical content knowledge" by Shulman, three different intersecting areas are raised: (1) technological pedagogical knowledge (TPK), (2) technological content knowledge (TCK), and (3) technological pedagogical content knowledge (TPACK) (see Figure 1).

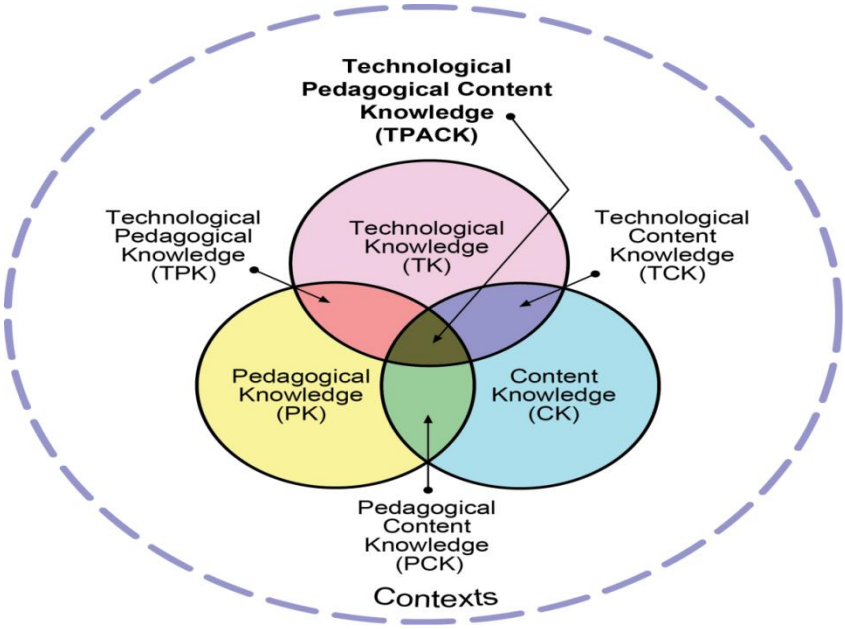


Figure 1. TPACK. (Taken by permission of the publisher, © 2012 by tpack.org)

In this respect, Mishra and Koehler define TPACK in the following way:

> TPACK is the basis of a good teaching with technology and requires 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; knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (Mishra, & Koehler, 2006, p. 1029)

As teachers become the center of question marks related to technology integration, TPACK starts to gain more attention on the track of technology integration (e.g., Archambault & Crippen, 2009; Cox & Graham, 2009; Koehler & Mishra, 2009). Archambault and Crippen (2009) aimed to gather data about the perspectives of k-12 teachers about their knowledge related to TPACK conceptual framework. Among the answers of 596 teachers that participated in the study, the least scored one is under the heading of technology. However, when technology is combined with pedagogy and content, the scores seem to be increased. On the other hand, high correlations are

found between TCK and TPK ($r$ =.743), TPACK and TCK ($r$ =.787), and TPACK and TPK ($r$ =.773) in a study conducted about TPACK. The researchers interpreted these high correlations that there can be theoretical problems in the structure of TPACK (Archambault & Crippen, 2009). Approximately three years after they introduced "TPACK", Koehler and Mishra (2009) revealed what it means to educators from the perspective of technology integration as "it offers for looking at a complex phenomenon like technology integration in ways that are now amenable to analysis and development" (p. 67). Parallel to the argument proposed by Archambault and Crippen (2009), Cox and Graham (2009) highlights the "sliding nature" (p. 64) which reasons that the necessity for this framework may lose validity once technologies are broadly recognized. The basic logic behind this proposition is the idea that "as the technologies used in those activities and representations become ubiquitous, TPACK becomes TCK" (Cox & Graham, 2009, p. 64). In the realm of using TPACK to foster technology integration, one of most promising arguments is that there is a need for longitudinal studies which seek to answer how TPACK shapes technology integration practices as teachers get expertise in profession (Chai, Koh, & Tsai, 2010). Once the focus is on the teacher side, it is inevitable to expect researchers to study the effect of professional development on technology integration.

Parallel to the argument of Chai and his friends (2010), the studies pursuing the effect of professional development on technology integration are usually of the longitudinal form (e.g., Brinkerhoff, 2006; Glazer, Hannofin, & Song, 2005; Luehmann & Tinelli, 2009). Brinkerhoff (2006) conducts a research with twenty-five teachers in a two-year long longitudinal study. The results of the study are categorized under three themes. According to the first theme, it is found that teachers

gain more proficiency as a result of the professional development program. For the second theme, it is observed that teachers show more confidence toward technology integration after the completion of the program. Lastly, the two-year study helped participants to alter their way of teaching. Luehmann and Tinelli (2009) designed a research project in which the effect of blog-based social interactions on the development of professional identities who intend to integrate technology is investigated. Fifteen science teachers participated in a year-long graduate level seminar. The chief outcome of this project is that social interaction with colleagues through blogging serves as an efficient means for teachers to participate in "reform-minded practice" (p. 332). In a distinct study, approximately one year before TPACK, a new perspective was offered: the collaborative apprenticeship model (Glazer, Hannafin, & Song, 2005). This model consists of 4 phases: introduction, developmental, proficient, and mastery. The model is formulated as an alternative to old-fashioned technology integration workshops. Through the community of practice formed among teachers, the model helps to increase the quality of technology integration.

When all stakeholders kindle their interest to allocate a significant amount of time and effort to provide hardware and software for technology integration, some researchers have already started to raise questions about whether it is the final barrier in technology integration (Cuban et. al, 2001; Ertmer, 1999). According to Cuban and his friends (2001), providing enough hardware and software is just a means, not the aim, in technology integration. Ertmer (1999), in parallel, states that "the underlying assumption was that once adequate resources were obtained, integration would follow" (p. 50) in the study in which she conceptualizes the source related barriers mentioned so far as first order barriers. Therefore, as second order barriers,

most researchers start to seek for the answer to ideal technology integration in teacher beliefs. In this new trend, the pursuit of ideal integration leads to a shift in the expectations for teachers from technical competency to a more belief-centered perspective (e.g., Sandholtz & Reilly, 2004).

One of the first attempts presenting the relationship between the barriers, especially on the transition to second order barriers, is to question the linearity of transition, which claims if the first order barriers are overcome, integration will follow (Ertmer, 1999). However, in such simplicity, the researchers discover a brand new phenomenon: the beliefs (Baylor & Ritchie, 2002; Ertmer, Gopalakrishnan, & Ross, 2000; Ertmer, 2005; Kim et. al., 2013). Ertmer (2005) bases the existence of this barrier by claiming that even though the conditions related to first order barriers are all in place, high level use is not frequent. Therefore, this claim puts forward that "additional barriers, specifically related to teachers' pedagogical beliefs may be at work" (p. 36). Considering the issue from a concrete perspective, Baylor and Ritcher (2002) add a new dimension to Ertmer's works (1999, 2005). In their study conducted with ninety-four teachers from twelve different schools, it is asserted that technology integration is explained by two main variables: "teachers' openness to change" and "the percentage of technology activities with others" (p. 411). In a very recent study, the relationship between teachers' beliefs and their technology integration is investigated (Kim et. al., 2013). The study is carried out as a longitudinal one which intends to increase the quality of technology integration through a four-year professional development program. Among twenty-two teachers, who were chosen from a total of forty-two participants based on some criteria such as being an active teachers during the project and participating in the project for at least two successive years, it was found that teachers' beliefs about the nature of

knowledge and learning, and beliefs about being an efficient teacher are significantly connected to their technology integration implementations. It is also stated in this study that first order barriers are taken for granted for the participants of the study.

Once the literature directs the whole focus on an obstacle as the latest in the integration process, a brand new one is sighted on the horizon. Nevertheless, to some researchers' minds (e.g., Melle, Cimellaro, & Shulha, 2003), this process may not to come to an end, with the claim that technology is itself still subject to change. However, since the falsifiability of this idea is highly questionable, the literature does not give convincing attention to this issue. Concretely speaking, some studies try to detect what is wrong with the belief perspective or try to define a brand new obstacle in the horizon (Belland, 2009; Chen, 2008; Kim & Keller, 2011; Tsai & Chai, 2012). In the following section, some recent distinctive studies which intend to go beyond belief-related explanations will be discussed.

## Some Studies with a Distinct Perspective

Chen (2008) tries to detect the relationship between teachers' pedagogy-based beliefs and practices related technology integration. The study is conducted with twelve teachers from a high school where the academic achievement of the students and the quality of technology integration practices are above the average in comparison with other schools in Taipei. According to the results, inconsistency between beliefs and practices stems from three main reasons: "factors related to first order barriers", "lack of theoretical understanding", and "other conflicting beliefs" (p. 69). This study brings a new perspective because, with the first reason, it seeks a solution for the inconsistency by an iterative process. To be more precise, instead of looking for the answer in the belief system, the focus goes back and looks for it in the first level

issues. Belland (2009), on the very other hand, questions the timing of the solution for insufficient technology integration. Specifically, he thinks that all the experiences teachers bring in their k-12 education and daily life should be taken into consideration. In this respect through the lens of the theory of habitus by Bourdieu, teachers' failure to integrate technology efficiently can be understood by the "folk pedagogies" shaped in the years before the teacher education program (Belland, 2009, p. 362). Even though by having a post-belief perspective, Belland has a parallel stance with Chen (2008), but they differ on a major point: Belland isolates the solution from the whole barrier issue. However, they agree on the point that the integration procedure does not progress linearly. In a different study, the track for technology integration is reorganized (Kim & Keller, 2011). The motto of the reorganization is that the role of motivation and volition is underestimated in the general picture. Therefore, together with overcoming first and second order barriers, motivation needs to be integrated in the recipe. In this respect, the study is conducted with fifty-six pre-service teachers to examine the effects of "motivational and volitional messages" (MVEM), which are e-mail messages that are designed to increase the motivation and volition of the participants, on technology integration. The result reveals that, though there is not a statistically significant difference, the pre-service teachers who get MVEM display more volition towards technology integration. In a recent study, design thinking is thought to be a 3rd order barrier (Tsai & Chai, 2012). The main question directs the researcher thinking the existence of a 3rd order barrier is that if both first and second order barriers have been removed, will technology integration happen? The study arguably gives an answer to this question: By ensuring teachers' design thinking such as reorganizing learning materials according to the needs of the groups, can teachers implement technology more

productively and fluently? However, the literature presents no additional data to justify this claim. At this point, barriers relating to technology integration can be summarized in Figure 2.

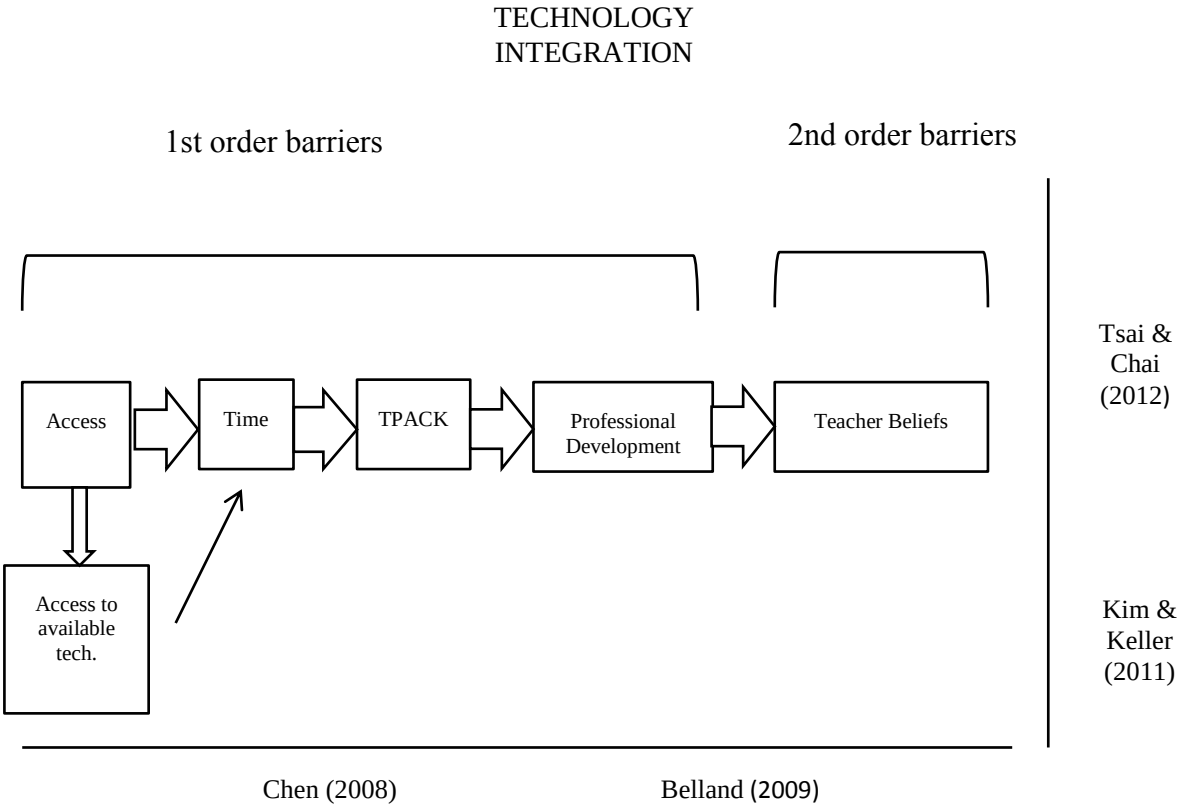


Figure 2. The literature in one chart.

It can be seen that four studies, which are stated under the heading "some studies having a distinct perspective", are positioned further from the general flow of the integration process. Thanks to such a distinct position, these studies offer a broader perspective. Parallel to this recent trend, by trying to answer the following questions, this study targets to develop an original approach to technology integration so that it can open a new window in this chart.

- What is the role of teachers' definition of self in integration efforts on technology integration?

- What are teachers' perspectives on the technology-pedagogy relationship and the role of this relationship on technology integration?
- What is the role of teachers' understanding of the nature of technology in today's world on technology integration?

# CHAPTER 3

# METHODOLOGY

The aim of this study is to develop an original perspective in understanding the barriers in technology integration to mathematics education. More specifically, it aims to go beyond source- and belief-grounded explanations for the barriers to technology integration and tries to derive a stance concerning the three literature-driven themes. In this respect, this study was conducted with six primary mathematics teachers from various schools. Data were collected through semi-structured interviews.

## Research Design

Collective case study design was selected for the study because six cases were determined for the research. In a collective case study, the researcher works with two or more cases in one overall study (Johnson & Christensen, 2010). The collective case study design outweighs the single case study because such a design enables the researcher to offset and satisfy the idea that there might be "artifactual conditions surrounding the single case" (Yin, 2008, p. 54).

## Participants

Six mathematics teachers from different schools participated in the study. While three of them were from private schools, the other three were from public schools. The descriptive data about the participants can be seen in Table 1. Another criterion for the selection of the participants is experience. For this reason, the participants are

selected accordingly so that two public school teachers have experience of less than 3 years and the other participant working in public schools is experienced more than three years. For private schools, two participants are experienced more than three years while one is experienced less than three years. Also, to ensure confidentiality, participants' real names were not stated in the study. Instead, a pseudonym was assigned to each participant considering their gender.

Table 1. The Descriptive Data about the Participants

| Teacher | School | Gender | Experience |
|---|---|---|---|
| Bahar | Private | Female | <3 |
| Ege | Public | Male | <3 |
| Barış | Private | Male | >3 |
| Elif | Public | Female | >3 |
| Pelin | Public | Female | <3 |
| Onur | Private | Male | >3 |

Convenience sampling method is used for the selection of the participants. The main advantages of this sampling method over the other types for the present study are first that it is the choice of most accessible participants, and that it enables to save time and effort in the whole process of the study (Marshall, 1996).

## Instrumentation

The main data were collected through semi-structured in-depth interviews with the participants. The literature was studied to construct the interview questions in coherence with the aim of the study. In this respect, the study of James (2009) was selected to adapt the interview questions since this study similarly seeks for the perspectives of middle school teachers about technology integration. The researcher developed the interview questions (see Appendix A) on the theoretical background of the four elements of diffusion, which are innovation, communication channel, time,

and the social system, offered by Rogers (1995). After determining the theoretical framework, the interview questions go through a dynamic process in which some modifications are made based on the answers of the participants. By doing so, the researcher aims to gather, initially, general information and as the interview proceeds, more specific data can be gathered (James, 2009). Since the adaptation process of this instrument is one of the critical parts of the study to ensure the trustworthiness of data; two interview trials with modified questions (see Appendix B) were conducted as a pilot study. Thus, by doing a pilot study, the aim was to make the instrument optimum in allowing participants to share their ideas in a coherent context concerning the main themes of the study (Ritchie & Lewis, 2003). Two mathematics teachers voluntarily participated in the pilot study. In the following part, the route to the final version of the interview questions will be stated.

## The Pilot Study and Interview Question Development

The original version of the interview consisted of 40 questions. For the purpose of doing in-depth semi-structured interview, the questions were revised both from the perspective of length and the content with a content expert to ensure the adaptation process with respect to content-related issues. Under the guidance of content-expert, these forty questions were revised. Even though there is not one right answer for the ideal length of an interview (Berg, 2000), the questions were narrowed down to be more consistent with the aim of the study. In this respect, some questions were combined into a single question. Also, probe questions were added to some questions. Lastly, some questions were added to require participants to particularly consider mathematics learning and to reflect deeper thoughts specifically about the aim of the study. After considering all these points, the interview questions were

accordingly designed to be used in pilot studies (see Appendix B). To test the current version of the questions, a pilot study with two primary mathematics teachers was conducted (See Table 2). In the following part, the details about the pilot study and the process to the final version of the questions will be mentioned.

Table 2. The Descriptive Statistics about the Participants in the Pilot Study

| Teacher | School | Gender | Experience |
|---|---|---|---|
| Teacher 1 | Public | Female | 6 years |
| Teacher 2 | Public | Female | 5 years |

First, the descriptive information asked throughout the whole interview was added as a separate part in the final interview. By doing so, it aimed to form an atmosphere in which the participants could share their in-depth observation and knowledge, not the basic information about them. After this separation and the other changes, the final version of the interview consisted of 11 questions (see Appendix C).

Prior to giving the details about the changes with their justification, it can be more beneficial to mention the theoretical classification of interview questions and about the only question added for the final version after pilot study was conducted. In this respect, each question was determined to refer to one of the perspectives this present study seeks to develop. With this respect, questions 1, 2, 3, 6, 8c and 11 go under teachers 'definition of self in integration efforts (Theme 1); questions 4, 5 and 11 go under teachers' perspectives on the technology-pedagogy relationship (Theme 2); and questions 7, 8, 9, and 10 go under teachers' understanding of the nature of technology in today's world (Theme 3). A new question (7) in which the participants are asked to put themselves in the given scenarios (see Table 3) was added after the pilot study.

Table 3. The Scenarios in the Interview

| Scenario No. | The Case |
|---|---|
| 1 | You want to pay your bills on time. |
| 2 | You heard a useful website for your teaching skills. |
| 3 | A friend of yours recommended you a nice book so you want to buy that book. |
| 4 | You want to follow the writings of a columnist on a regular basis. |
| 5 | A student's parent is given an appointment for 20 days later. You need to remember. |

This question aims to dig up the past experiences of the participants or their possible stances in such cases. Therefore, in such narrative-telling format, it can give more clues about the real meanings attributed to those experiences (Riessman, 1993). In Table 4, the process the interview questions have undergone can be seen.

Table 4. The Justifications of the Questions in the Final Version of the Interview

| Theme | Question | Explanation/ Justification |
|---|---|---|
| Theme 1 | 1 | Both participants in the pilot study made a differentiation between the courses taken in undergraduate education and the ones taken in graduate education. Therefore, a probe question is added to clarify such a differentiation for the actual participants. |
| | 2 | This question remained unchanged. |
| | 3 | This question remained unchanged. |
| | 6 | In the pilot study, what are the expectations of today's students vs. teachers' self-sufficiency in integration efforts was asked towards the end of the interview, exactly after 10th question in Theme 3. However, since it, at the first glance, seems to question their qualification as a teacher, they approached this question with a skeptical manner. Therefore, to diminish the possibility of encountering such a case in the actual interviews, it was decided that this question would be added as a probe question, instead of stating as a separate question under 6th question which is thought to be more consistent with this question. |
| | 8.c | In the pilot study, this question was theoretically designed under Theme 3. However, the participants mostly defined the teachers' stance in integration efforts while they were explaining the stakeholders of technology integration in education. Hence, this probe question is decided to be moved under Theme 1. Even though the content of this question remained unchanged after the pilot study, the theoretical framework of the questions was changed. |
| | 11 | This question remained unchanged. |
| Theme 2 | 4 | This question remained unchanged. |
| | 5 | This question was asked as two separate questions in pilot study (questions 9 & 12). However, to make the transition better to the probe question about educational choices of teachers (5.a & 5.b), it was decided that these two questions would be combined for the final version of the questions. |
| | 11 | This question remained unchanged. |
| Theme 3 | 7 | This question was intended to be asked as a probe question (20.a) in the pilot study version. On the other hand, with both participants in pilot study, the intended data was not properly collected because 20th question in the pilot interview had already a heavy content. Therefore, initially this part was decided to be separated. However, this question even could not be asked to one participant (teacher 1) after the researcher had to intervene for the 20th question many times and the other participant (teacher 2) did not seem to be able to propose further argument after first reaction (No, I don't think so). As a result, the nature of this question is decided to be changed. In this respect, a narrative format is used to get more clues and in-depth data. |
| | 8 (except 8.c) | In the pilot study, a question was used to gather data about using homework in technology integration and this question has a probe question about homework. However, in both interviews of the pilot study, it was observed that with homework questions, the focus shifted to student perspective which is beyond the scope of this study. Also, because of the shift in the focus from teachers to students, the flow of the interview was seen to be disrupted. By taking these points into consideration, the homework-based questions were eliminated. |
| | 9 | In the interview with one participant (teacher 1), in the flow of this question, another probe question as "According to you, what would be taken as a means to offset such a variance?" The participant teacher proposed lots of content in the reply. Consequently, this probe question was added under the 9th question. |
| | 10 | This question is the original version of narrative-telling format question (7th). This question is stated towards the end of the interview after participants already answer the narrative question. It is aimed by this question to back up the data gathered through the narrative one by comparing and contrasting the two data. |

# CHAPTER 4

# FINDINGS FOR WITHIN CASE ANALYSIS

## Case 1: Bahar

Bahar is a novice teacher who has one year teaching experience. She has a master's degree in mathematics education. She is working in a private school. She graduated from the mathematics department of the faculty of arts and sciences. Thus, in graduate education, she got familiar with educational applications since she decided to get her master's degree in primary mathematics education (see Table 5).

Table 5. Demographics about Bahar

| Participant | Bahar |
|---|---|
| Teaching Experience | 1 year |
| Private / Public | Private School |
| M.A./ Ph.D. | M.A. |
| Technological Devices | Smartphone, Personal P.C., Tablet |

In her thesis, she specifically focused on the use of dynamic software in mathematics education. She says it was really beneficial for her to spend time to study on such software for her thesis because this makes her more adaptable to making research and putting some effort needed to efficiently adapt some technology to her teaching style. Succinctly to say, as in her words, "I am a teacher who really wants to create the best atmosphere for learning. In today's world; it is mostly possible through technology."

## Theme 1: Teachers' Definition of Self in Integration Efforts

### What should be the Characteristics of a Teacher?

Bahar thinks that, first of all, a teacher needs to believe that learning occurs in the whole life span. Therefore, learning does not stop for a teacher when they are graduated from university. Inevitably, such life-long learning can be achieved with a continuous desire for research according to Bahar. Another point Bahar emphasizes is that teachers always should be flexible in case of the need for plan B. When I asked her how she would react when she needs to use software that would cost much both to parents and the school administration, she replied:

> A teacher needs to be flexible to the conditions of both schools and parents. For example, if the financial status of the students in a class is not that good, then I cannot ask parents to buy that software for the class. Then, I would try to find a free alternative to that software. There are many free materials I guess I can use in that case. If this is not possible, trying to contact with the producers of that software for a possible discount could be another way. (Bahar)

The cooperation with colleagues is another point. To Bahar, the cooperation with colleagues has a considerable place in the efforts of a teacher for technology integration. The cooperation, in this sense, has many subheadings:

Multi-disciplinary atmosphere: Through the communication with teachers from other departments such as science or language courses, a multi-disciplinary atmosphere can be created. In such an atmosphere it can be easier to motivate teachers to take the initiative for using technology as Bahar underlines. However, at the same time, some negative attitudes towards technology use and some imprecise applications can be very demoralizing in the following way:

> When some people see someone who is very interested in technology, they can think that "we are nearly surrendered by technology already, there is no need that much for technology in education. Even, technology is not that useful in education as you think." Such comments make me discomfort…When I see enthusiastic teachers about technology, this makes me more motivated indeed. However, when I see some, especially young, teachers who do not favor technology use in education, this really makes me sad. (Bahar)

Creating this atmosphere is also important because it can enable teachers to encourage each other to participate in seminars or workshops about technology in education. Bahar says that she participated in a seminar about technology in education thanks to one of her colleagues.

Creating materials as the product of cooperation: She takes a multi-disciplinary focus one step further and claims that a teacher can create materials together to competently use technology. To do so, she thinks that the physical conditions of the school and scheduling need to be arranged:

> To create time and places in which teachers can communicate, producing and sharing ideas about technology can be beneficial. That's why, arranging a place and time for teachers to meet specifically for this reason is important. (Bahar)

What is the Ideal Training for Teachers?

Prior to any kind of education, Bahar thinks that teachers need to understand the purpose of using technology. The purpose, then, is: "To academically take the school and students one step further. If every stakeholder agrees on this aim, then the achievement will occur." (Bahar).

After creating an atmosphere where everybody shares the same aim, the second issue can be the form of the training. In this respect, the communication with universities and schools plays an important role. Especially this communication gains

more importance considering the rapid changes in technology. While stressing the importance of assisting teachers, she says:

> In these days, it is not that easy to follow the developments in technology. So, this difficulty can be counterweighed by providing teachers with courses. And, the content of these courses shouldn't be in the form of providing very concrete receipts because, then, it may put a pressure on teachers. Instead, with the active participation of teachers, universities and schools need to work in cooperation. In that case, since teachers internalize the need for technology on their own, they will be the ones who take initiatives to use technology. (Bahar)

Even though she thinks providing concrete receipts are not the solution, she further states that in such trainings, teachers need to be provided with concrete examples of technology in mathematics education. Therefore, for teachers, such courses can yield more pragmatic opportunities to use technology. Last but not least, she considers that the Ministry of National Education has the greatest responsibility to help teachers to use technology effectively. She puts forward that, besides organizing seminars and workshops about the use of technology, in the process of designing curriculum the Ministry should reach more teachers to ask their ideas. This reflective collaboration for designing the curriculum will also enable teachers to create opportunities to incorporate technology into their teaching. In Figure 3, the representation of Theme 1 for Bahar can be seen.

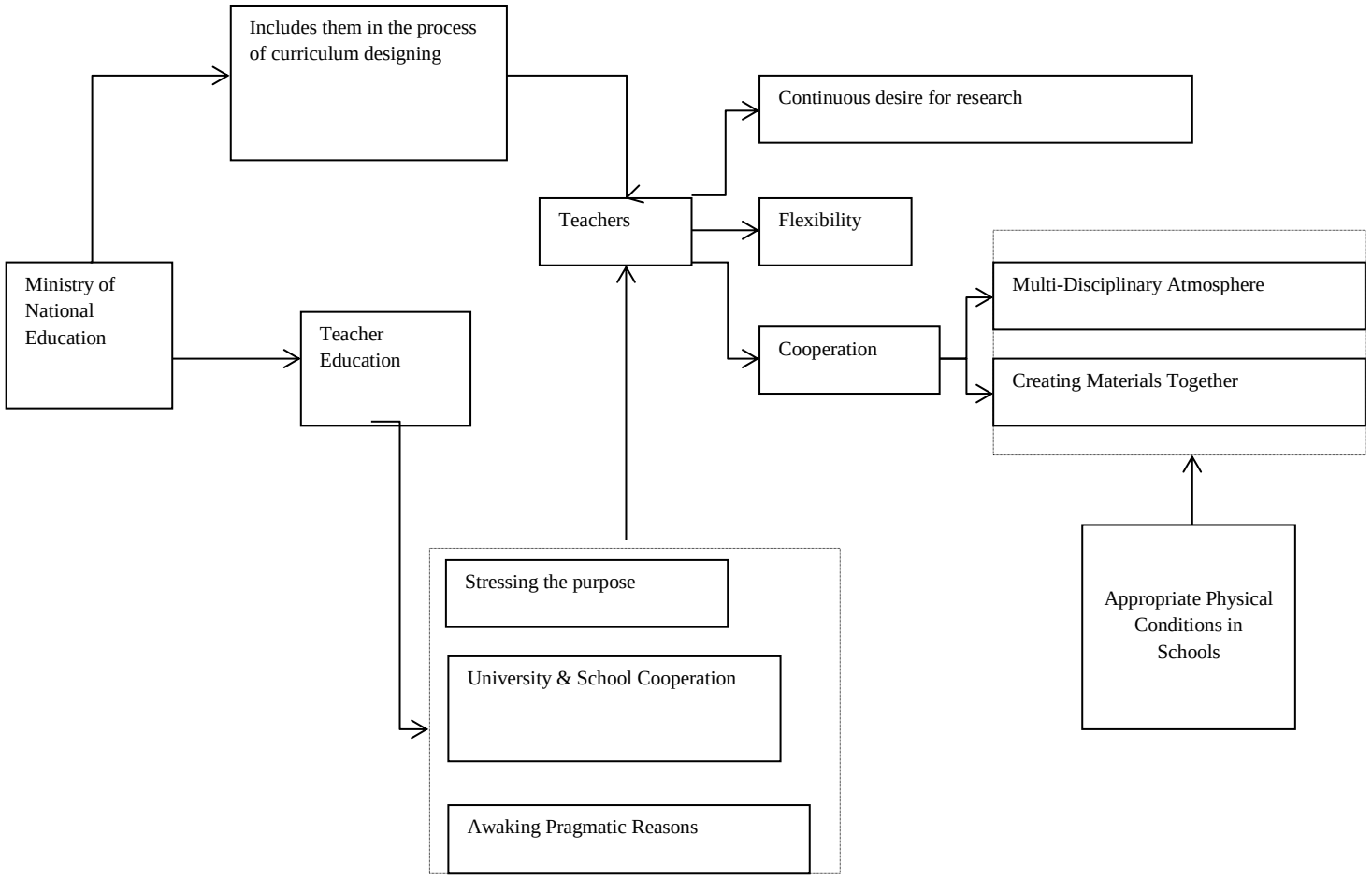


Figure 3. The representation of Theme 1 for Bahar.

Theme 2: Teachers' Perspectives on the Technology - Pedagogy Relationship

Any pedagogical step, to Bahar, needs to be taken while considering the needs of students. Therefore, pedagogically speaking, creating the most appropriate atmosphere in the class is of critical importance. In this respect, she underlines that: "I think the mission of a teacher is to form the ideal environment in a classroom for the learning of students. This is placed on the top in my educational philosophy." (Bahar). She further elaborates the ideal environment as the atmosphere in which students have the necessary skills to use the technology and they are encouraged to apply those skills. She says:

> Teachers need to ask themselves what kind of profile I would like to help my student to gain. To me, I really want to have students who can keep up with the requirements of the 21st century, namely, working in groups, being innovative, and using technology efficiently. (Bahar)

To encapsulate the meaning of this quotation, it can be asserted that the students' profile in Bahar's mind has three important features as the requirements of the present century: the ability to work in groups, the ability to use technology, and being innovative. She concretizes "using technology" by stating that using technology in a classroom attracts students' attention. As a result, this helps teachers make ideal learning occur. Similarly, Bahar thinks that teachers needs to adapt themselves in the classroom according to the styles their students learn best, not according to the method they teach best. Therefore, she explains the reason for using technology by constructing on the comparison of teaching method and learning style:

> At the end, if our ultimate aim is to create the ideal learning, then we cannot construct this according to our teaching methods. For example, if using technology makes the students more motivated towards lessons, more successful, and more socializing persons in their future life, then even though the teacher does not like to use it, he or she should use technology. We need to prioritize the needs of students more. (Bahar)

However, she adds that this should not mean that all teachers have to adopt the same method into their teaching. Indeed, she claims that diversity in teaching methods should be respected as long as there is a harmony between teachers and students. However, additionally she says: "When efficiently and consciously adapted, technology can be combined with any kind of teaching method." (Bahar). In general she summarizes that the pedagogical stance of teachers on the use of technology should be in accord with the needs of students.

### Theme 3: Teachers' Understanding of the Nature of Technology in Today's World

To propose a general picture, the answers to the scenarios are listed in Table 6 prior to detailed analysis for Theme 3. In the following part, the analysis of Theme 3 through the lens of these scenarios will be stated.

Table 6. Bahar's Answers to the Scenarios

| Scenario No. | The Case |
|---|---|
| 1 | I am using automatic payment. |
| 2 | I would try to note down on my smartphone. |
| 3 | I would buy on the net. |
| 4 | I subscribe to the site of the columnist. |
| 5 | I am using Google Calendar. |

Bahar thinks that any technology in general can be used for educational purposes. In other words, with an appropriate educational perspective, any technology can be converted to educational use. She explains this conversion with a popular tool these days:

> To me, there is not such a distinction as general technology and educational technology because we can use any material in the lessons. For instance, Facebook can be considered as a social media tool for communication. However, at the same time it is a web 2.0 tool. Therefore, it can also be categorized under educational technology. (Bahar)

In the following part, the three objects of her main idea, which are general technology, appropriate educational perspective, and educational technology, will be elaborated.

General Technology

She first points out that people always need to be careful when using technology. Otherwise, without self-control they may become addicted to technology. Otherwise, technology becomes the most dominant factor in peoples' lives. She adds that creating technology-free hobbies and times can play a vital role:

> As a person and teacher, I really support the use of technology in education and daily life. However, at the same time, for me, the enjoyment of reading a book with touching its pages is much more than reading it online. (Bahar)

Appropriate Educational Perspective

In the transformation of general technology to educational one, teachers take the responsibility. Therefore, to Bahar, this responsibility requires being able to detect the appropriate technological tool and to use it in the right time and place to achieve this transformation. By generalizing the timing issue, she emphasizes the importance of taking measures according to the age of the children while using technology. Otherwise, exposing them to technology in early childhood may harm their physical development:

> At the end, children also need to play with soil, plant a flower and they may even need to do needlework. That is, they need to exercise for the appropriate development of psychomotor abilities. Thus, it may not be a healthy idea to introduce students with technology in early childhood years. (Bahar)

Educational Technology

The wide array of options in educational tools for mathematics education has many important outcomes according to Bahar. First, she thinks that having a wide range of options for teachers is motivating because it indicates that there is a remarkable effort to integrate technology. However, at the same time, when teachers have many options in hand, this may make teachers feel that trial and error is a legitimate way of improving their teaching methods. This fallacy, according to her, leads to another negative outcome:

> Teachers say "I used this technological tool last time but it did not work out. So, next time I better use another one". In that case, the lessons become a guinea pig. Then, this inevitably leads to a waste of time. (Bahar)

She proposes that guiding teachers not to get lost in these options can be a solution for those two negative outcomes. In such guidance, teacher can be provided assistance to choose the appropriate technological tools to cover specific objectives. However, while doing so, she adds that such trainings should encourage teachers to make a need analysis, instead of dictating teachers follow an objective-technological tool match. In Figure 4, Bahar's views related to Theme 3 are schematized.

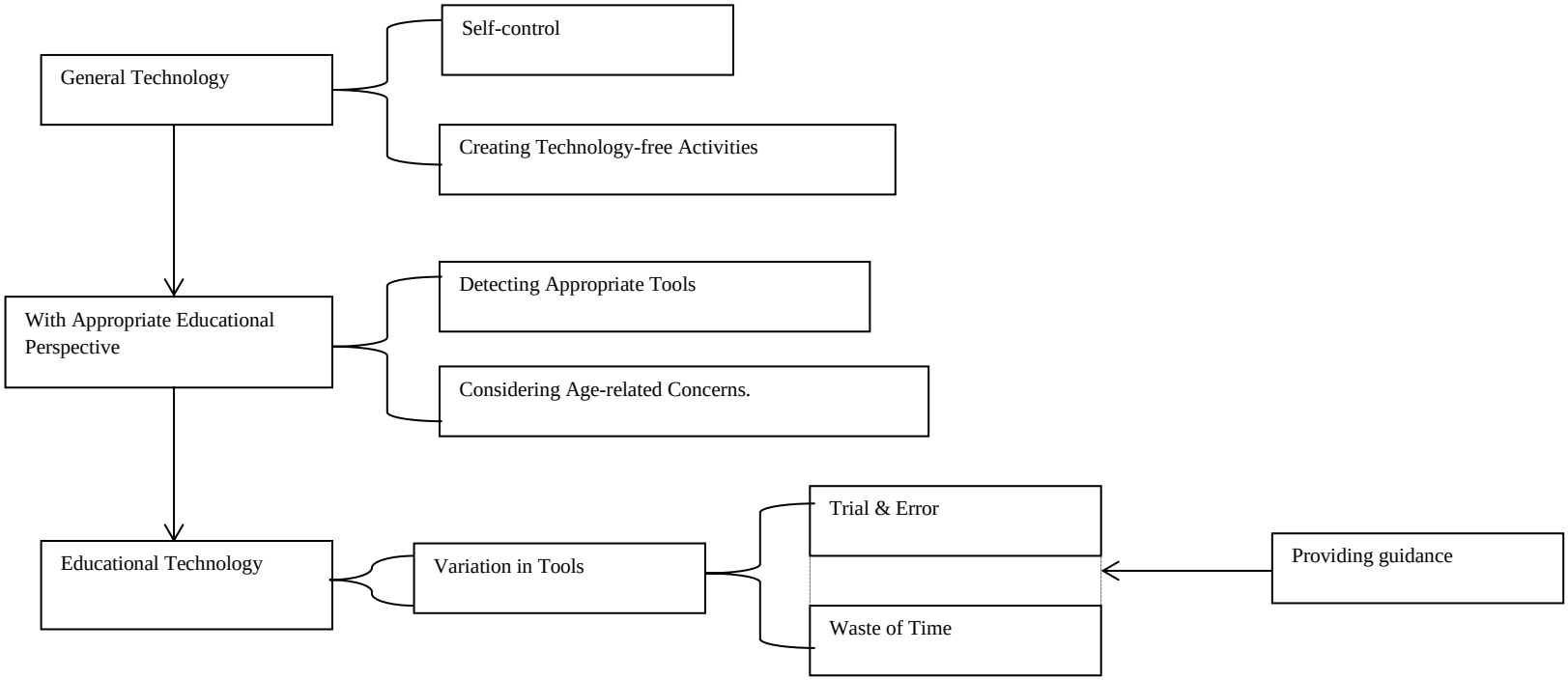


Figure 4. The representation of Theme 3 for Bahar.

## Case 2: Ege

Ege works in a public school. He has two years' experience in teaching. He has a master's degree in mathematics education (see Table 7). In his graduate education, he mostly concentrated on teaching fractions by using problem solving strategies in primary education. He summarizes his way of seeing the world and himself as a teacher with the proverb "enough is as good as a feast." Similarly, he thinks that this philosophy also holds true for using technology in education.

Table 7. Demographics about Ege

| Participant | Ege |
|---|---|
| Teaching Experience | 2 years |
| Private / Public | Public School |
| M.A./ Ph.D. | M.A. |
| Technological Devices | Smartphone, Personal P.C. |

### Theme 1: Teachers' Definition of Self in Integration Efforts

#### What is the Role of Teachers?

First, Ege thinks that teachers are responsible, to some extent, for the integration of technology. He therefore states that equilibrium should be reached between teachers and Ministry of National Education. In this respect, he states the following:

> At this point, teachers definitely have some inabilities. I think besides teacher training, teachers also have to show enough effort. Also, the Ministry of Education should assist teachers in those efforts. For example, how can I learn to use smart boards on my own? The Ministry should provide me with technical support. As a result, we need to state a balance here. (Ege)

The Ideal Atmosphere

He further comments on the ideal atmosphere for technology integration. According to him, the available hardware is one of the dominant factors affecting teachers' use of technology. He says that the available technology can encourage teachers to use them in their teaching methods. For example, he postulates that:

> Science teachers are using the technology more frequently than other departments in my school. I think the reason of this is that science classroom has an interactive whiteboard. Thus, since there is not a normal board, the teacher compulsorily uses it. That's why he always has to follow the internet to download useful materials. (Ege)

What if teachers do not have adequate technology in their hands? For example, he has a mathematics classroom where he can use some concrete materials. However, in this classroom, there is not an interactive whiteboard with an internet connection. Therefore, he takes his students to a computer lab when he needs to use technology. Nevertheless, such mobility, besides its pedagogical outcomes – which will be mentioned separately in the next section – causes timing problems for teachers. Since the computer lab is used by many teachers for various courses, scheduling of lab hours can be problematic according to Ege. As an alternative solution for the mobility of students, the social sciences teacher in the same school as Ege asked the president of the Ministry of Education for help to have an interactive whiteboard in his classroom. Therefore, he states that having a communication with local leaders may be helpful to overcome first order obstacles. In essence, he summarizes the responsibility of the teacher in efforts for the integration of technology: "When I come across with a new technology, the difficulty for me is to use it at the first place. Then by sparing my leisure time, I try to go into this new technology." (Ege).

## Theme 2: Teachers' Perspectives on the Technology – Pedagogy Relationship

The conversation with Ege about this relationship was mostly shaped by two arguments: Why use technology, and motivation problems concerning pedagogical issues. In the coming part, these two headings will be mentioned.

### Why Use Technology?

Ege counts many reasons for using technology, such as saving time, reducing paper consumption, student motivation, better use of the board, and effective use for proof. First, he bases his time-saving perspective on the idea that with the help of technology, preparation time decreases. Also, he adds that using technology helps teachers to make the pace of the lesson faster. Besides saving time, decreasing cost and making better use of the board are other two other reasons for using technology. He thinks that better use of the board also helps teachers to display a proof-related problem in a more effective way: "I think the drawings are more accurate when you use technology. Once, there was a problem related to bisectors. To prove the solution of this question, I used the interactive whiteboard. It was very effective." (Ege).

Although he does not order these reasons for using technology according their importance, two items comes to the forefront when a probe question was asked: "Could you still achieve the objective of the lesson if you did not use technology in your teaching method?" He replies: "Yes, I could. I could prepare the materials as a hard copy handout to the student. Nevertheless, since it requires photocopying and therefore using paper, those would cost more time and money." (Ege).

Motivation as a Pedagogical Concern

He thinks that the physical conditions have a crucial role for the motivation of students. In his school, he has a mathematics classroom. As it was stated in Theme 1, there is not an internet connection for the interactive whiteboard in this classroom. Therefore, he has to take his students to the computer lab whenever he wants to use a material that requires internet connection or interactive whiteboard. First, he asserts that having a mathematics classroom serves an efficient means to create an atmosphere for the learning of mathematics. He bases this proposal on the following idea: "In our mathematics classroom, students always know that we will do mathematics in this classroom so it becomes easier for me to keep them motivated about the lesson." (Ege). Therefore, when he takes the students to the computer lab, he directly thinks that he loses this advantage. In addition to losing this advantage, he thinks this may even become a disadvantage. That is to say, the thinking of the students is that if they go out of mathematics classroom for an activity, then this activity must not have much to do with mathematics. Therefore, such a way of thinking creates an unsuitable environment for the motivation according to Ege. Through an objective lens, if a motivation-meter can be invited, one can say that motivation is really high in the computer lab when students work on technology related activities. However, pedagogically speaking, Ege read this situation as follows:

> It would be like a dilemma but while the motivation of students is increasing, this motivation increase is getting far from the core of the lesson. This is not an increase towards the core mathematics behind the lesson, indeed they just want to use technology such as the interactive whiteboard. For example, even a student who actually does not show any interest in the lesson can be very active in such lessons just for the sake of using technology. (Ege)

Actually, therefore, the method used by the teacher in that lesson becomes the aim in the eyes of the students. To Ege, this fallacy makes them miss the real mathematics in the lesson. Lastly, he puts forward that the place of technology in students' daily lives can be questioned. Namely, the frequency of using technology in their daily lives determines the contentedness of students towards the technology in schools. The students in his school exemplify this condition as follows:

> Also, my students are mostly coming from low-income families. Therefore, they have a strong desire to use technology in schools since they do not have such a chance at home. Thus, this inconsistency may cause them to be much more motivated to use technology instead of using them as a tool to learn the lesson. To tell the truth, if my students were more saturated towards using technology in their homes, I think the atmosphere in schools could be much different in a positive way. (Ege)

As a result, in a pedagogic sense reaching an effective result via technology is also affected by how familiar students are with technology in their daily lives. In essence, he defines such kind of motivation as "extracurricular motivation*"* and this should be controlled by teachers' effort concerning classroom management issues.

Theme 3: Teachers' Understanding of the Nature of Technology in Today's World

To draw a general picture, the answers to the scenarios (see Table 8) are presented prior to detailed analysis for Theme 3. In the following part, the analysis of Theme 6 through the lens of these scenarios will be stated.

Table 8. Ege's Answers to the Scenarios

| Scenario No. | The Case |
|---|---|
| 1 | I am using automatic payment. |
| 2 | I would use my smartphone to note down the name of that site. |
| 3 | I would buy on the net. |
| 4 | I am using Twitter to follow. |
| 5 | I would set up a reminder in my smartphone. |

Ege thinks that there is an apparent distinction between technologies used for educational purposes and technologies used for general purposes. However, according to him teachers can be the ones who can determine the existence of such a distinction:

> I think this is completely dependent on the awareness of the teacher. If the teacher has high awareness, he or she can apply any kind of technology into education. Therefore, there exists no such distinction for such a teacher. At the same time, some teachers can only apply technologies which are specifically designed for educational purposes. (Ege)

As a result, he thinks that for integrating technology, increasing teachers' awareness can be an important multiplier.

Technology and Our Lives

Ege does not deny that technology has an important role in today's world. However, while technology plays its role, to him, people are exposed to technology. Therefore, they become passive and lose control. In this respect, he defines his stance as follows:

> The school I am currently working in is not that technologically equipped. After all, I am not bothering myself with the thought that 'I always need to use technology'. I believe technology should be used for some specific chapters in mathematics so I am not challenging myself to integrate it for every single chapter. In a word, I switch on technology when I need to use it, and after I am done, I switch it off. (Ege)

Therefore, technology in his eyes backs up the "enough is as good as a feast" proverb. Also, his point of view about the place of technology in education holds true for the technology in daily lives. He believes that people can take some steps to control the technology in our lives. For example, when he has a chance, he prefers to shut down his computer at home or cut the internet connection of his smartphone.

The Variety of Options for Using Technology

He argues that the diversity in the available options for technology makes it more difficult to integrate technology for educators. He further adds: "In such a confusing array of options, the idea that I need to learn about all of these makes me feel discomfort." (Ege). However, since he cannot spend that much time on learning about all of these technological innovations, he pays attention specifically to the ones which can meet the objectives of what he decides to teach students. Consequently, needs analysis is his solution to overcome the disadvantage that comes along with the variety of options for using technology in education.

Besides his personal stance on this phenomenon, he states two distinct perspectives needed to be taken into consideration: young teachers and experienced teachers. For the young teachers, since they were born into the technological development of the age, they are more familiar with the latest developments in technology. Also, the changes in technology after some point progress in a systematic way according to those teachers, so they can keep up with these changes more easily. On the other hand, for experienced teachers, the technology already seems to be a very tough challenge. Hence, any advancement or brand new perspective just adds new dimensions to the already existing problem. In sum, while the nature of technology in today's world can be manageable and beneficial for young teachers, for more experienced ones, it can be a problem which obtains another dimension after any advancement in technology.

## Case 3: Barış

Barış is one of the most experienced teachers in this study. He has worked as a mathematics teacher for 9 years. He worked in many private schools during these 9 years and he did not have a chance to work in a public school (see Table 9).

Table 9. Demographics about Barış

| Participant | Barış |
|---|---|
| Teaching Experience | 9 years |
| Private / Public | Private School |
| M.A./ Ph.D. | None |
| Technological Devices | Smartphone, Personal P.C. |

He graduated from a primary mathematics education department. Even though he did not pursue master's degree in his career, the academic environment is not unfamiliar to him. He made some presentations and displayed some materials he created in seminars and workshops. Prior to going into more detail, it can be beneficial to state his understanding of technology in a few sentences. Contrary to the popular belief that technological advancement fosters the social relations in today's world, he thinks that technology deforms those relations. That is to say, with such a socialization understanding, "We can raise up a generation who can save the world in cyber world, yet when it comes to reality, who cannot even construct a sentence in front of three people." This idea does not differ too much when it comes to technology in education. In short, he does not attribute too much pedagogical meaning to technology in education:

> I think technology mostly is the fun face of education. I am using technology because the children are active users of technology in their lives. Therefore, using technology serves as a tool for me to speak the same language with my students. (Barış)

## Theme 1: Teachers' Definition of Self in Integration Efforts

Barış defines teachers' stance in integration efforts from a chronological perspective. In this perspective, pre-service and in-service are the two reference points.

### Pre-service Teachers and Technology

He first thinks that teacher education programs should provide teacher candidates with concrete outcomes for using technology in their classrooms. For example, he shares "In one of the lessons, we were taught how to construct a website but in that lesson I did not learn how to put that website online." (Barış). Therefore, he claims that such courses should be designed in an outcome-oriented manner which specifically demonstrates every single step of the technological material targeted. Besides aiming for an outcome-oriented design, for Barış, designing all the activities only intended for students' use is another crucial point. To be precise, teacher candidates should be provided with the opportunities to test the materials they create with real students. In this regard, the directors and designers of teacher education programs should revise the contents of the teacher education programs to create such opportunities.

### In- service Teachers and Technology

To have teachers who can efficiently integrate technology into their teaching methods, Barış stresses that it is inevitable to present them good role models. For that reason, in-service training is an invaluable method to exhibit good examples of using technology. However, he underlines that in such trainings creating an atmosphere that encourages teachers to internalize the materials they practice in these trainings is very critical. Also, creating such an atmosphere is vital to make teachers be reflective

in their work. Otherwise, in Barış's mind, teachers just become the imitators of those examples so, in time, their motivation will inevitably go out. He bases the idea on a metaphor 'learning a computer program':

> Using technology efficiently in education cannot be achieved through a couple hours of in-service training provided by the Ministry of Education. On the top of it, is it not like learning a computer program? They show some general guidelines to you in the beginning about the program. Then, if you do not play with the program on your own, you cannot learn it. Obviously, you can make some mistakes at first, but after some time you learn from those mistakes and you start to learn how to fix them. I think learning after such trainings can also proceed like this. (Barış)

Also, in the trainings, directing teachers to update the technological devices according to the requirements of the present day is another point that needs to be considered. For example, he states that using an overhead projector has become old-fashioned thanks to the interactive boards who can serve as even a computer. In this respect, he thinks that informing teachers to revise the technologies can be another objective of in-service trainings.

Teachers' Profile and the Appropriate Working Environment

After sharing some points about preparing teachers to use technology in an efficient way, he draws an image about teachers' profile and the appropriate working environment. In this respect, he attributes an importance to the relations both between and within the departments in schools. The assumption in this attribution is that teachers can learn from each other. He gives two examples to stress its importance. First of all, within the department, when a teacher in the department comes across a new technological tool, they mostly argue the usefulness of this tool in their department meetings. Secondly, for the importance of the relation between departments, he states:

> For example, I recently used a website to teach 5th graders about measurement of length. I heard that site from a colleague in foreign language department. She was using that site to make matching activities. And, it is really also useful for me too for some topics. (Barış)

Also, he adds another example; after the end of the semester they, as the mathematics teaching department, requested training on using advance Microsoft Excel under the supervision of a computer teacher.

Lastly, but as in his words 'most importantly', teachers need to keep their enthusiasm alive during their whole career. In this respect, internal motivation and the effort put by teachers play a significant role to achieve efficient technology integration. Consequently, he underlines that no matter how efficient in-service training programs teachers are provided with, without internal motivation and self-effort, it would be over-optimistic to expect positive results. The representation of Theme 1 for Barış can be seen in Figure 5.

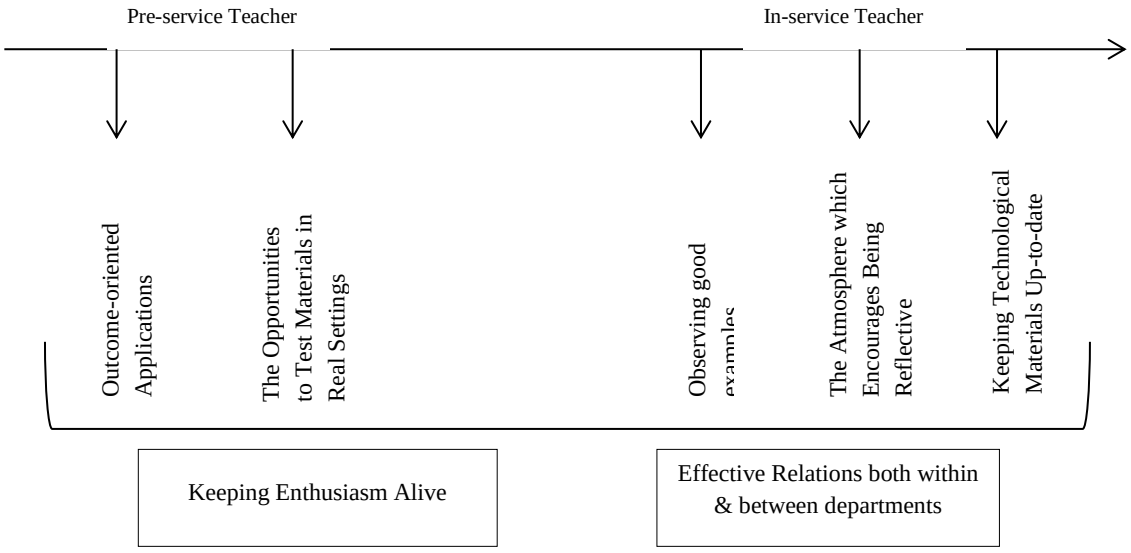


Figure 5. The representation of Theme 1 for Barış.

## Theme 2: Teachers' Perspectives on the Technology – Pedagogy Relationship

### Being a Teacher and Technology

To start with the quotation "Pedagogically speaking I cannot tell that technology is in the center of my teaching." (Barış) can be the best way to reflect technology in his teaching philosophy. In the following part, what he attaches priority to is going to be stated.

Initially, he thinks that it is of very critical importance to raise students as individuals who are self-sufficient in life. Technology plays a secondary role in this kind of education.

> I had a chance to have a conversation with Ali Nesin about technology in mathematics education. He said to me: 'we cannot turn down the technology. However, I do not think that being smart is related to the use of technology. If a kid can stay on his own without getting bored or intelligently pass the time on his own, this means that you are doing a great job for the education of that kid.' I do completely agree with him. (Barış)

As a result, technology can play a necessary but not sufficient role in education. Besides the image of general education, he also questions the place of technology specifically in mathematics education. According to him, teaching mathematics with concrete materials generally yields more positive outcomes. In other words, he states:

> Yes. You can teach many topics in mathematics by using technology. However, I experience that working mathematics with concrete tools is more important and effective in most cases. For instance, if you can teach fractions with Cuisenaire roads, this is a really invaluable teaching experience for me. (Barış)

Consequently, the ideas about the technology in his understanding of pedagogy stems from one chief idea: Technology is a pedagogical tool, not the aim itself. This idea has some outcomes and those outcomes make it easier to understand what

motivates him to use technology while he is not centering it in the focus of his pedagogy. These outcomes will be touched upon in the coming part.

First, as it was stated in the beginning, he perceives technology as a way to speak the same language as the students. In such an environment where everybody speaks the same language, teaching and learning gains a more positive atmosphere for both teachers and students. Also, thanks to this environment, he believes it becomes easier for teachers to handle motivation-related problems. Secondly, he touches upon a very distinct point that using technology helps teachers to apply more accurate assessment methods.

> For example, after teaching a topic, you mostly make interactive exercise. Students work on those exercises as individuals or in groups. Afterwards, you can see how effectively learning took place. There are many online-based working quizzes so you can get some statistics like how many of the students answered correctly, who answered as first etc. (Barış)

Nevertheless, he does not agree that technology-based materials which are produced by a professional company may not yield precise results for every group of students. That is to say, every group has its own characteristic so it is inescapable to assess them through those characteristics. For that reason, the effective materials are the ones which enable teachers make some modifications according to the needs of the group. He highlights that this is an important prerequisite for teachers to use technology efficiently in terms of assessment-related issues.

Education without Technology

First of all, education without any technology can be a manageable atmosphere according to Barış. Just as having technology has still some advantages that can be benefited even though he does not favor it most in his philosophy of education. Not

having technology, to him, has both positive and negative outcomes. Starting with a positive one, he reckons that classroom management would not be more problematic than it is with technology. At this point, mathematics classroom plays a significant role because he says: “My students can be more motivated in a place different then the classroom and in that atmosphere; I can present my lesson in a much more efficient way.” (Barış). However, when students are fascinated by the fun side of using technology, even in a mathematics classroom, then it causes some management problems in the classroom. Therefore, as a teacher he thinks they need to put more effort to minimize such problems. Lastly, for teachers in a world of education with no technology, the preparation time for lesson would be much shorter than it is today. Yet, in such an education, while the preparation time would get shorter, at the same time the pace of the lesson gets slower since you have to draw all the figures accurately and you have to prepare handouts for the students. Barış constructs a formula for this variable as “The topic I can cover in one lesson hour with the help of technology would be covered at least in three lesson hours without using technology.” At the end, it is hard to draw the exact picture in Barış’s mind but what is for sure that the time issue for teachers would not have the same dynamics of today’s world where teachers aim to use technology.

### Theme 3: Teachers’ Understanding of the Nature of Technology in Today’s World

The answers to the scenarios (see Table 10) are presented prior to detailed analysis for Theme 3. In the following part, the analysis of Theme 6 through the lens of these scenarios will be stated.

Table 10. Barış's Answers to the Scenarios

| Scenario No. | The Case |
|---|---|
| 1 | I mostly pay through my smartphone or the net. |
| 2 | I would note down in my personal agenda. |
| 3 | I first look for the book stores near to me. If not possible, I would buy on the net. |
| 4 | I mostly prefer to read through hardcopy. It is also the case for books. |
| 5 | Again, I would note down on my personal agenda. |

Barış first addresses the definition of using technology in terms of "ability". He elaborates on this issue as follows:

> I do not think using technology requires ability. For example, I read an article in a newspaper. A CEO of a big technology company, I guess of a tablet producer company, says that 'using tablet is not a sign of being smart for my child. He can use it even if when he is 20 or more because we are already designing them in a way that everybody from all ages and different backgrounds can use it.' (Barış)

Furthermore, in the previous part the pedagogical need to make modification on the materials was emphasized to ensure the particular characteristics of each group. In this part, he approaches the same issue from a different perspective. According to him, such materials should always keep students in the educational frame. Therefore, the details of materials play an important role. He puts forward an example:

> I do not think that it is feasible to efficiently use Facebook and Twitter in education. That is to say, there are too many details in such tools which can get the students off the educational aim. Instead, there are some applications like Bugclup working in the same logic. (Barış)

In other words, he claims that materials or tools used should be prepared for merely educational purposes. Otherwise, the details which are not related to education may distract students' attention and make students miss the educational core behind the lesson.

Additionally, he approaches the variety of technological tools from four different points, which are accessibility, pollution, developmental stages of students, and experienced teachers in face of the variability (see Figure 6). In the coming part, these four points will be mentioned.

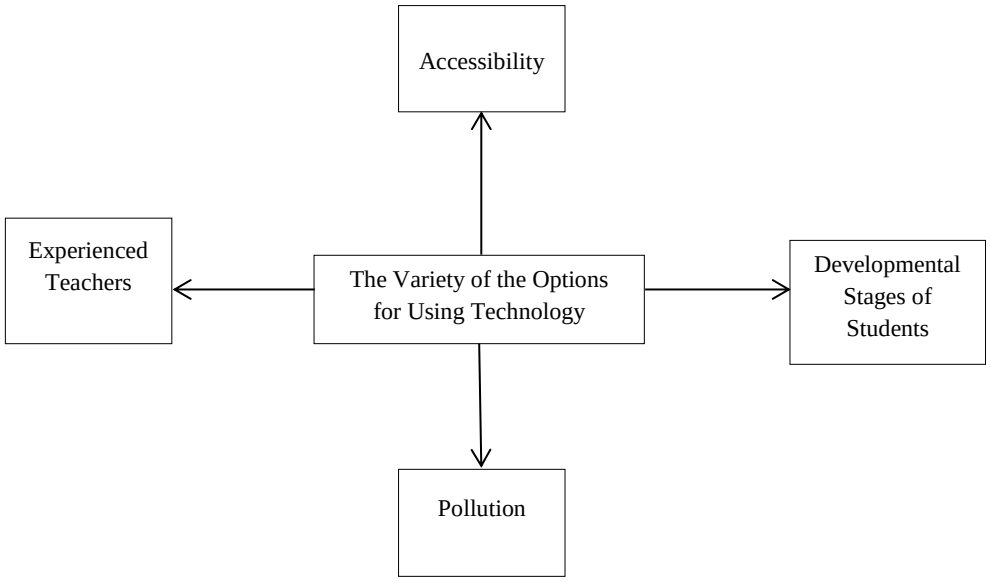


Figure 6. The representation of Theme 3 for Barış.

First of all, having diverse ways of using technology enables its users reach the data whenever it is necessary. This is also an effective outcome educators can benefit from because, as he highlighted the differences particular to the groups of students, such variability can be useful to meet such differences in groups. Despite this positive outcome, he attributes great importance to create technology-free atmospheres. He defines this atmosphere as the boundaries formed against the exposure to technology in today's world. To put it succinctly, in addition to its pedagogical benefit, people need to use technology carefully not to become antisocial persons.

Secondly, he proposes that it is inevitable to come up with pollution if educators cannot manage this variability. He interprets that this issue also holds true

in education. The present pollution related to using technology stems from two main reasons. Initially, using technology in education becomes a case that commercial concerns outweigh the educational aim. As a result, such variability inevitably entails a market many companies target an income. Therefore, the key point he offers for the solution is to apply an effective educational filter to distinguish the good ones. Later, he thinks that since mostly online platforms are used to share ideas and materials about technology, sometimes people who are not knowledgeable enough may contribute to those platforms. This, at the end, may pollute such platforms with insufficient examples. As a result, this is another idea that proves the importance of applying educational filter to sort out good examples.

Also, he states that considering the ages of children while applying technology can be another filter for the variety of choices. He bases this idea on a metaphor:

> To me, it is definitely wrong to leave students alone in using technology. If we talk about the internet here, letting them to use the internet is just throwing them into the sea to learn swimming. So, nobody can guess what will happen to them. That's why, I think considering age is of critical importance. (Barış)

In that sense, he further adds that using technology should not forestall the physical development. Since children also need to practice with their psychomotor skills to develop them, meeting these children with technology from very early ages may harm their physical development. As a result, to him the age of students seems to be a vital factor to determine when and how to use a technology in education.

Lastly, he reads this variability through the lens of more experienced teachers. For such teachers, this variety is a difficult process to learn. Hence, it may be useful to come with a formula to make such teachers feel more comfortable in this case. He puts forward a vital prerequisite for his formula. That is, educators or curriculum

designers should encourage the experienced teachers to actively participate in the solution of problems faced during the integration of technology. To achieve this, it is really important to convey to them the idea that their way of teaching is not wrong in all aspects and that their contribution is invaluable for educators. Thanks to such a formula, he thinks the experienced teachers who mostly are thought to be the ones not favoring technology can be encouraged to choose the best option from the variety of options.

## Case 4: Elif

Elif has an experience of 9 years in mathematics teaching. Presently, she is working in a public school. The demographics about Elif can be seen in Table 11.

Table 11. Demographics about Elif

| Participant | Elif |
|---|---|
| Teaching Experience | 9 years |
| Private / Public | Public School |
| M.A./ Ph.D. | None |
| Technological Devices | Smartphone, Personal P.C., School P.C. |

She graduated from a primary mathematics education department. In her career, except for one year in a high school, she has always taught at primary school level. In the general picture, she recognizes the role of technology in education. However, she has some concerns about technology exposure in daily life:

> There is an unmanageable technology exposition in today's world. Even though it is always said that we live in the communication age, I do not believe that we communicate in the real sense. There is a growing trend to process this communication through the cyber world. Technology has been integrated into our lives in such a way that we even walk with our heads down because while walking, people look at their smartphones, not the face of the people they come across. (Elif)

### Theme 1: Teachers' Definition of Self in Integration Efforts

In the efforts to integrate technology in education, Elif puts teachers at the center. She thinks that teachers are the most responsible ones by leading the other stakeholders like school administrators, teachers, and parents. In the picture where teachers are in the center, she defines four more important factors determining the effective use of technology by teachers. First, she attributes great importance to teacher education. This education, according to her, has two important features. Formerly, in teacher education programs, the courses related to the use of technology in education should be in coherence with the trends of the time. She, also, adds: "I

took some courses in university education. They were mostly about using GSP program. However, when I took those courses, technology was not at the point as it is today." (Elif). For this reason, she thinks in-service training plays an important role to fill the gap between the technology in teacher education programs and the technology of present day. However, the format of these trainings should be designed in a way that it goes beyond superficial suggestions. She states that a passive voice is used in such trainings:

> The trainings are designed according to the outline determined by the Ministry of Education. The trainers go through PowerPoint Presentation. They mostly say 'technology is developed so you can use many tools in your lessons. We apply those tools in these ways, you can practice like that' it mostly sounds to me like a suggestion. (Elif)

Secondly, observing good examples of using technology is another factor that affects teachers' use of technology in education. She conceptualizes this feature as an alternative way for teacher education in the absence of in-service trainings. Also, she considers that observing good examples of using technology can motivate teachers to use technology. For this reason, designing environments both in schools and in training activities in a way that teachers are able to observe and comment on the good examples of using technology is invaluable in this concern. Thirdly, she thinks sharing good materials is of critical importance to take 'observing good example' phase one step further. Thanks to this sharing, teachers can practice the good examples they observe in their teaching methods. However, necessary physical and technical conditions should be met to encourage teachers to share good materials between them. In this respect, she states an example from her current school:

> When we meet the teachers from both the mathematics department and other departments, if a teacher comes across a new tool or material, he or she does not hesitate to share it with other teachers. There is a

> computer in the teachers' room which is open for all teachers. Therefore, we share such materials through this computer. (Elif)

She further adds that the support of the local authorities to afford the hardware for such an environment in schools can be very helpful for school administrators and teachers. For instance, the municipality provided a netbook for each teacher in the school and she states this netbook, since she only uses it for school work, functions very efficiently.

Lastly, she underlines the importance of teachers' maturity in their teaching philosophy. While this is one of the most discrete factors she mentions, she simply bases this proposition on the idea that teaching is a job which is completely related to experience. She tells that this issue was the topic of a debate with her colleagues:

> We also discussed this in our conversations with my colleagues. Once, I think we make teachers somehow dependent on help. However, the training, as a form of help, mostly does not work out for some teachers since they already do not reach stability in their way of teaching. As a result, the training becomes superficial to them. (Elif)

From this perspective, she positions the last element somewhere where it is connected with other three elements. In this connection, she thinks that teachers' gained experience as a function of time, besides its effect in the general picture about teachers' role in integration efforts, somehow affects the other three elements individually. The representation of Theme 1 related to four points she puts forward can be seen in Figure 7.

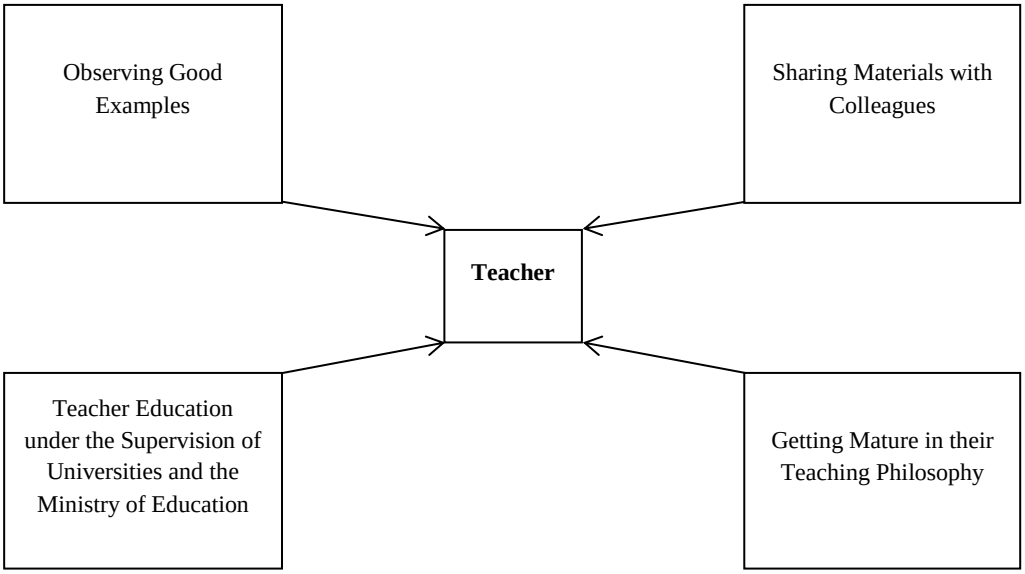


Figure 7. The representation of Theme 1 for Elif.

Theme 2: Teachers' Perspectives on the Technology - Pedagogy Relationship

Elif first puts forth that using technology is a beneficial tool for her methodology because it helps her to increase the pace of the lesson. This fast pace in lectures has a pedagogical outcome:

> Thanks to this fast pace, you can cover much content. Moreover, since you do not spend time on writing or drawing on the board, you have a chance to let more students to practice the problems or exercises on board. Therefore, you can create a better environment to make more students participate in the lesson. (Elif)

In addition to increasing the pace of the lecture, she thinks that using technology helps her to perform more efficiently at the board. That is to say, thanks to technology, the drawings at the board become more accurate. Therefore, she stresses that especially the geometrical proofs are more understandable for students. Furthermore, considering the age of the group she is teaching, visual materials are mostly more attractive to the students. As another element in the positive side, she states that: "When you start your lesson by showing them such a well prepared

visual material, the readiness level of students automatically gets higher. I have observed this many times." (Elif). Lastly, she states that using technology motives her to improve herself as a teacher. When she analyze her career, in the first five years when she did not use technology as she says, she took a more traditionalist stance on a continuum whose poles are teacher-centered instruction and student-centered instruction. Consequently, she highlights that using technology encourages her to keep her teaching methods up-to-date.

On the other side of the list, she mentions technical problems. In this respect, she regards the problems related to hardware as the most compelling ones in her efforts to integrate technology. She counts the problems in cables, projection, or computer related ones under the problems related to hardware. Also, the necessary time to set up the computer, connect it to the projection, and provide the internet connection every single time when she enters a new classroom consumes valuable time from her lessons. She defines this situation a waste of time in her lessons. However, she proposes a solution:

> I am asking the school administration for a mathematics lab. Hence, I do not waste time carrying my computer from one classroom to another. I can keep all the materials in that lab and technological infrastructure can be ready for use anytime. I hope such a lab can be constructed soon. (Elif)

On the other hand, in the wider picture, she sets a condition for all these benefits to reach maximum efficiency: a new revision in curriculum for teaching mathematics at primary level. She states her reason as follows:

> The highest priority is the heavy content in primary mathematics education. The Ministry of Education has to solve this immediately rather than any other reforms in mathematics education including integrating technology. (Elif)

She attaches great importance to this reform on the top of technological concerns because she believes that it will create a room for maneuver for teachers to practice their own teaching methods. Hence, such teachers with minds free from the pressure of covering a heavy content can also perform better in integrating technology according to her.

Theme 3: Teachers' Understanding of the Nature of Technology in Today's World

To draw a general picture, the answers to the scenarios (see Table 12) are presented prior to detailed analysis for Theme 3. In the following part, the analysis of Theme 6 through the lens of these scenarios will be stated.

Table 12. Elif's Answers to the Scenarios

| Scenario No. | The Case |
|---|---|
| 1 | I pay through the net. |
| 2 | I would use my smartphone to note down the name of that site. |
| 3 | I would buy on the net. |
| 4 | I read on the site of the newspaper. |
| 5 | I would set up a reminder in my smartphone. |

Elif presents two main headings about the technology in both daily lives and the education. In the following part, these two headings will be mentioned separately.

First, as stated in the beginning, she points out the technology exposure in daily lives. Independently of the case in education, she thinks people need to take some steps against this exposure. For example, as an individual she does not install any game on her smartphone because she indicates that such games waste her time. Furthermore, she attaches great responsibility to parents in this respect. She summarizes parents' responsibility in the following words:

> Parents have an indispensable role in controlling the overuse of the internet facilities at home. This is also related to raising awareness of the public. I keep asking for the administration to organize meetings for

> parents to inform them. Even though most of the parents of my students are young individuals, they mostly spend time watching series or keeping busy with their smartphones. Naturally, their concerns about the time their children spend on the internet make no sense. (Elif)

Therefore, she prescribes a two-stage plan consisting of first raising the awareness of parents about the use of internet at home, then informing parents to become role models to their children at home.

Besides the technology as the exposure in daily lives, the technology in today's educational world is another topic to question for her. She thinks that the exposure in daily lives turns out to be variety of options for teachers. As a result, on the contrary of the case in daily lives, she interprets this case as a positive outcome for education. She reasons:

> Actually, I approve this variety. At the end, everybody does not learn in the same way, and teachers do not teach in the same way either. Thanks to this variety, the ones who favor very different teaching styles can find an appropriate technological tool for themselves. Therefore, every single teacher can use a different way but the targeted destination is the same for all: to teach mathematics efficiently. (Elif)

Furthermore, she puts a condition to effectively manage this variety of options. According to her, teachers should be knowledgeable enough to choose the most appropriate tool for them. She defines this as an iterative process (see Figure 8)

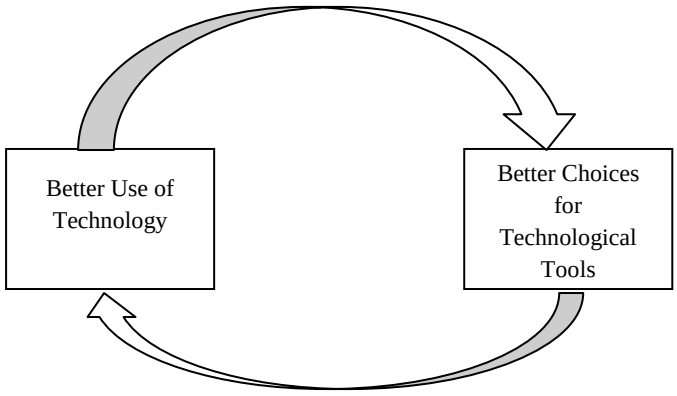


Figure 8. The iterative process of choosing the appropriate tool.

where teachers become better users of technology as they are able to choose the good sources, and they are making better choices to decide what kind of technology to use as they get more proficiency in using technology.

## Case 5: Pelin

Pelin is another teacher who is in the first year of her teaching experience. Unlike Bahar, she is working in a public school (see Table 13).

Table 13. Demographics about Pelin

| Participant | Pelin |
|---|---|
| Teaching Experience | 1 year |
| Private / Public | Public School |
| M.A./ Ph.D. | M.A. |
| Technological Devices | Smartphone, Personal P.C. |

She graduated from a primary mathematics education department. Furthermore, she continued with a graduate degree in teaching mathematics. After she got her master's degree degree, she started to work as a teacher in a public school. She believes that there is a time and place to use technology in education. In her words, she explains as follows:

> I find using technology in education beneficial. However, educators need to know the most appropriate time for using it to get more efficiency. Actually, I guess there is an optimum point in using technology vs. efficiency graph. Thus, for teachers it is important to detect this point. (Pelin)

### Theme 1: Teachers' Definition of Self in Integration Efforts

Pelin defines two vital characteristics teachers should have in the efforts for using technology and three subjects affecting teachers in gaining those adjectives. First, she thinks that teachers need to criticize themselves as teachers. She further adds:

> In our society, it is really hard to teach someone without coercion. This is also the case for teachers. For example, a teacher who has teaching experience of more than 20 years can say "why do I need to bother myself to learn all about this?" If a teacher wants to teach better, then he or she needs to self-criticize. (Pelin)

Also, she calls this self-criticism as the key to motivate teachers to attend the trainings about the use of technology in education. That is to say, she thinks that in-service trainings can yield an effective outcome if teachers attend trainings thanks to internal motivation. Secondly, teachers need to be prepared to teach in any circumstance, according to her. Namely, teachers should be able to go into Plan B when it is necessary. To reach the ideal product for the integration of technology, she states her reason for the need of Plan B in the following words:

> I started a teacher education program after 2006. Therefore, almost in all lessons the focus was to teach students by using the technological tools available in this age. At the end, when I graduated, I was thinking that I could use such methods we are taught in university. However, I have assigned to a school which only has blackboards in classroom and one projector for the whole school. This school I am working in now is not really feasible to apply those methods I learned in the university. (Pelin)

In other words, she defines 'Plan B' as establishing a buffer zone so that while putting plan b in action, teachers can gain time to create their opportunities to form a suitable environment for the technology-based methods they learn in the university education. In sum, she forms the ideal teacher in the efforts of using technology as the one who has a tendency to self-criticize and has a Plan B in case of need. As an external factor affecting those adjectives, she considers that academics have an important role to play. In this respect, academicians are the experts who can be consulted for the integration of technology. She specifically defines their role as:

> When I come across a new technological tool, I first try to skim over the instructions book if available. However, sometimes such instruction books can be superficial and may not be that enlightening. In that case, I am doing my best to consult an academician who has an expertise in that area. I have done this many times. (Pelin)

Besides academicians, Pelin thinks that students also have a secondary role to play. Namely, to her, students can be an indicator for teachers to realize the need for using

technological tools in education because, to a great extent, students are using technology in their daily lives. Succinctly to say, observing the place of technology in students' daily lives can help teachers to self-criticize themselves more reflectively. Lastly, she includes the parents to the general picture. She believes that parents should be placed in the background of the picture so that every single step is taken in harmony with parents. She states her reason in the following words:

> You need to convince parents before taking any step concerning technology because it mostly has a cost for parents. Therefore, parents should be involved in the decision-making process to yield more educationally grounded results. (Pelin)

The representation of Theme 1 for Pelin can be seen in Figure 9.

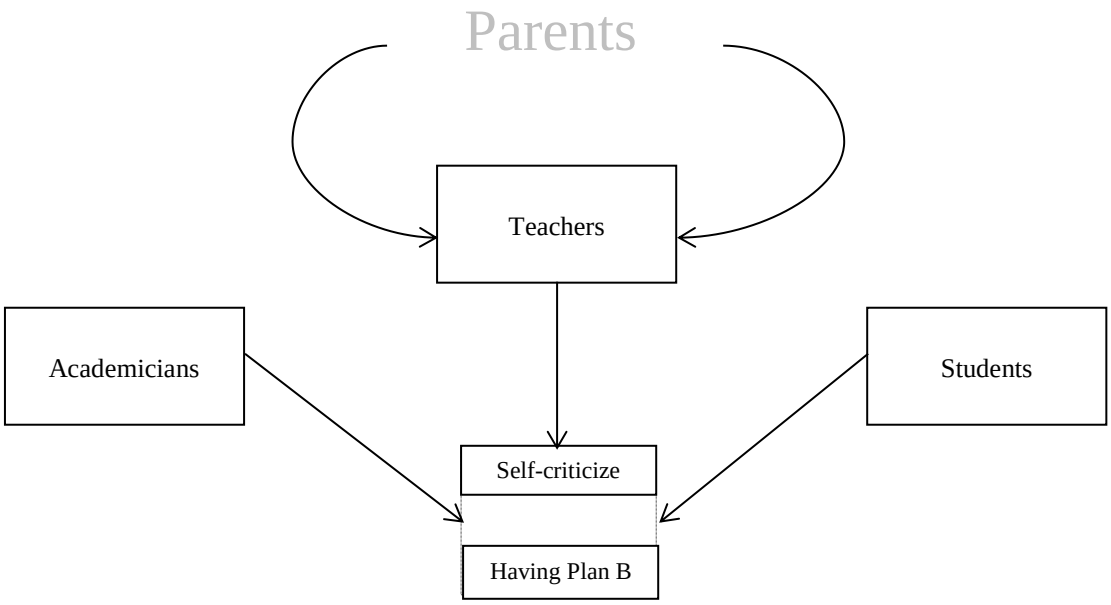


Figure 9. The representation of Theme 1 for Pelin.

## Theme 2: Teachers' Perspectives on the Technology - Pedagogy Relationship

### Why Use Technology?

Pelin first thinks that using technology helps her to materialize mathematics. In other words, to most of the children mathematics a very abstract object. Hence, she states "thanks to technology, children can visualize mathematics concepts so it becomes more attractive to them." (Pelin). Along with materializing the concepts, the motivation of the students becomes higher in the lessons according to Pelin. However, to reach these outcomes in a more efficient way, she underlines that:

> I guess it is pretty much dependent on the objective you want to teach. In order to attract students' attention, you need to prepare your technological materials specifically according to the objective you want to teach. (Pelin)

Lastly, she formulates using technology as an important multiplier for the pace of the lesson. She, for example, postulates that a topic which is covered in two lessons only with a blackboard can be taught in 15-20 minutes thanks to using technology. Consequently, materializing mathematics, increasing the motivation of students, and fast pace of lesson are three reasons she states why to use technology.

### Technology and Teaching Methods

Pedagogically speaking, using technology has an invaluable effect on the methodology of teachers according to Pelin. That is to say, using technology diversifies the ways teachers teach. Based on this diversification, she highlights two important points. First, using technology will change her teaching methods over time. To be more precise, she states:

> For example, I do not think that for the next year I will teach 'fractions' in the same way I did today. This is because I am following many sites, which are mostly foreign materials; this motivates me to keep myself up-to-date. (Pelin)

Secondly, she thinks that it can be a fallacy to think that all students prefer to learn through technological materials. In her classroom, there are some students who clearly state that they do not understand efficiently for instance with interactive whiteboard. To create opportunities for the learning of such students, she stresses the significance of 'having a Plan B for a teacher. She explains her Plan B as follows:

> I first try to detect such students. Actually, they give you many clues about this. I mostly try to create extra time for such students both during and after class time. In most cases, the best option is to work on concrete materials with those students. (Pelin)

The Frequency of Using Technology vs. the Benefit

Pelin conceptualizes her argument about this issue on 'benefit vs. technology use' graph (see Figure 10). In this graph, she identifies an optimum point yielding most ideal benefit of using technology.

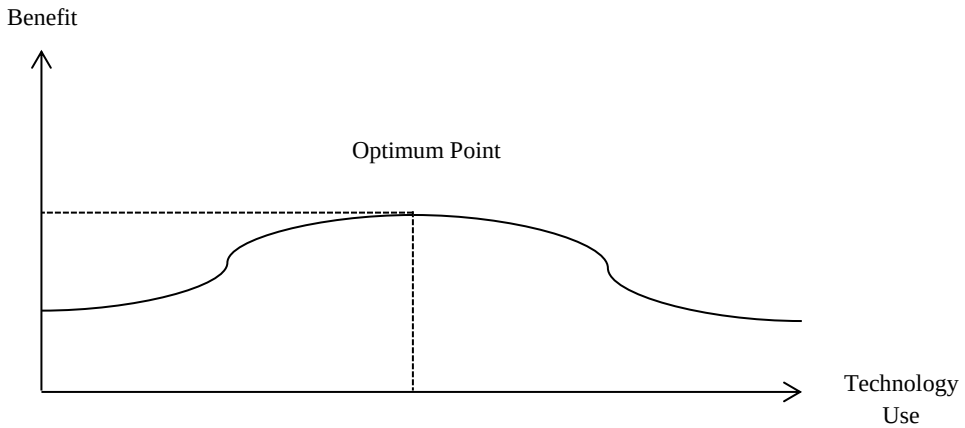


Figure 10. The graph of technology use vs benefit.

According to Pelin, this optimum point is what she defines as "the most appropriate time to use technology" in a subject as mentioned in the beginning. With a reference

to optimum point, if a teacher moves left along with x-axis, it would be expected that teachers would lose the chance to benefit from three advantages (materializing mathematics, higher motivations of students, and fast pace of lessons) mentioned early. On the other side, if a teacher moves to right along with x-axis, which means more technology use, the 'motivation' advantage in the optimum point turns out to be a disadvantage according to Pelin. She elaborates this transformation in following words: "When you use technology for every single topic in mathematics, then technology becomes ordinary in pedagogical sense. At the end, you have an unmanageable motivation in the classroom." (Pelin). She further adds that in such a case it is inevitable for a teacher to have some problems related to classroom management issues since students mostly show more interest to the technology than the objective of the lesson.

Theme 3: Teachers' Understanding of the Nature of Technology in Today's World

To frame the ideas related to Theme 3, the answers to the scenarios (see Table 14) are presented prior to detailed analysis. In the following part, the analysis of Theme 6 through the lens of these scenarios will be stated.

Table 14. Pelin's Answers to the Scenarios

| Scenario No. | The Case |
|---|---|
| 1 | I pay in the banks. |
| 2 | I would use my smartphone to note down the name of that site. |
| 3 | I would buy on the net. |
| 4 | I subscribe to the site of the columnist. |
| 5 | I would set up a reminder in my smartphone. |

Pelin questions the technology in her life. In this respect, she expresses that "my life is in this smartphone". Technology is an indispensable part of her life, as she underlines with that quotation. On the other hand, she believes that the nature of

technology in today's world has many reflections on educational applications. In the following part, those reflections are going to be stated.

She first of all does not think that there is a distinct concept as "educational technology" in today's world. That is to say, with an appropriate educational perspective teachers can use any technological tool as instructional material. Furthermore, this phenomenon entails diversity in the technological tools. She approaches this diversity positively:

> The diversity in technological tools is beneficial because it may be really ineffective to teach with a specific technological tool. Therefore, having more options in hand helps me to choose the most appropriate tool to teach the targeted objective. (Pelin)

Finally, she mentions about populist expressions about the technology in education. According to her, the investment in technological devices in education can sometimes be misread by parents. She illustrates this situation as:

> These days 'technology' as a concept is spoken out loudly by stakeholders in both the Ministry and the companies producing technology. I know a parent who is financially in a very bad shape. Recently, I heard that he bought a tablet just to assist his child in his lessons. As a result, if technology is overstated like that by educators, such a perception may take hold among parents. (Pelin)

In sum, she counts three reflections of the technology in daily lives on the educational applications. At this point, it can be useful to state her stance as a teacher on these reflections. When it is read backward, if teachers do not take any step against these reflections, after some time they may find themselves addicted to using technology in their teaching methods. In this respect, she attributes great significance to creating pedagogically technology-free environments if possible.

## Case 6: Onur

With 12 years, Onur is the most experienced teacher in the study. Presently, he is working in a private school. He graduated from a primary mathematics teaching department (see Table 15). He did not prefer to pursue an academic career after graduation. During his career, he worked in 3 different private schools. In one sentence, he summarizes his stance on using technology in education: "Instead of designing twice in a week, I prefer to design once a week."

Table 15. Demographics about Onur

| Participant | Onur |
|---|---|
| Teaching Experience | 12 years |
| Private / Public | Private School |
| M.A./ Ph.D. | None |
| Technological Devices | Smartphone, Personal P.C. |

### Theme 1: Teachers' Definition of Self in Integration Efforts

Onur's ideas about the teachers' role in integration efforts can be collected under two main headings: The physical environment with appropriate atmosphere and the ideal teacher education. In the coming part, these two heading will be elaborated.

#### The Physical Environment with Appropriate Atmosphere

There is some technological hardware such as interactive whiteboard in each classroom in the school. However, Onur mostly prefers to take his students to the computer lab when he needs to apply a technology-based material. Besides creating a chance for students to work on the activity individually, he states the main reason in the following words:

> If you keep your students always in the boundaries of the classroom, then this may cause a decrease in the efficiency of the activity you designed. On the other hand, if you take your students to another place, namely

> computer lab for our school, then this can provide positive outcomes. I believe that sometimes different places to apply such activities can be better choices. (Onur)

However, as one can guess, for this advantage to reach its full potential, there are some conditions which need to be met, according to Onur. First of all, such a mobility of students requires preliminary preparation such as setting air conditioning, healing, or setting the technological hardware. Otherwise, he states that it is inevitable to come across problems related to physical conditions according to him.

Besides the physical environment, he proposes some hints to create a coherent atmosphere in working environment. In this respect, he attributes great importance to the communication both within and between departments. He defines the meetings in mathematics department as the first instance for the solution of his problems concerning technological tools he wants to use in his teaching. Also, the communication between departments is significant to him. He illustrates this situation in the following way:

> Sometimes I say to myself that this material is useless for me. Yet, when I have a further look at it, I see that, for example, with a little modification, it can be very beneficial for a social sciences teacher. Then, I contact my colleague in the social sciences department and share my ideas about the material. (Onur)

The Ideal Teacher Education

He believes that one of the most appropriate ways to start is to work on teachers' beliefs. Within this context, analyzing their defense mechanism like "A good teacher can teach in any case. If a teacher is not effective, no matter how hard you try it is still futile. Also, if a student does not want to learn, a teacher can do nothing more." (Onur) can be an efficient way to help them to formulize their efforts about integrating technology. Otherwise, such efforts to use technology can be seen an

extra burden which causes them to sacrifice their spare time. After analyzing the beliefs part, making teachers take active roles in teacher trainings is of critical significance. He states three reasons of the necessity for the active role of teachers. Initially, the distrust atmosphere which is mostly formed by the passive roles of teachers in trainings can be replaced with the teachers who have self-confidence in taking initiatives to integrate technology. Secondly, for the retention of learning active roles in trainings can produce more positive results. He demonstrates this case in detail as follows:

> I believe that a teacher can remember how to use an application even after 10 years if s/he actively took initiative to learn it. However, I really doubt the retention of the learning if the teacher just informed the students and showed the application. (Onur)

Lastly, he thinks that the trainings which put the teachers in the center can serve for more pragmatic outcomes for teachers (see Figure 11). In other words, if academicians dominate the trainings and if teachers become listeners, then such training may not present concrete examples for teachers. Therefore, while editing the roles, it is important to make teachers feel as the active element of the integration efforts.

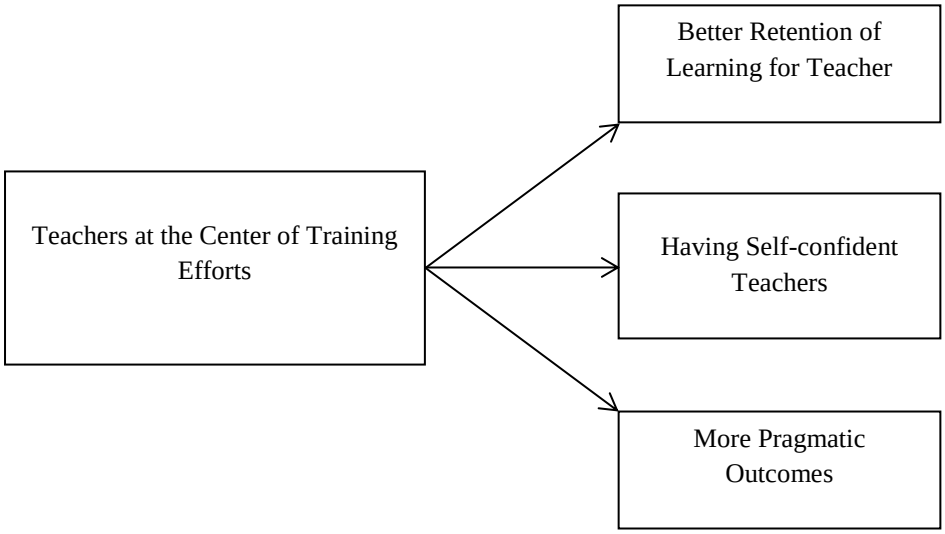


Figure 11. The schema for teacher education.

Theme 2: Teachers' Perspectives on the Technology - Pedagogy Relationship

First of all, Onur positions his stance as a "traditional perspective" about using technology in education. The traditional viewpoint in this respect means this to him:

> Actually, I guess I have a bit of a traditional perspective on this topic. To me, teachers should use the blackboard and students should use their notebooks to take notes. However, this does not mean that one should cover the entire curriculum like this. (Onur)

Nonetheless, he recognizes most of technology-bases materials are structured on a solid pedagogical reasoning. Namely, the materials designed by professionals pay attention to many general pedagogical rules such as from easy to difficult and assessing objectives precisely. In this respect, he states a formula as "in appropriate time, with the appropriate material, on the appropriate topic" (see Figure 12) for ideal pedagogical outcome in technology integration.


Figure 12. The formula for ideal pedagogical outcomes.

In this formula, if a teacher can satisfy all three 'appropriates' at the same time, according to Onur, using technology can provide with many advantages. In the coming part, these advantages will be stated.

First, using technology plays an indisputable role in increasing students' motivation. He elaborates this role with following scenario:

> If I did not use technology for this activity, then I could apply that on hardcopy. Possibly, students would react like "what is the point of this activity, why are we doing this? It is nonsense." However, if you use technology in the activity, it may arouse sympathy among students. (Onur)

Besides motivation, using technology helps teachers cover more topics in a specific time. Thanks to technology, according to Onur, teachers can for example present ten examples while they can solve at most three without technology. Hence, technology in this sense makes teachers use time more efficiently in the classroom. Also, he believes technology in classroom easiness for students as well because technology keeps students form the necessity of writing down everything on notebooks.

Turning back to the formula in the beginning, if one of the three "appropriates" is missing, Onur thinks that the advantages states above may convert to disadvantages. For instance, in a group work a teacher uses a material which actually is not designed according to a group study. Then, he thinks that this teacher will not have a pedagogically valuable outcome, and that even this improper activity may

cause some classroom management problems. Therefore, he underlines the importance of ensuring all the elements before designing an activity requiring the use of technology.

### Theme 3: Teachers' Understanding of the Nature of Technology in Today's World

First, the answers to the scenarios (see Table 16) are presented prior to detailed analysis for Theme 3. In the following part, the analysis of Theme 6 through the lens of these scenarios will be stated.

Table 16. Onur's Answers to the Scenarios

| Scenario No. | The Case |
|---|---|
| 1 | I am using automatic payment. |
| 2 | I would use my smartphone to note down the name of that site. |
| 3 | First, I would try to buy from a book store. If not possible, then I would buy on the net. |
| 4 | I would set up a reminder in my smartphone when the columnist writes. |
| 5 | Again, I would set up a reminder in my smartphone. |

Onur starts with an analogy to express his thoughts about the perception of technology in today's world. To him, most people nowadays share the idea "being without technology equals being unhappy." Therefore, it can be over optimism to expect that this perception is not affecting the use of technology in education. He thinks that this perception of technology turns out to be 'imposition' in education because, thanks to this popular perception, educators consider using technology as a must. In the shape of butterfly effect, this imposition entails information pollution and materials which are produced just for the sake of commercial concerns. At this point, Onur finds it ridiculous to consider a chicken and egg situation: imposition causes unqualified materials produced for commercial concern or big amount of money invested on technology in education causes unqualified materials produced

just to earn profit from the investment. More importantly, he proposes three ways to bypass this dead-end (see Figure 13).

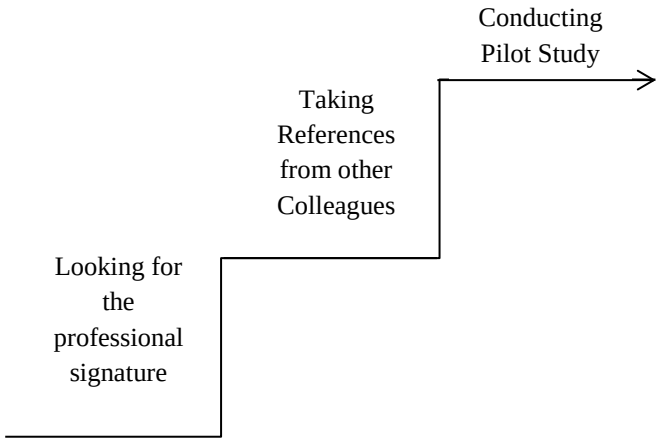


Figure 13. The three-stage plan

First, he thinks that prior to using a material, it is vital to look at the producer. Even though he accepts that there is growing tendency to use technology in education, the number of ideal materials can be inversely proportional with this tendency. He explains this case in detail as follows:

> At some point, the level of quality is getting to decrease because among the materials produced, there are many unnecessary ones which are not serving the purpose. Therefore, very first, I look at the signature behind the material and I try to use the ones which are produced by professionals. (Onur)

Secondly, taking references from other colleagues who already used the material can be another way. This method has many advantages such as detecting weak points, having an idea about possible students' reactions, and even the reactions of school administration and parents. With the help of this method, teachers have a chance to fix the repeated mistakes and to reach an ideal material for a specific topic. Lastly, conducting a pilot study prior to applying it in real classroom settings can be very beneficial for teachers. He conceptualizes the pilot study as "the last control

mechanism with colleagues within the department." In sum, one can see that towards today's understanding of technology in education Onur proposes a plan which has successive three stages to reach ideal technology integration.

# CHAPTER 5

# FINDINGS FOR CROSS CASE ANALYSIS

In this section, the three themes will be analyzed individually in the general picture. This analysis studies the similarities and differences across the cases to form a standing point about the themes.

## Theme 1: Teachers' Definition of Self in Integration Efforts

To draw a general picture of the ideal teacher in the efforts of using technology, it may be better to start with teacher education programs and the trainings provided for in-service teachers. In this respect, Barış seems to be the only teacher who made a clear distinction between the properties of teacher education programs and in-service trainings while other participants draw general guidelines about how to train teachers to use technology better. According to points stated by teachers, a model consisting of two phases with 10 steps to reach a self-confident teacher who can take initiative to use technology is going to be formed (see Table 17). In this model, the first two steps cover the pre-service teacher education. Among the remaining 8 steps, while the third one is about the properties of technological materials as an interpretation of access issue in first order barriers, the other 7 steps mostly concern the pedagogical and attitudinal development of teachers as an interpretation of access issue in first order barriers.

Table 17. The 10 Step Model to Reach Ideal Teacher

| | Steps | Explanation | The Relevant Stakeholder |
|---|---|---|---|
| Phase : Preservice Teachers | Having Outcome-oriented applications | The candidate teachers need to work on materials that will be useful for them in the future. | The designers of teacher education programs. |
| | Testing materials in real settings. | The candidate teachers should be provided with opportunities to test the materials they created in real settings. | The designers of teacher education programs. |
| | Keeping technological devices up-to-date | The tools and materials should be in coherence with the trends of the current time. | *MoNE. |
| Phase: In-service Teachers | Analyzing teachers' beliefs | The very first step is to analyze teachers' beliefs and propose some arguments against their resistance. | MoNE in the cooperation with academicians. |
| | Underlining the purpose of using technology | A consensus should be reach about the ultimate why of using technology. | MoNE in the cooperation with academicians. |
| | Creating a reflective atmosphere | There should an appropriate climate in the trainings that makes teachers to feel comfortable to comment each other's work. | MoNE. |
| | Creating opportunities to be observed good examples | Teachers should be provided with good role models of effective technology use. | MoNE in the cooperation with academicians. |
| | Awaking pragmatic reasons | It is important to create a concrete tool or material for teachers' use at the end of trainings. | MoNE in the cooperation with academicians. |
| | Providing an active role for teachers. | In the trainings, to achieve a better retention of learning, teachers need to be actively engaged in applications. | MoNE in the cooperation with academicians. |
| | Encouraging teachers for self-confidence to take initiative to use technology. | | |

*MoNE: The Ministry of National Education

As another point, while Barış and Onur, namely the most two experienced teachers in the study, mostly concentrated on the concerns related to teacher training, the other participants emphasized the musts a teacher should be equipped with. According to the items highlighted by the participants, a teacher should have four main characteristics to integrate technology in an effective way (see Figure 14). These characteristics are cooperative, flexible, self-critical, and eager for research.

Cooperative: Teachers need to share ideas and materials with their colleagues both within mathematics department and between other departments. (Bahar)

Flexible: Teachers need to be able to tolerate some changes in their methods of teaching in case of need for Plan B. (Bahar, Ege, Pelin)

Self-Critical: Teachers need to question their proficiency in using technology and to have a tendency to keep their methods up-to-date. (Pelin)

Eager for Research: Teachers need to keep their enthusiasm to learn new trends in education that may advance their teaching methods. (Bahar)

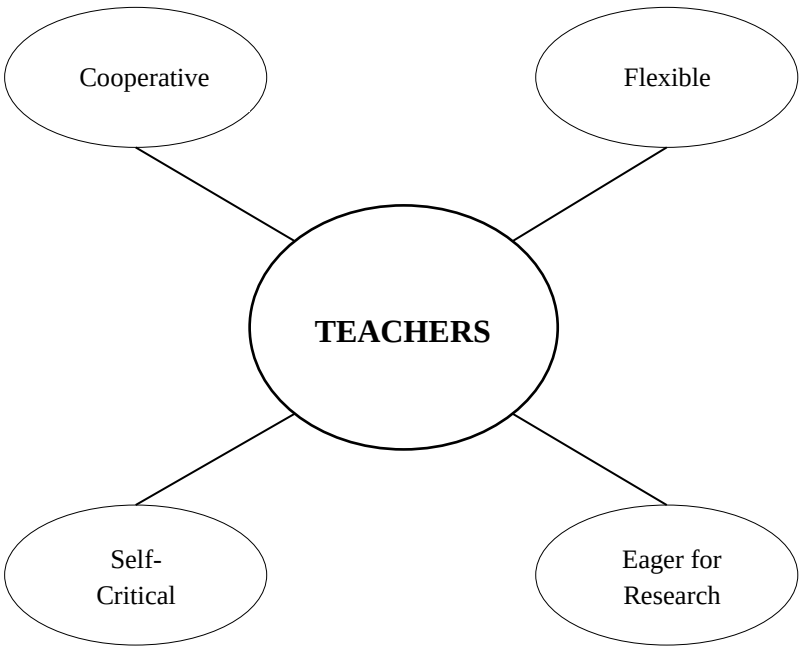


Figure 14. The diagram for the characteristics of an ideal teacher.

## Theme 2: Teachers' Perspectives on the Technology - Pedagogy Relationship

Among the participants, Bahar is the only one who centers technology as a methodology in her teaching. She considers that teachers need to shape teaching methods according to the ways the students learn best. In this respect, using technology is of very critical importance to create the harmony in that sense and to speak the same language with students. From this perspective, Barış seems to agree with Bahar about the benefit of using it to create a common language shared both teachers and students. While she thinks that using technology is a must to catch up with the requirements of 21st century, the other participants agree on that technology has a secondary but essential role to play in education. This role has many advantages that educators can benefit from according to the participants. In the coming part, these advantages will be mentioned.

To begin with, all participants, including Bahar, arrive at a consensus that technology increases students' motivation. However, this advantage has a potential risk to turn out be a disadvantage at the same time as they point out, with the exception of Bahar and Elif. Namely, Ege, Barış, Pelin, and Onur think that if using technology is not based on a pedagogically solid surface, this may cause something negative as they put in words "extracurricular motivation." With distinct perspectives, Ege and Pelin put forward an explanation to extracurricular motivation. In this sense, Ege suggests that students' daily internet use can be a descriptor for this issue. Therefore, he conceptualizes this explanation as "the contentedness of students towards technology use in daily lives". Besides, Pelin attributes great importance to detecting the optimum point in technology use vs. benefit graph. Hence, as a teacher moves away from this optimum point, she believes that it is more

possible to experience such kind of problems related to motivation. In addition to motivation, all participants build an agreement on that using technology helps teachers increase the pace of lessons. The other district advantages and disadvantages are listed in Table 18.

Table 18. The Pros and Cons List for Using Technology

| Pros | Cons |
|---|---|
| Motivation (All Teachers ) | Extracurricular motivation (Except Bahar) |
| Increasing the pace of lessons (All teachers) | Technical Problems (Elif) |
| Less financial cost (Ege) | Time loss (Elif & Barış) |
| Better use of board (Elif & Ege) | |
| Better representation of proofs (Elif & Ege) | |
| More accurate assessment (Barış) | |
| Materializing mathematics (Pelin) | |
| Encouraging teachers to be innovative (Elif) | |
| Diversifying the methods teachers use (Pelin) | |

As can be seen in Table 18, under the pros side, two items "materializing mathematics" and "diversifying the methods teachers use" stated by Pelin and the item "more accurate assessment" can be highlighted. These items come to the forefront by having pedagogically strong arguments. Lastly, the "encouraging teachers to be innovative" item put forward by Elif can be a significant indicator for professional development of teachers. All in all, according to Table 18, there are three items on the right-hand side of the table. Two of them (time loss & technical problems) are directly related to first order problems. However, the 'extracurricular motivation' seems to have a more complex structure to be analyzed. According to participants, this structure is linked with students' daily technology use (their access to technology at homes) and the frequency of teachers' technology use in schools (see Figure 10 for the graph of technology use vs. the benefit). Therefore, it can be

proposed that to fully reach the advantages listed on the left-hand side; teachers should be provided with assistance to overcome the disadvantages stated in Table 18.

### Theme 3: Teachers' Understanding of the Nature of Technology in Today's World

Teachers' perspectives mostly focus on the arguments about the distinction between the technology designed for daily use and the technology designed for educational purposes, and variety of tools in technological tools in mathematics education.

For the distinction between technologies designed for daily use and educational use, there are three different arguments among participants. First, Bahar believes that there exists no such distinction. Therefore, she thinks that all technological tools can be used for educational purposes. Secondly, Ege and Pelin partially agree on this distinction. Namely, they think there can be such a distinction yet one can use any technological tool with an appropriate educational modification. Barış, however, believes that there is a distinction and that an educator cannot adopt other technological tools for educational use. He further claims that every single detail in a tool intended to be used in the lesson should be designed in accordance with pedagogical concerns. From this perspective, it seems difficult to come up with a general definition for the distinction between technological devices designed for daily use and educational use. However, it can be proposed that teachers can be provided with many options for the use of technology so that they can choose the most appropriate one among those options. At this point, the word "choose" can be underlined. How can teachers choose the appropriate technological tool for the topic they teach and what rules do they need to follow in this decision process? In the coming paragraph, the answers to these two questions will be stated.

Also, the variety of options for technological tools in mathematics education is another topic the participants put forward different arguments about. Bahar states that teachers should be provided with guidance in such a variety of options. Otherwise, it can entail trial and error in the methods of teachers until they find the most appropriate tool. Ege and Onur elaborate this guidance and propose concrete plans towards this diversity. Ege suggests that educators need to have two different approaches as young teachers and experienced teachers. That is to say, since young teachers have been born into the age of technology, it is easier for them to get a harmony with the advancements in technology, while it requires more efforts for experienced teachers to be more comfortable using technology. Unlike Ege, Onur offers a 3-staged plan to reach an educationally stable outcome from the variety of options to use technology in mathematics education. According to a plan, one teacher can (1) look for the professional signature; (2) take references from other colleagues; (3) conduct a pilot study. Besides, through a more general lens, while Pelin finds this variety, in just one word, "positive", Elif further adds that this variety is positive for teachers because it helps teachers to diversify their teaching methods as well.

# CHAPTER 6

# DISCUSSION AND CONCLUSIONS

## Discussion

To begin with, this study did not aim to determine which participant uses technology most efficiently. Rather, this study aimed, in the light of the interviews with the participants, to detect the reasons that prevent primary mathematics teachers from using technology efficiently. Therefore, to read the following arguments through this lens will yield more productive insights.

First of all, it can be said that the "access barrier" is taken for granted by the participants in the study. Among participants, only Ege states "having enough number of technological hardware" as the most significant problem in the efforts of using technology. However, all participants reach an agreement on the idea that having technology in school does not mean they can automatically use this technology. Therefore, this agreement in the study shows parallelism with the related studies in the literature. In this respect, it can be concluded that when teachers become "dependent on the sources which are beyond their control" as Zhao and his colleagues (2002) express, the efficiency of using technology gets lower. As a result, it is of very critical importance to provide teachers with sources they have a control on. Also, having such sources creates scheduling problems as mentioned by the participants. This also supports the study conducted by Becker (2000a), who claims that having a reasonable number of computers in each classroom is more effective

than having a computer lab. Within this framework, it can be proposed that the "access barrier" and the "time barrier" have a strong two-way link.

When pedagogical concerns are taken into consideration, participants stated many advantages and some disadvantages of using technology (see Table 18). Among these items, motivation and increasing the pace of lessons are the items participants reach a consensus on. Nonetheless, there seems to be confusion about these two items. Considering motivation, "the contentedness of students towards technology use in daily lives" and "determining the optimum point in technology use vs. benefit graph" are two trends appearing in this study. These results refers to the "wow factor" stated in the literature (Beauchamp & Parkinson, 2005; Glover, Miller, Averis, & Door, 2007; Glover & Miller, 2009). According to this factor, using technology is appreciated for its presentational benefits and its reflections on students' motivation (Glover & Miller, 2009). From this perspective, arranging technology-based activities by taking into the consideration of the frequency of students' technology use in their daily lives can be two of the ways to bring the pedagogical part to the forefront. Besides, increasing the pace of lessons is another item that needed to be clarified. Two participants, namely Elif and Barış, think that besides the pace of lessons, using technology also increases the preparation time of lessons. At this point, it is hard to reach a concrete formula to present the dynamic structure of the time barrier. Therefore, further research can be conducted to elaborate this phenomenon.

Another implication is about the effect of technology over the teachers' methodology. At this point, technology seems to have a significant role to play as it is emphasized by the items "materializing mathematics" and "diversifying the

methods teachers use" stated in this study. One can recommend different terms to refer those items in the study such as technology as "enabler or change agent" (Ertmer et al., 2000) or "technology as Trojan horse" (Bennett & Lockyer, 2008; Betcher & Lee, 2009). If "Trojan horse" is categorized under the same heading as "change agent", then, this study puts forward some arguments supporting both technology as an enabler and technology as a change agent. For example, while Elif thinks that using technology encourages teachers to be innovative in their ways of teaching, Barış and Ege perceive technology as an enabler. Rather than forcing someone to use technology for the other purpose between these two perspectives, determining which category the purpose of a teachers' technology use falls in can be a better way. To do this, one can benefit from the headings proposed by Ertmer and her colleagues (2012): (1) to deliver content and reinforce skills; (2) to enrich the curriculum; (3) to transform teaching and learning. In that sense, this study has its participants under different headings above. Therefore, this outcome supports the idea that it is more productive to encourage teachers to use technology to contribute to the curriculum which they feel more comfortable (Ottenbreit-Leftwich et al., 2010).

Another point all participants agreed on is the necessity of professional development. For this reason, with this study a model is proposed to reach the ideal teacher in technology integration efforts. Yet, this model has an important feature that differs itself from available models in the literature. This model includes pre-service teachers' experiences in teacher education programs. With this respect, it is connected to the idea that all experiences teachers bring in their k-12 education and daily lives should be taken into consideration. Hence, applying this model starting with teacher education programs and continuing with in-service trainings during

teachers' career can yield more stable and productive results for the use of technology in education.

Lastly, teachers' perspectives about the nature of the technology in today's world can be stated. Without any exceptions, all participants mention creating time and places free from technology. While Elif frankly mentions about creating technology-free environments in education, Bahar implicitly stated in scenario question that she prefers sometimes not to use technology in her life. This result may entail some question marks about the existence of "technophobia" among the participants of the current study. However, future research needs to be conducted to reach a scientifically reliable result. Besides, the variety of options for technological tools in mathematics education is another main implication of this study. Barış and Onur state that the commercial concerns nowadays outweigh pedagogical concerns. While Barış calls this circumstance as "the pollution in the technological tools in mathematics education", Barış underlines "the information pollution". From this perspective, this study contributes to the existing literature through the idea that from the variety of options for the technological tools in mathematics education, to choose the most effective one, a teacher needs to apply an educational filter. In this respect, this study suggests three important features of this filtering process. First, Bahar and Barış believe that a teacher needs to consider students' age prior to choosing the appropriate technological tool because the physical and mental development of students should not lag behind the technology they are using. Afterwards, a three-stage plan is proposed to choose the most appropriate tool in this variety. According to this plan, a teacher should (1) look for the professional signature; (2) take references from other colleagues; (3) conduct a pilot study. Thanks to this plan, a teacher can put away the necessity of trial-and-error which consumes valuable

teacher time. Therefore, it can be claimed that today's technological advancements have an important role to play in the time barrier. Thirdly, towards this variety one can choose the appropriate type of training by making a distinction between young teachers and experienced teachers. The logic behind this idea is that young teachers were born into the age of technology. Therefore, it is easier for them to keep up with the advancements in technology. However, for more experienced teachers, it is not easy to catch the developments in technology. All in all, can the asserted pollution in the technological tools coming with the variety of the tools make one conclude that today's nature of technology in education itself becomes a barrier to the teachers who want to use technology efficiently? Within its limited scope, this study is far from answering this question on its own. Future research needs to be conducted to support or disprove this proposition.

## Concluding Remarks and Future Research

This study shows that access barrier is taken for granted for nearly whole participants (Only one participant considers access is the most important barrier to technology integration). However, more importantly the access to the available sources in schools is the most encountered problem in this study. Related to this argument, "time barrier" is another point this study underlines. Even though participants propose that using technology increases the pace of the lessons, at the time some of them believes that using technology requires longer preparation time. Therefore, both to analyze the relationship between "time barrier" and "access barrier" and to determine the changing dynamics within "time barrier" future research can be conducted.

Considering pedagogy-related part, as the main argument this study recommends a 10-step model for "professional development" barrier. Taking teachers as the chief subject, this model sets two conditions to reach its full potential. Firstly, teachers need to have four characteristics in the process of integration (see Figure 14 for these characteristics). Secondly, in the formula of the aim (technology as an enabler or change agent) for using technology in education, teachers should be provided with an appropriate atmosphere in which they can make their choices without any pressure. From this perspective, it can be concluded that this study can add a new perspective to "professional development" barrier by applying this model with two determined conditions.

Also, this study focuses on the understanding of technology in today's world. ın this respect, one of the prominent issues is *technophobia*. Revisiting "teachers' beliefs" as a second order barrier from the perspective of technophobia can be a valuable effort for further studies. Lastly, the question "does the nature of technology in today's world itself become a standing barrier in the efforts of using technology in education?", which has its roots in the arguments like "the information pollution in technology-related sources" and "the pollution in the variety of the options for technological tools", is one of the biggest question marks this study puts forward. For the time being, this question mark cannot be located in the barrier chart of the current literature (see Figure 2). For that reason, future studies can seek an answer to this question and suggest convincing arguments about whether this question mark stands as a new barrier or it reorganizes the current barrier schema of the literature.

# APPENDIX A

## ORIGINAL INTERVIEW QUESTIONS

1. Teacher subject area:

2. Grade level:

3. Number of years teaching:

4. Did your college education include any learning activities on how to use technology for teaching? If yes, please describe.

5. Have you taken any workshops provided by the school or district on how to use technology for teaching? If yes, please describe.

6. Was the computer lab easily accessible?

7. Why did you decide to use technology for this lesson?

8. If it was a planned lesson, was the lesson new or one that had been used with other classes?

9. Where did the idea for the lesson come from?

10. Is this part of a larger instructional unit? If yes, describe.

11. Was the lesson successful?

12. Would it have worked without the use of technology?

13. How long have you been using technology for teaching?

14. Why did you first begin using technology?

15. Do you find it easy or difficult to use new technologies? Can you give me a brief example of a new technology you recently adopted?

16. How often do you use computer technology with your teaching?

17. Do you use technology equally with all your classes or some more than others?

18. How well do you feel technology use fits in with the way you teach?

19. In what kind of environment do you think students learn best? Give an example?

20. How complex or easy-to-use do you feel is the technology that is available to you?

21. What was the last assignment that you gave to your students that asked them to use computer technology? When was it?

22. Describe the assignment.

23. "What does technology integration mean to you?"

24. What types of technologies are included in this concept?

25. What does it mean to integrate them into your teaching?

26. What are some of the different technologies you use with your students?

27. Do you feel that you have integrated technology into your teaching, based on the definition you provided?

28. How do you think your understanding of what "technology integration" came about?

29. Are there any advantages to integrating technology?

30. Are there any disadvantages?

31. Are you required by either your department or school administration to use technology? Or is using technology your own choice?

32. If you wanted a specific software or hardware that wasn't available in the school right now, but you wanted to use it with your class, how would you go about requesting it? What are the chances that you would get it?

33. How do you think your peers generally see technology? As a positive or a negative factor?

34. Do you think that most of your peers use technology?

35. Do you discuss or share the lessons that incorporate technology with your peers?

36. Describe the most effective lesson you have taught that integrated technology.

37. Could you have taught the lesson just as well without the technology?

38. Where do you usually get your ideas from for integrating technology?

(magazines, colleagues, workshops, technology coordinator, Internet, etc.)

39. How has your technology integration evolved?

40. Do you face any challenges in integrating technology?

# APPENDIX B

## PILOT INTERVIEW QUESTIONS

1) Konu alanınız nedir?
2) Çoğunlukla hangi sınıf aralığında çalışmaktasınız?
3) Öğretmenlik mesleğinde kaçıncı yılınız?
4) Üniversite eğitiminizde hiç teknoloji kullanımına yönelik bir ders aldınız mı? Eğer cevabınız evetse lütfen tanımlar mısınız?
5) Size okul ya da bölgesel merkezlerce (MEB, proje, Halkeğitim) sunulan bir seminer ya da atölye çalışmasına katıldınız mı? Eğer cevabınız evetse, lütfen tanımlar mısınız?
6) Okulunuz size teknik donanımı nasıl sağlıyor? (Bilgisayar laboratuvarı, zümre odaları, her sınıf kendi altyapısına sahip)
7) Yakın zamanda teknoloji kullandığınız bir dersiniz oldu mu? Eğer evetse,
    a. Bu dersin planında teknoloji kullanma fikrini nasıl elde ettiniz?
    b. Bu derste teknoloji kullanmasaydınız, yine de ilgili kazanıma ulaşabileceğinizi düşünüyor musunuz?
8) Peki, biraz daha konuyu genelleştirirsek, teknolojiyi ne kadar süredir derslerinizde kullanmaya çalışıyorsunuz?
9) Teknoloji kullanımızdaki en önemli motivasyon kaynağınızın ne olduğunu düşünüyorsunuz? Bir liste yapsanız ilk üç maddeniz neler olabilir?
10) Yeni teknolojileri kullanmakta zorluk yaşıyormusunuz?

11) Yine genelleştirirsek, sizin öğretim yaklaşımınızla (felsefenizle) teknoloji kullanımınızın ne ölçüde örtüştüğünü düşünüyorsunuz? Bunu 1 den 5 e kadar ölçeklendirsek;
    a. 1: bana kalsa hiç kullanmam.
    b. 5: Öğretmenlik anlayışımın ana unsurlarından olduğunu düşünüyorum
    c. Peki, teknoloji kullanımının sizin eğitim felsefinizi değiştirdiğini düşünüyor musunuz?
12) Peki, size göre, öğrencileriniz ne tür bir atmosferde en iyi şekilde öğreniyorlar?
    a. Ve teknoloji kullanımı bu atmosferin neresinde? Bir örnekle açıklayabilir misiniz?
    b. Teknoloji kullanımı bu atmosferde ne gibi bir değişiklik oluşturuyor?
13) Peki, şimdi bakış açımızı öğrenciler üzerine çevirirsek, onlara teknoloji kullanmaları gereken bir ödev verdiniz mi? Eğer cevabınız evetse,
    a. Ödevi kısaca anlatabilr misiniz?
14) Eğitimde teknoloji kullanı mı size genel manada ne ifade ediyor?
    a. Bu tanımın paydaşları (ilgilileri) kimler? Rollerini tanımlayabilir misiniz?
    b. Yaptığınız tanıma göre, sizin en başta örnek olarak verdiğiniz ve ödevin bu tanıma uyduğunu düşünüyormusunuz?
15) Peki, bakış açımızı yine genelleştirirsek, teknoloji kullanımın eğer varsa avantajları / dezvantajları nelerdir?
16) Zümreniz ya da okul yönteminin istekleri sizin teknoloji kullanımınızı nasıl etkiliyor?

17) Okulunuzda olmayan bir donanım ya da yazılımı kullanmak istiyorsunuz diyelim. Bu sorunu çözmek için nasıl bir yöntem izlersiniz?
18) Teknoloji kullanma da sizi en çok rahatsız eden olgu nedir?
19) Peki teknolojilerdeki çeşitlilikleri düşünürsek bu durum sizin teknoloji kullanımınızı nasıl etkiliyor?
    a. Bakış açımızı daha da genele alırsak kendi günlük yaşamanızda maruz kaldığınız teknoloji kullanımı bahsettiğimiz tercihi yapmadınızda nasıl bir etkiye sahip?
20) Üniversite eğitiminize geri dönersek, aldığınız eğitim pedagojik derslerin teknoloji kullanımına altyapı oluşturduğunu düşünüyor musunuz?

APPENDIX C

FINAL INTERVIEW QUESTIONS

| | |
|---|---|
| Öğretmen No: | Özel / Devlet |
| Çalışılan konular: | Y. Lisans / Doktora |
| Dersler: | Seminer/ Proje/ Çalıştay: |
| Kişisel çalışma adresleri (Web, Blog, Online-Portfolio) | Meslek Yılı: |
| Teknolojik Cihazlar: | |

1) Üniversite eğitimizde teknoloji kullanımına yönelik bir ders aldınız mı? Lütfen dersi kısaca tanımlar mısınız?
2) Size okul ya da bölgesel merkezlerce sunulan (MEB, proje, seminer) sunulan bir seminer ya da atölye çalışmasına katıldınız mı? Lütfen tanımlar mısınız?
3) Okulunuz size teknik donanımı nasıl sağlıyor? (Bilgisayar Lab, zümre odaları, her sınıf kendi alt yapısına sahip)
    a. Artıları/ eksileri neler olabilir?
4) Yakın zamanda teknoloji kullandığınız bir dersi tanımlayabilir misiniz?
    a. Teknoloji kullanma fikrini nasıl elde ettiniz?
    b. Teknoloji kullanmasaydınız yine de başarılı olabileceğinizi düşünüyor musunuz? Yani, teknoloji neyi farklı kıldı o zaman?
5) Teknoloji kullanmada en önemli motivasyon kaynağınızın ne olduğunu düşünüyorsunuz? (Liste yapsak ilk 3 maddeniz ne olur? ) ve size en çok rahatsız eden şey?
    a. Eğitimde kullandığınız teknoloji ile eğitim yaklaşımınızın ne derecede örtüştüğünü düşünüyorsunuz?
    b. Peki, teknoloji kullanımınızın eğitim felsefenizi/duruşunu değiştirdiğini düşünüyor musunuz?
6) Yeni bir teknoloji ile karşılaştığınızda nasıl bir plan izliyorsunuz?
    a. Süreçte ne tür zorluklar yaşıyorsunuz? Yeni teknolojiyi kullanmanızı kolaylaştıran/zorlaştıran faktörler neler?
    b. Öğretmenlerin genel tutumunu nasıl yorumlarsınız bu noktada?
7) Peki, ben size şimdi bazı senaryolardan bahsedeceğim. Siz olsaydınız hangisini yapardınız / yaptınız?
    a. Faturalarınızı zamanında ödemek istiyorsunuz.

b. Arkadaşınızdan çok faydalı bir internet sitesi öğrendiniz.
c. Çok güzel bir kitap önerisi aldınız ve hemen bu kitabı temin etmek istiyorsunuz.
d. Bir köşe yazarının yazılarını düzenli olarak takip etmek istiyorsunuz.
e. Bir öğrencinizin velisine 20 gün sonrası için randevu verdiniz. Unutmamanız gerekiyor.

8) Bakış açımızı biraz genelleştirerek, eğitimde teknoloji kullanımı size ne mana ifade ediyor?
   a. Bir tanımlama yapsak, hangi teknolojiler bu tanıma dâhil olur?
   b. Eğitim teknolojisi/ Genel teknoloji ayrımı var mı?
   c. Eğitimsel olarak yaptığınız tanımın paydaşları ve rolleri neler?
9) Teknolojilerdeki geniş yelpazeyi düşünürsek, sizin teknoloji konusunda genel duruşunuzu/ tercihlerinizi nasıl etkiliyor?
   a. Somut olarak bu çeşitlilik sizi nasıl etkiliyor?
   b. Peki, sizin bu çeşitlilik karşısında çözümünüz nedir?
10) Günlük hayatımıza teknolojinin çok fazla müdahale ettiğini düşünüyor musunuz? Siz teknolojinin müdahalesi noktasında bir çizgi çekiyor musunuz?
   a. Peki, bu durumu eğitimde nasıl yorumluyorsunuz?
11) Son olarak meslektaşlarınızdan konuşursak, onları nasıl değerlendiriyorsunuz teknoloji kullanımında?
   a. Branşlara göre bir farklılaşma olduğunu düşünüyor musunuz?
   b. Görüş ve materyal alışverişinde bulunmanız için uygun bir ortam var mı?

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