The Effects of Teacher Professional Development and Self-Efficacy on Classroom Uses of Information and Computer Technologies

Elif N. Gokbel
DUQUESNE UNIVERSITY

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THE EFFECTS OF TEACHER PROFESSIONAL DEVELOPMENT AND SELF-EFFICACY
ON CLASSROOM USES OF INFORMATION AND COMPUTER TECHNOLOGIES

A Dissertation
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the degree of Doctor of Education

By
Elif Nagihan Gokbel

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THE EFFECTS OF TEACHER PROFESSIONAL DEVELOPMENT AND SELF-EFFICACY
ON CLASSROOM USES OF INFORMATION AND COMPUTER TECHNOLOGIES

By
Elif Nagihan Gokbel

Approved December 11, 2019

Rachel Ayieko, Ph.D.
Assistant Professor in
Mathematics Education
(Committee Chair)

Melissa Boston, Ed.D.
Professor of Instruction and
Leadership in Education
(Committee Member)

Gibbs Kanyongo, Ph.D.
Professor of Educational Statistics
(Committee Member)

Cindy Walker, Ph.D.
Dean and Professor
School of Education

Sandra Quinones, Ph.D.
Director, Doctoral Program in
Educational Technology
ABSTRACT

THE EFFECTS OF TEACHER PROFESSIONAL DEVELOPMENT AND SELF-EFFICACY ON CLASSROOM USES OF INFORMATION AND COMPUTER TECHNOLOGIES

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May 2020

Dissertation supervised by Dr. Rachel Ayieko

The uses of new technologies during mathematics instruction are essential for maintaining opportunities for students to gain better understanding of the content and become digital learners in the information age. Although scholars found technology integration is helpful in improving students’ mathematics achievement, the role of teachers’ preparedness for technology integration remains critical.

Technology professional development and self-efficacy are two major factors impacting teachers’ successful integration of instructional technologies. The purpose of this study was to provide a more in-depth look into (i) mathematics teachers technology uses during direct instruction, dialogic instruction, and assessment; (ii) the relationship between various types of professional development activities (online collaboration, face to face collaboration and course-
based) and classroom technology use; and finally (iii) the mediator role of self-efficacy between professional development and classroom technology use.

The findings demonstrate that eighth grade mathematics teachers tend to integrate technology more often through direct instruction than dialogic instruction and assessment. Teacher self-efficacy, collaboration, and online collaboration for professional development had a significant relationship with technology use through direct instruction. Next, the results indicated that self-efficacy, collaboration, and course-based professional development were three significant factors for technology use in dialogic instruction. These three factors also significantly contributed to increasing technology use through assessment. Third, when self-efficacy mediated the hypothesized relationship, only face to face collaboration among teachers had a significantly positive association with teachers’ technology use through any type of instruction. Based on the findings, this study concludes that face-to-face collaboration among teachers were more effective than online professional interactions to make a change in teacher practices. Online learning communities should be encouraged for teachers who seek further guidance and resources sharing after joining a face-to-face training. Recommendations for future research and implications for practice are discussed.
DEDICATION

I dedicate this dissertation to my beloved husband, Veysel Gokbel, who managed my stress, fear, excitement and absence with patience, kindness, and love far beyond my expectations. You were always my biggest fan and supporter. You have encouraged me to always be better, and you challenge me to be my best self. I could not have done this without all the support you have given me. Thank you for your love, friendship and support throughout this difficult process.

To my son, Emirhan, who came into my life as I began this project. You are the sunshine of my life. I hope this accomplishment inspires you and teaches you that you can be anything you want to be if you try hard enough. Thank you Emirhan for being patient when mommy was busy and absent sometimes. It is done now.
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CHAPTER I: INTRODUCTION

In today’s world, technology is easily accessible and readily available in everyday life. It is especially powerful in sustaining educational reforms (Toh, 2016). The potential of the use of digital technologies in teaching and learning is increasing dramatically, as technology becomes rapidly integrated in education. Classrooms today have many forms of technology, including computers, mobile devices, digital cameras, social media platforms and networks, software applications, the Internet, etc.

The uses of new technologies during instruction are essential for maintaining opportunities for students to become digital learners in the information age (Greenhow, Robelia, & Hughes, 2009). Specifically, scholars found that technology is effective in improving student learning and achievement in mathematics (Barrow, Markman, & Rouse, 2008; Demirbilek & Tamer, 2010; Eyyam & Yaratan, 2014; House & Telese, 2012) and science (Delen & Bulut, 2011). Although technology integration is helpful in improving students’ mathematics achievement, the role of teachers and their preparedness to use technology effectively in their classrooms remains critical and should be examined (Polly, Mims, Shepherd, & Inan, 2010).

The massive portion of research related to the use of educational technologies has been conducted within developed countries (most of them in Europe, North America and East Asia) and informed by the needs of education systems in these same countries. However, this existing paradigm has been changing in this decade, as there are increase in research studies in developing countries along with investments in education technology. Turkey is one of the developing countries who substantially invested in educational technology in the last two decades (Gumus, 2013).
Besides to the recent investments, many international and national studies agree that the effective integration of technology into classroom instruction has yet to be realized in Turkey. For instance, in their report from the Trends in International Mathematics and Science Study (TIMSS) 2011 study, Mullis and his colleagues (2012) indicated that, in Turkey, 24% of eighth grade mathematics teachers allowed their students to explore mathematics principles and concepts on the computer at least monthly; 26% of math teachers had them look up ideas and information on computer; 22% of teachers had students process and analyze data at least monthly; while only 21% of mathematics teachers had them use computers to practice skills and procedures. In the following study, TIMSS 2015, these percentages were as follows: 13% for exploring mathematics principles and concepts; 11% for look up ideas and information on computer; 15% for process and analyze data; 12% for use computers to practice skills and procedures (Mullis, Martin, Foy, & Hooper, 2016).

These low figures might be the result of many factors, especially, lack of knowledge and skills of mathematics teachers to teach with technology (Wachira and Keengwe, 2011). It is believed that to integrate technology in the classroom successfully, the teacher must be competent in technology, must understand how to engage the student in learning, must have an in-depth knowledge of their subject matter, and must integrate all the components into the teaching (Koehler, Mishra, Kereluik, Shin, & Graham, 2014). Hagerman, Keller and Spicer (2013) found that most teachers would like to use technology in their classrooms but did not have the knowledge to effectively use the technology (Hagerman, Keller, & Spicer, 2013). Therefore, integrating technology into the classroom instruction requires that teachers must not only know the content, but also be pedagogically proficient in technology and be able to integrate it into their content area.
Previous studies point out the need for mathematics teachers to take quality technology education in order to facilitate technology integration into teaching. According to the Teaching and Learning International Survey (TALIS) 2013, the top two professional development needs of teachers were: (i) Learning to teach information and computer technology (ICT) skills (mentioned by 19% of teachers); (ii) using new technologies in the workplace (18% of teachers) (OECD, 2014). In another study in Turkey, only 27% of eighth grade mathematics teachers reported that they had participated in a professional development activity focused on using technology in mathematic instruction in the past two years (Mullis et al., 2016). The recent investments and initiatives (e.g., the FATIH Project – in Turkish, Fırsatları Artırma ve Teknolojiyi İyileştirmme Hareketi) aims to increase the opportunities for teacher training on technology (Pouezevara, Dincer, Kipp, & Sariisik, 2003). As there are more training support for Turkish teachers than ever before, there is need to gain a better understanding about the influence of ICT related professional development on the growth of teachers’ ICT competences in Turkey (Aslan & Zhu, 2017; Aydin, Gurol, & Vanderlinde, 2016; Yuksel, 2012).

**Statement of the Problem**

Turkey is one of the developing countries who increasingly invested in educational technology in the last two decades (Gumus, 2013). Besides to those investments, findings from international assessments such as TIMSS and Program for International Student Assessment (PISA) indicated that Turkey’s academic achievement is far below the international average in mathematics (Gurria, 2013; Mullis et al., 2016). The International Computer and Information Literacy Study (ICILS) 2013 study also revealed that computer and information literacy scores of students in Turkey were noticeably lower than those of other participating countries. The findings show that students in Turkey need support not only for fostering mathematics
knowledge and literacy but also for training in computer literacy. To make learners more literate in both ICT skills and the content of mathematics, meaningful technology exposure should be offered to them and to their teachers. This can be done through; i) teachers’ technology integration into mathematics classrooms; and ii) teacher professional development to use technology. Focusing on a developing country for this study would finally contribute to the policies and practices in other developing countries as well.

Mathematics Teachers’ Technology Integration

Technology is an inevitable part of students’ lives and should be promoted in learning so that students experience the richness and flexibility it offers in learning and exploring phenomena. The praise for technology implementation in teaching and learning mathematics is reflected in recommendations from a number of organizations such as the International Society for Technology in Education (ISTE, 2014), the National Council of Teachers of Mathematics (NCTM, 2000, 2014), and the National Council for the Accreditation of Teacher Education (NCATE, 2008). As stated in NCTM’s Principles to Actions (2014), “technology in mathematics classrooms influences not only how teachers teach but also what they are able to teach” (p.84).

The significance of technology implementation in improving student understanding of mathematics cannot be undervalued (Barrow, Markman, & Rouse, 2008). The studies found that technology integration into classrooms has a positive influence on students’ mathematics learning (Barrow et al., 2008; Demirbilek & Tamer, 2010; Eyyam & Yaratan, 2014). Thus, the presence of technology in mathematics classrooms makes learning different as it mediates learning (Heid, 2005).
Teacher Technology Professional Development and Self-Efficacy

In-service teachers’ professional development (PD) and self-efficacy are keys to successful integration of instructional technologies (Beas & Salanova, 2006; Pan & Franklin, 2011; Serin, 2015; Uslu & Bumen, 2012). There is a need to understand what makes professional development effective for teachers to foster their expertise and skills about technology (Garet, Porter, Desimone, Birman, & Yoon, 2001; Kang, Cha, & Ha, 2013). Also, these studies do not highlight particular features of PD that are important for mathematics teachers’ use of technology as well as the role of ICT self-efficacy for technology use in mathematics classrooms. What is documented in the literature include 1) the role of collaboration, and 2) the role of technology as subject matter or mediator in PD.

In sum, when teachers are exposed to quality in-service education, they are more likely to have high confidence to use technology and provide quality instruction for students (Desimone, 2009; Yuksel, 2012). The improvement of mathematics teacher quality through useful professional development activities and ICT self-efficacy is essential for promoting instructionally innovative ways of teaching in mathematics instruction. Also, such a change in classroom practices can lead to an increase in students’ mathematics learning and more proficiency in a fundamental 21st century skill.

Purpose of the Study

This study uses nationally representative data of Turkey from the ICILS 2013 dataset, which is the latest version. This data was collected by country representatives in collaboration with the International Association for the Evaluation of Educational Achievement (IEA). The aim of the study is to a) describe eighth grade mathematics teachers’ uses of information and computer technologies in classroom instruction; b) examine the relationship between the
participation in technology related PD (Professional Development) and ICT self-efficacy, and ICT use; and c) the role of ICT self-efficacy as a mediator in the relationship between PD and technology use.

This study builds on the conversation about the relationships between eighth grade mathematics teachers’ PD activities and ICT self-efficacy and the degree to which they have implemented technology in Turkish classrooms. More importantly, this study is essential in adding to the literature by recognizing the mediating role of teachers’ ICT self-efficacy between professional development and teaching practice, which was also recommended for future research in a study of Kang and his colleagues (2013).

**Research Questions**

The questions guiding this study as follows:

1. How does eighth grade mathematics teacher ICT implementation occur through (i) dialogic instruction, (ii) direct instruction, and (iii) assessment?
2. Is there any significant impact of ICT professional development and ICT self-efficacy on eighth grade mathematics teachers’ classroom ICT implementation?
3. To what extent does ICT self-efficacy mediate the relationship between ICT professional development and eighth grade mathematics teachers’ classroom ICT implementation?

**Significance of the Study**

Recent studies investigating barriers to teachers’ integration of technology into their classrooms underline the lack of professional development opportunities and lack of support for teachers (Brun & Hinostroza, 2014; Inan & Lowther, 2010; Valcke, Rots, Verbeke, & Van Braak, 2007). Many of the studies conclude that there is a need to provide appropriate
professional development to increase teacher skills and competence (Guskey, 2002; Serin, 2015; Uslu & Bumen, 2012).

In considering Turkey’s recent attempts to support the integration of ICT into education and teacher training on ICT, it is important to determine the extent to which teachers and students benefit from these efforts and investments. This study aims to evaluate the influence of various types of PD activities on mathematics teachers’ integration of ICT in their classrooms. In light of this intention, this study will inform policymakers and educational leaders on the types of PDs that matter for training teachers.

Significance of this study is various. First, the ICILS 2013 is a valuable dataset that is the largest and most recent technology survey in which Turkish teachers participated. Using this dataset validates the current study since the results are generalizable and reflect on the recent changes in Turkish education. Second, the study will focus on teachers of mathematics. Different from other content areas, technology is fundamental in effective mathematics teaching and has the potential to change traditional ways of doing mathematics. Finally, the importance of studies related to technology-supported mathematics education is growing in Turkey, considering the increasing awareness and support for technology integration in schools. Although the number of such studies has increased during the last decade, there is still research need for those investigating the influence of ICT-related PD programs and ICT self-efficacy on ICT use for teaching (Aslan & Zhu, 2017; Aydin et al., 2016; Uslu & Bumen, 2012; Yuksel, 2012). Thus, this study would contribute meaningfully to the policies and practices and build on the literature by including the context from a developing country.
Organization of the Document

This document has five major segments: Introduction, Literature Review, Methodology, Results, and Discussion. Chapter I describes the introduction, problem statement, purpose of the study, research questions, significance of the study, limitations, and key definitions. In the next chapter, the literature on technology professional development, ICT self-efficacy, and mathematics teachers’ integration of instructional technology during classroom instruction are discussed in relation to the research questions. Categorizations for the teacher technology professional development and instructional technology usage are discussed in detail in Chapter II. Chapter III describes the dataset used in this study, the research methods used to answer the research questions, and how variables are operationalized. Chapter IV will present results of data analysis while Chapter V will discuss the results, implications of this study, and recommendations for further study.
Definitions of Terms

The following key terms corresponding definitions are described below, and these terms are used throughout this dissertation.

**Information and Computer Technologies (ICT):** ICT is a term that includes any information gathering technologies and computers. It is a tool for accessing resources, communicating, analyzing or conducting simulations.

**Self-Efficacy:** According to Bandura (1982), “Self-efficacy is concerned with judgments of how well one can execute courses of action required to deal with prospective situations” (p. 122).

**ICT Self-Efficacy:** ICT self-efficacy refers to beliefs in teachers’ ability to accomplish tasks on computer technologies.

**Teacher Professional Development:** Professional development is a set of activities teachers participates to earn or maintain knowledge and skills in a specific content and/or pedagogy such as conferences, courses, trainings, workshops, study groups, mentoring, and other online and face-to-face collaborative activities.

**ICT Use:** ICT use refers to the types of teachers’ information and computer technologies implementation in the classrooms through (i) dialogic instruction, (ii) direct instruction, and (iii) assessment.

**Direct Instruction:** The direct instruction model refers to instructional approaches that are structured, sequenced, and led by teachers and the presentation of content to students by teachers, such as in a lecture or demonstration.

**Dialogic Instruction:** Dialogic instruction means using talk and collaboration effectively for carrying out teaching and learning. In this model, students take active roles in their learning
whereas teachers facilitate student-led learning experiences including mathematical discussions, explorations of ideas (Lewis, 2014).

**Zone of Proximal Development:** Vygotsky (1978) defined ZPD as “the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (p. 86).
Key to Abbreviations

The following abbreviations have been used in the document:

ICT: Information and Computer Technologies

PD: Professional Development

ZPD: Zone of Proximal Development

ISTE: International Society for Technology in Education

ICILS: International Computer and Information Literacy Study

IEA: International Association for the Evaluation of Educational Achievement

NCTM: National Council of Mathematics Teachers

TALIS: Teaching and Learning International Survey

OECD: Organization for Economic Co-operation and Development

TIMSS: Trends in International Mathematics and Science Study

FATIH: Movement to Increase Opportunities and Improve Technology, in Turkish,

Fırsatları Artırma ve Teknolojiyi İyileştirmeye Hareketi
CHAPTER II: LITERATURE REVIEW

Many research studies have revealed the benefits of technology in improving student achievement. However, the role of teachers, and whether they are prepared to use technology effectively in their classrooms, should be examined (Polly et al., 2010). The following studies address critical and key ideas that guide the framework of this dissertation. The first section provides an overview of the theories and their relationship to teacher education, specifically in terms of a general description of Desimone’s (2009) framework and its application to the current study to interpret the relationship between teachers’ PD and self-efficacy with ICT integration in classrooms. ZPD (Zone of Proximal Development) theory and Bandura’s self-efficacy theory have been utilized to support Desimone’s argument. ZPD is applicable to research on technology integration and can explain the association between PD and mathematics teachers’ use of ICT tools while Bandura’s self-efficacy framework explains the influence of teachers’ self-efficacy in technology integration. The second section discusses previous research studies with a purpose of explaining the connection of teachers’ ICT professional development and ICT self-efficacy with teachers’ technology implementation into the classroom. The final section describes the educational background in Turkey and the function of technology in Turkish education.

Theoretical Framework

Technology integration is helpful in teaching and learning mathematics (NCTM, 2000). Teachers’ knowledge, beliefs, and how they implement technology in their classrooms are fundamental factors that impact this integration effectively and meaningfully (Wachira & Keengwe, 2011). This section provides an overview of the theories and how they were utilized to develop the framework of this dissertation. There are three essential concepts that guide the theoretical approach of this dissertation. First, Desimone’s (2009) framework and its application
to the current study are discussed. Desimone’s (2009) conceptual structure addresses the influence of teacher professional development and self-efficacy on classroom practices. As Vygotsky’s ZPD explains the idea of professional development generating teacher change in practice, it is utilized to support Desimone’s argument in terms of the association between PD and mathematics teachers’ use of ICT tools. Third, the study gives an outline of Bandura’s self-efficacy to justify the effect of teachers’ self-efficacy in technology integration.

**A Framework for Studying the Effects of Professional Development on Teachers**

Desimone’s (2009) conceptual framework has been introduced as a useful and comprehensive framework suggested by literature and empirical research to evaluate the influence of professional development and beliefs on teachers’ classroom practices. This comprehensive framework explains three facets: 1) the definition of effective professional development, 2) the path showing how this effective professional development impacts teachers’ practices, and 3) the contextual factors influencing professional development (Kang et al., 2013).

![Desimone’s (2009) conceptual framework](image)

*Figure 1. Desimone’s (2009) conceptual framework*
Desimone (2009) proposed five core features of effective professional development that are critical to improving teacher knowledge and skills, improving their classroom practices, and finally increasing student achievement: (i) content focus, (ii) active learning, (iii) coherence, (iv) duration, and (v) collective participation.

**The content focus.** Content focus is the most effective feature of professional development (Desimone, 2009). Content indicates what teachers learn through professional development (Garet et al., 2001). Specifically, Kennedy (1998) defined two main types of content in professional development: knowledge of the subject matter, and the knowledge of how students learn that content. Desimone (2009) pointed that focus on subject matter content is linked to increases in teacher acquisition, practices, and student learning of that content.

**Active learning.** Active learning occurs when the professional development maintains opportunities for teachers to engage in the evaluation of teaching and learning (Garet et al., 2001). And, it includes observations of expert teachers or being observed, allowing for constant feedback, and interactive discussions while reviewing student work, etc. Previous research studies have suggested a variety of ways to support active learning, such as observations of expert teachers or being observed, classroom visits, developing and presenting lessons, leading discussions, peer coaching, mentoring, and interacting with teachers to discuss steps for improving teaching practice both face to face and virtually (Corcoran, 2007; Desimone, 2009; Harris, 2008b, Ryymin et al., 2008).

**Coherence.** Coherence is another feature that emphasizes the consistency of the content and underlying perspectives of professional development activities with the realities of teachers’ day-to-day work (Kang et al., 2013). Professional development is most effective when school
and state reforms and policies are aligned with what teachers are learning in professional development.

**Duration.** Time span is also an important feature to increase the quality of professional development. Hochberg and Desimone (2010) defined duration as “both the number of contact hours of a professional development activity, and the length of time over which engagement in the activity spans” (p. 96). For meaningful change in teacher beliefs and practices to occur, a professional development activity should be offered over a semester or intense summer program with at least 20 hours.

**Collective participation.** Collective participation is proposed as another feature that requires teachers from same school, grade, and/or content area to participate in the professional development programs collectively. A correlational analysis found that collective participation has a significant relationship with teacher changes in technology integration practices (Penuel, Fishman, Yamaguchi & Gallagher, 2007). Therefore, teachers have more change in classroom practices when they join the professional activities with other teachers from the same department, grade groupings, school, or set of schools.

In addition to the core features, Desimone (2009) proposed a conceptual framework for studying the effects of professional development on teachers and students (See Figure 1). This model allows researchers to study the change that professional development generates in teachers’ beliefs, knowledge, or practice. Also, this model can be utilized to understand how the change in instruction might influence students learning outcomes.

A previous study that used Desimone’s framework analyzed the effectiveness of an instructional-technology professional development program in a multiphase evaluation (Martin et al., 2010). The authors first examined the program, and then determined the impact of various
features in program implementation on teacher outcomes and student achievement. Martin and his colleagues (2010) found that greater PD participation was linked to higher-quality teacher products and higher student achievement. Those teacher products involved instruction modeling, technology integration, and inquiry-based learning. Another previous study utilized Desimone’s framework to examine the effect of PD on only student outcomes. Campbell (2011) conducted a 3-year randomized control study and found that over time mathematics coaches who highly engaged in PD courses including mathematics content, and pedagogy were positively effective in student achievement in grades 3, 4, and 5.

This current study intends to investigate the influence of eighth grade mathematics teachers’ technology professional development and technology self-efficacy on teacher changes in classroom technology integration practices. Also, it aims to picture the mediating role of technology self-efficacy between teacher professional development and classroom practices. Therefore, the framework for this study draws from Desimone’s (2009) conceptual framework to examine the contribution of several types of professional development activities and ICT-self efficacy on the effectiveness of ICT implementation in mathematics classrooms.

**Zone of Proximal Development Theory**

The Zone of Proximal Development (ZPD) is one of the major themes in Vygotsky's sociocultural theory. Vygotsky (1978) defined ZPD as “the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (p. 86). That is, the ZPD addresses the gap between an individual’s ability to perform a task and the higher level of performance that can be promoted by others with
more experience (Vygotsky, 1962). The ZPD involves a variety of tasks that individuals can accomplish with the help of others but cannot yet perform independently.

Originally, this concept was intended to explain child development. However, researchers in the literature noted that the Zone Theory could be practiced in the context of teacher education (Blanton, Westbrook, & Carter, 2005; Fani & Ghaemi, 2011; Hussain, Monaghan, & Threlfall, 2013; Kuusisaari, 2014). Zone theories were employed in teacher education research in various subject areas such as language, science, and mathematics. In their study, Shabani, Khatib, and Ebadi (2010) examined the instructional implications of Vygotsky's concept of Zone of Proximal Development and its applications to the notion of language teacher professional development. Kuusisaari (2014) utilized ZPD theory to explore the benefits of in-service teacher collaboration in teacher development. In that study, the author concluded that teachers can foster their knowledge with collaboration when they raise questions and revise collaboratively developed ideas (Kuusisaari, 2014).

Goos (2005) first applied Vygotsky’s ZPD to analyze how collaboration might influence the integration of pre-service and novice secondary mathematics teachers’ technology (e.g. computers and graphics calculators) into classroom practice. Then the concept was utilized in a series of studies investigating factors (beliefs, knowledge, professional development activities, teacher collaboration, etc.) influencing secondary mathematics teachers’ application of digital technologies in classroom instruction (Bennison & Goos, 2010; Goos, 2012; Goos & Bennison, 2008).

Regarding the theoretical framework discussed above, teachers’ professional development experiences and collaboration efforts can be explained as complementary components of a teacher’s Zone of Proximal Development. By applying the theory of ZPD,
professional development programs as “capable others” could promote teachers’ competencies and skills, as learning shifts from individual to collaborative settings (Wu, 2004). Therefore, it is appropriate to extend the theory in order to understand the influence of teachers’ collaborative development activities on classroom use of technology by placing teachers in the learner position.

Self-efficacy Theory

All teachers hold various educational beliefs about work, students, subject matter, and their roles and responsibilities (Pajares, 1992). Although the construct of educational beliefs is itself wide-ranging and “too difficult to operationalize” (p. 316), Pajares has identified several types of educational beliefs: teacher efficacy, epistemological beliefs, perceptions of self-worth (self-esteem), beliefs about a particular subject, and the self-efficacy of performing specific tasks. As Pan and Franklin (2011, p. 29) asserted, “due to the fact that what people do and believe may not always be consistent, people’s behaviors are usually guided by their perceptions of self-efficacy instead of their actual capabilities.” Since its introduction in the literature, the construct of self-efficacy has been identified as a significant variable for predicting an individual’s behavior (Joo, Lim, & Kim, 2013; Pajares & Miller, 1994).

Bandura (1986) defined self-efficacy as “People’s judgment of their capabilities to organize and execute courses of action required to attain designated types of performances” (p. 391); it is categorized as either high or low. If people have a high self-efficacy, they have a high level of belief in their ability to perform an action and finally achieve a goal. Task accomplishment provides the basis for further improvement in self-efficacy (Hale, 2013). The lower self-efficacy is, the less the level of belief in one’s ability to perform a particular task.
Bandura (1977) identified four main sources of self-efficacy: experiences of mastery, vicarious experiences, social persuasion, and emotional states. *Experiences of mastery* are one of the most prominent sources of self-efficacy, including prior successful experiences leading to the development of personal efficacy (Bandura, 1982). *Vicarious experiences* originate from the observation of peers or “others.” If the observed others perform a task successfully, this observation may increase the observer’s self-efficacy (Fanni, Rega, & Cantoni, 2013). But seeing them fail may negatively influence self-efficacy level of the observer. Third source of self-efficacy is *social persuasion*. It explains that one’s self-efficacy may be positively affected if others’ encouragement occurs. As Bandura (1982, p. 127) states, “Although social persuasion alone may be limited in its power to create enduring increases in self-efficacy, it can contribute to successful performance if the heightened appraisal is within realistic bounds.” According to Bandura, *emotional states* symbolize the final piece of self-efficacy. Individuals with a high level of self-efficacy may employ even negative psychological factors such as stress or tension to foster their performance, while those with a lower self-efficacy take these emotional states as a barrier to performing well (Fanni et al., 2013).

Teachers’ perceived ICT competency is an influential factor in their integration of technology in instruction (Beas & Salanova, 2006). High correlations were often found between teachers perceived self-efficacy and technology implementation (Pan & Franklin, 2011; Sang, Valcke, Braak, & Tondeur, 2010), although a few studies found technology self-efficacy was not significantly correlated to teachers’ efficient use of technology (e.g., Fanni et al., 2013). This study will utilize Bandura’s concept of self-efficacy to investigate how teachers’ ICT self-efficacy might influence their actual implementation of ICT in classrooms.
The Theoretical Model

Figure 2 below represents the theoretical model of this study. This study investigates the influence of ICT related professional development and self-efficacy on mathematics teachers’ technology implementation in the classroom and also examines how ICT self-efficacy mediates the relationship between PD and technology implementation. The three types of professional development considered in this study are listed in the left-hand boxes of Figure 2: Course-based ICT learning, ICT-supported collaboration for learning, and collaboration for seeking ICT-related knowledge. These three types of teacher PD have several components, drawn from the literature reviewed in this chapter. Teachers’ ICT self-efficacy represents a scale to measure teachers’ ability to perform a series of tasks on a computer by themselves. Furthermore, this study focuses on three types of ICT usage in mathematics classrooms. These are ICT use supporting dialogic instruction, ICT use supporting direct instruction, and ICT use through assessment.

Figure 2. Theoretical model
Previous Research Studies

Teachers’ Technology Use

Teachers have always been considered as the key to student success. As their role is changing, the International Society for Technology in Education (ISTE) has proposed new technology standards for teachers. In the latest available standards instituted in 2008, the ISTE outlined the novel skills and pedagogical visions teachers need to teach, work, and learn in the digital age. The ISTE technology standards for teachers are as follows (ISTE, 2014, pp. 1-2): (i) Facilitate and inspire student learning and creativity; (ii) Design and develop digital-age learning experiences and assessments; (iii) Model digital age work and learning; (iv) Promote and model digital citizenship and responsibility; and (v) Engage in professional growth and leadership.

Rubin (1996) emphasized that inquiry-based learning has usually occurred without technology; indeed, technology is not always needed. But, the author added, “Technology can play a special role in supporting inquiry-based learning and in transforming classroom practice” (p. 36). For a better understanding of how technology can support effective learning, Rubin (1996) noted two important distinctions: (i) technology being used as the subject of instruction or as a tool for teaching, and (ii) technology being used as amplifiers and transformers. Using technology as amplifiers can change the classroom practice in a more efficient way, while using technology as transformers can change the learning process and the way the instruction is carried out (Rubin, 1996).

Ainley, Banks, and Fleming (2002) investigated the ways in which ICT influence teaching and learning in technology-rich elementary and secondary classrooms. Based on case studies, they classified instructional computer use in four categories: computers as information resource tools, computers as authoring tools, computers as knowledge construction tools, and
computers as learning reinforcement tools (Ainley et al., 2002). Baylor and Ritchie (2002) believed that, in the classroom, technology could be used either as the subject matter for study or as an instructional tool for teaching and learning. In addition, they included the following types of educational technology in their classification: the use of computers for collaboration, constructivist use of technology, and the use of computers for higher-order skills (Baylor & Ritchie, 2002).

Similar to Rubin’s (1996) categorization, Hughes (2005) classified technology-supported teaching practices into three phases: Replacement, amplification, and transformation. In the replacement phase, teachers tend to implement technology as a tool that does not change instructional goals and learning processes. The amplification phase requires technology to be more effective than replacement, but again the tasks remain the same. Transformational use of technology is the most effective, as it may change the instruction from teacher-centered to student-centered and also foster student development (Hughes, 2005). Moreover, in a previous study, Tondeur, Van Braak, and Valcke (2007) identified three reliable factors for primary school teachers’ ICT competencies as follows: “Technical ICT skills, ICT competencies focusing on the learning process, and social and ethical ICT competencies” (p. 967). Finally, using a nationally representative dataset of 1653 Norwegian eighth-grade teachers, Scherer, Siddiq, and Teo (2015) classified some constructs to contribute to the literature on typologies of ICT usage. Their classification divides instructional ICT use into three categories: assessment and feedback, collaboration among students, and fostering the development of students’ skills.

Snoeyink and Ertmer (2001) attempted to identify factors impacting technology integration by teachers by classifying them into two categories: first-order (external) barriers, including resource-related issues such as lack of equipment and lack of support, and second-
order (internal) barriers, including organizational culture as well as teachers’ beliefs and attitudes about teaching and technology. Similarly, Wachira and Keengwe (2011) also identified a range of factors influencing mathematics teachers’ interest in and implementation of technology. These included availability and reliability, time, anxiety and confidence, access to appropriate teaching materials, access to technical support, the level of technology leadership, knowledge of technology integration into mathematics teaching, and beliefs about technology in learning (Wachira & Keengwe, 2011). This study specifically focused on teachers’ access to appropriate professional development activities and self-confidence in using ICT, both widely acknowledged to be critical factors that affect teachers’ classroom technology usage.

Technology use in mathematics classrooms. For effective learning of mathematics, technology must be fundamental part of the classroom instruction (NCTM, 2014). In the 21st century, instructional technologies in mathematics classrooms can be found in several formats, such as graphing calculators, web-based sources, instructional software, tablet PCs, desktop-based devices, Interactive White Boards, mobile devices, etc. From these forms of technologies, it can be seen that the technology in the mathematics classroom is changing from calculators to information and computer-based technologies. National Council of Teachers of Mathematics’ Principles and Standards for School Mathematics (2000) addressed technology in six crucial issues in mathematics education in addition to equity, teaching, learning, curriculum, and assessment. Because mathematics education is articulated across all six principles (Sherman, 2012), the role of technology in mathematics education has been intriguing.

According to NCTM’s Principles and Standards for School Mathematics (2000), “Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student learning” (p.24). While technology is influential as a teaching and
Learning tool in mathematics classrooms, it is not technology itself that causes the difference in teaching and learning. In particular, how technologies are used and by whom are critical factors making that difference (Heid, 2005). Therefore, technology-supported mathematics teaching approaches receive special attention.

There are several studies in the literature that focus on patterns of technology’s role in mathematics teaching and learning. For example, Goos, Galbraith, Renshaw, and Geiger (2003) proposed four roles for technology in math classrooms in terms of teaching interactions: Master, servant, partner, and extension of self. Technology as master refers to using technology as an instructional tool in the case that teachers have limited expertise with technology. In this model, students are usually encouraged to use technology to present ideas (e.g., projector, whiteboard) to fill the lack of teachers’ technical competence (Goos et al., 2003). Technology as servant means that technology is utilized as a replacement for basic mathematical procedures such as calculations and visual representations and the tasks remain same (Hughes, 2005). This use of technology supports teaching but does not involve any creativity to change the nature of activities (Goos et al., 2003). Technology’s role as a partner generates new ways for students and teachers to facilitate learning. This model requires that the technology mediates mathematical discussion and student interactions to promote understanding (Baylor & Ritchie, 2002). The last type, technology as extension of self, is the most advanced that has teachers and students as technological experts who are integrating technology inherently into teaching and learning (Goos et al., 2003). This naturally changes the instruction from teacher-centered to student-centered (Hughes, 2005).

In a recent study, Munter, Stein, and Smith (2015) described two distinct models of mathematics instruction in terms of pedagogy. Those included dialogic and direct instruction.
Although dialogic and direct instruction models have similarities, they especially differ in terms of students’ roles in learning, mathematical creativity, group work, and role of representations (Munter et al., 2015). For instance, dialogic instruction provides more opportunities for students to engage in small group and whole-class discussions to talk about their ideas, questions, and disagreements (Lewis, 2014). Through dialogic instruction, students take an active, dominant role in their learning whereas teachers facilitate student-led learning experiences including mathematical discussions, explorations of ideas (Lewis, 2014).

As the present study focuses on teachers’ technology implementation in mathematics classrooms, three important types of mathematics teachers’ instructional technology use were determined based on the existing literature (e.g., Munter et al., 2015) to form the focus of this study.

**Technology use supporting dialogic instruction.** Dialogic instruction is an effective teaching method of mathematics. It refers to student-centered and active learning process in which students build on prior knowledge with new experiences in socially constructed ways (Munter et al., 2015; NCTM, 2014). The Standards for Mathematical Practice (SMP) in the Common Core State Standards recommend that students should work collaboratively in developing and discussing ideas and concepts to enhance understanding (CCSSI 2010, SMP 2 and 3, p. 6). Also, students should use technology appropriately and communicate precisely to others in a mathematical discussion (SMP 5 and 6, p. 7).

Effective uses of ICT tools in student-centered mathematics instruction enable student-led discussions, proper communication, and collaboration among students. McCoy (2014) investigated the effect of information technology on attitudes toward mathematics in a middle graders’ algebra class. The study revealed that group collaboration generated more better
learning and understanding of mathematics. Therefore, McCoy (2014) suggested that technology was effective for students’ modeling, collaboration, and communication with understanding.

Furthermore, Mullins, Rummel, and Spada (2011) examined how collaboration might affect students learning of mathematics in a computer-supported classroom. It was found that collaborative student-centered activities generate a significant change in students’ mathematics learning outcomes in a technology-integrated classroom. However, teacher-centered and procedural instruction resulted in no effect on the development of mathematics understanding (Mullins et al., 2011).

**Technology use supporting direct instruction.** According to Munter et al. (2015), the direct instruction model represents lessons that include the followings: (a) The teacher’s descriptions of an objective and connections to previous topics; (b) presentation of necessary concepts; (c) demonstration of how to complete the target problem type; and (d) scaffolded phases of guided and independent practice, accompanied by immediate corrective feedback (p.6). Differing from dialogic instruction, this model does not require any communication or collaboration among students.

Direct instruction model does not only depress students’ role but also technology’s role in learning. In teacher-centered instruction, ICT tools can be used to present information through direct class instruction and reinforce learning of skills through repetition of examples. This type of technology uses only functions as a replacement and does not change any instructional practice, processes of student learning, or lesson goal (Hughes, 2005). When teachers assign passive roles to students and technology during classroom instruction, students’ mathematics understanding does not increase (Mullins et al., 2011).
**Technology use through assessment.** Assessment is a fundamental part of instruction. In effective mathematics instruction, assessment should help students identify the difficulties and strengths of past performance and that foster their learning (NCTM, 2014). Assessment should have four different functions in mathematics teaching and learning: (i) Tracing students’ progress to foster learning; (ii) making instructional decisions to adjust teaching; (iii) evaluating students’ achievement to report understanding of students; (iv) evaluating programs for decision-making about instructional programs (NCTM, 2014, p.89).

Assessment has two common types: Formative and summative. Summative often occurs at the end of a particular course, degree, or year whereas formative assessment primarily aims to inform teachers about students’ learning progress. There are also two common forms of formative assessment including oral and written assessments. Currently, a novel form emerged, assessment via ICT (Van den Heuvel-Panhuizen, Kolovou, & Peltenburg, 2011). ICT-based assessment generates better assessment in three ways: (i) Tasks can demand high mathematical procedures; (ii) tasks become more accessible; (iii) it exposes student-thinking process (Van den Heuvel-Panhuizen et al., 2011). The research underlines that ICT use in combination with formative feedback and assessment improves mathematics development of students (Genlott & Gronlund, 2016).

**Teacher Professional Development**

Professional development activities aim to generate a change in behavior. Guskey (2002) identified three primary goals of such programs as a change in the classroom traditions of teachers, a change in their views and beliefs, and a change in the learning outcomes of students. According to Guskey’s Model of Teacher Change, the sequence of such changes occurs as follows: “Teacher professional development -> changes in the classroom practices of teachers ->
change in the learning outcomes of students -> change in teachers’ attitudes and beliefs” (Guskey, 2002, p. 383). Therefore, efficient technology professional development programs first influence teachers and students to use technology in the classroom. As this use leads to better learning outcomes, teachers develop more positive attitudes and beliefs about technology.

In professional development literature, various criteria have been used to classify the types of effective professional development that foster teacher competencies and expertise. In an earlier study, Lauro and Dennis (1995) proposed five approaches to effective professional development for teachers: (1) A comprehensive learning approach that brings experts into a district or school to facilitate staff development sessions; (2) a one-shot deal that occurs before the academic year starts and brings in a presenter for staff members to focus on a particular topic; (3) conferences in only one location and in a specified time period that provide significant amounts of information on different practices and theories; (4) in-house training offered by experts for ongoing development; and (5) video-based learning where teachers utilize online resources and videos as a source of inspiration and long-term change for themselves. Each training approach can be useful in different cases according to learners’ needs and learning types. Lauro and Dennis (1995) described the comprehensive option as the most efficient, while the one-shot deal was defined as the type usually chosen for teacher development. Similar to the above classification, Corcoran (1995) also attempted to fit professional development into three categories: Traditional in-service programs (designed by state education departments, universities, etc.), in-house district activities, and school-based staff development. Furthermore, Harris (2008b) divided 20 educational technology PD models into five types: (a) Instructor-organized sessions (demonstrations, hands-on workshops, large-group and small-group interaction sessions, group work for problem solving); (b) individualized learning (independent
exploration, unassisted or assisted exploration, individual learning plans, prescribed and managed instruction); (c) collaborative learning (classroom visits, mentoring, peer coaching, sharing best practices both face-to-face and virtually, lesson study); (d) data-based inquiry (independent, collaborative, or externally assisted action research); and (e) development of materials (collaborative and individual). In the same year, Ryymin, Palonen & Hakkarainen (2008) analyzed the collaboration structure of teachers concerning their use of ICT. Four patterns of collaborative learning were introduced: The Counselor, the Weakly Social, the Collaborator, and the Inquirer. The Counselor actively provides guidance and advice without seeking information from colleagues. The Weakly Social favors media rather than face-to-face interactions in his/her information seeking. The Collaborator uses several kinds of media for web-based learning, while the Inquirer is an active seeker of ICT-related information and engages in face-to-face connections in the school (Ryymin et al., 2008).

In their study, Garet et al. (2001) used a nationally representative sample of mathematics and science teachers to show the effects of various types of PD on teachers’ skills. They proposed several structural and core features of effective professional development activities in order to make positive changes in teachers’ knowledge, skills, and classroom practices. Structural features refer to the form of activity, its duration, and the collective participation of teachers from the same school, while core features focus on content knowledge, opportunities for active learning, and coherence with other learning activities (Garet et al., 2001, p. 920). They also identified two broad categories of PD activities that are distinct in form, namely: Traditional vs. reform. Non-reform types of PD include workshops, conferences, courses, training, etc. Reform types of PD include study groups and network that support for collaborative learning. There are three types of professional development as the focus of this study: (i) Course-
training-based model (Corcoran, 1995; Garet et al., 2001); (ii) ICT mediated collaboration for learning (Bates, Phalen, & Moran, 2016; Duncan-Howell, 2010; Tinker, 2001; Ryymin et al., 2008); (iii) collaboration for ICT-related information (Borko, 2004; Carlson & Gadio, 2002; Ryymin et al., 2008).

**Course- and training-based model.** Course-based and training-based professional development activities have often been defined as non-reform types of professional development (e.g. Corcoran, 1995; Garet et al., 2001). These types of PD usually occur outside the teacher’s school or classroom and are delivered by experts in the various fields (Garet et al., 2001). Although non-reform PD programs are extensively used for teacher development, they are often criticized as not being useful in aiding teachers to incorporate technology successfully into their teaching and to feel confident using it (Carlson & Gadio, 2002). As a result, a new paradigm in professional development has emerged, involving study groups, mentorship, and coaching (Carlson & Gadio, 2002).

**Collaboration for ICT-related information.** Ryymin and his colleagues (2008) define this type of teacher collaboration use as active seeking of ICT-related information and engaging in face-to-face connections in the school. This type of learning usually occurs during the school day, particularly during classroom instruction supporting collaboration among teachers and experts. Harris (2008a) points out, “Collaborative learning is a promising model of professional development for teachers that has a growing research base demonstrating its effectiveness. It is the most desired—but unfortunately, also one of the least frequently practiced” (p. 24). Putnam and Borko (2000) suggested that teachers learn best in their own classrooms. As the teachers’ learning is situated directly in classroom practices, teacher change becomes powerful (Putnam & Borko, 2000). Therefore, teacher collaboration during school hours might effectively create a
significant change in teachers’ technology learning and implementation. Finally, collaborative teacher learning might occur not only face–to-face but also virtually (Harris, 2008a).

**ICT mediated collaboration for learning.** ICT mediated collaboration is defined as a networking structure in which teachers use several kinds of media for web-based learning including discussion boards, forums, and blogs, etc. Bates, Phalen, and Moran (2016) have broadly defined online PD as synchronous, asynchronous, and hybrid. *Synchronous* PD activities happen in real time and provide in-person PD in a virtual setting. *Asynchronous* PD happens at different times and includes self-paced interaction. Teacher social networks, discussion boards, and resource-sharing websites are the most common types of asynchronous platforms for teachers’ PD. *Hybrid* model of collaboration includes online learning activities take place as part of a larger in-person learning opportunity. For example, in-person trainings or courses that require virtual collaboration or other online tasks between sessions. These hybrid opportunities may use synchronous or asynchronous online tools based on the tasks (Bates et al., 2016).

A well-designed PD needs to enhance teachers’ abilities to use technology in collaboration and communication with colleagues in both local and global platforms (NCTM, 2014). Teachers need to actively seek out ways of using technology to support mathematics learning of students. As technology lets teachers collaborate with others, they bring more innovative ways into classrooms for students to use technology to describe mathematical thinking and generate mathematical discussions (NCTM, 2014).

Online spaces for PD can be an ideal choice “when teachers need access to colleagues with similar interests, but these collaborators are not available at their home schools” (Bates et al., 2016, p. 72). Supporting this, the previous studies state that online learning communities can become more effective when it is designed as a follow-up support platform for those who seek
further guidance and resources sharing after joining a face-to-face PD (McConnell, Parker, Eberhardt, Koehler, & Lundeberg, 2013; Sentence & Humphreys, 2015). These studies also highlight the fact that teachers mostly prefer face-to-face trainings and meetings for professional learning.

Professional Development and Technology Use

Researchers see a correlation between the style of professional development and its effectiveness in teachers’ technology integration. Uslu and Bumen (2012) conducted a study to analyze the impact of a six-week PD program on teachers’ technology integration and attitudes towards ICT. The results showed that the PD program significantly increased technology integration of teachers as confirmed by pre- and post-tests, while no difference was detected on the teachers’ attitudes towards ICT.

Lavonen and his colleagues investigated the effect of a PD program on science teachers’ ICT competence and integration (Lavonen, Juuti, Aksela, & Meisalo, 2006). They observed a substantial increase in science teachers’ ICT use and skill during the PD program. They also proposed some suggestions to improve the effectiveness of ICT-related PD programs on technology integration. For example, the programs should encourage collaboration (sharing ideas, group work, etc.) and should be pedagogy focused (Lavonen et al., 2006). Similarly, Serin (2015) conducted a quantitative study to investigate the relationship between science teachers’ perceived needs in ICT-related PD and their ICT-related classroom practices. He found that science teachers who reported no need for any PD already showed significantly higher use of technology during classroom instruction (Serin, 2015).

In addition, Cristo (2005) investigated the effect of a training designed to guide mathematics teachers to learn the instructional uses of ICT on mathematics teachers’ technology
implementation. The study focused on the ICT tools of Geometer’s sketchpad and Excel. In conclusion, Cristo (2005) suggested that familiarity with an ICT application and knowledge of how to use them was influential factors for the teachers to be able to integrate them in mathematics classrooms. Supporting Cristo’s (2005) findings, Goos and Bennison (2008) found professional development as a significant predictor for the frequency of mathematics teachers’ technology implementation in teaching. Eventually, Loong (2003) carried out a small-scale survey study on 63 secondary mathematics teachers in Australia. The survey asked about frequency of Internet use, ways in which teachers used the Internet for mathematics learning, and their professional development experiences. No statistically significant relationships were found between use and competency, and professional development (Loong, 2003).

Different than the studies cited above, there were previous research focused on the effect of online PD on teacher outcomes. Dalgarno and Colgan (2007) investigated the benefits of an online community on improving elementary mathematics teachers’ knowledge gain in terms of technology, pedagogy, and content. It has been emphasized that mathematics teachers are active seekers of technology mediated professional development experiences and opportunities for sharing and communicating, and access to quality resources (Dalgarno & Colgan, 2007). Therefore, as mathematics teachers can have access to knowledge through technology-facilitated learning, their technology integrated classroom practices might change. In their study, Fishman and his colleagues (2013) examined differences in science teacher and student learning from professional development (PD) in two modalities: Online and face-to-face. They found that teachers and students exhibited significant gains in both conditions, and that there was no significant difference between conditions. Therefore, science teachers’ knowledge, beliefs, and classroom practices significantly increased after both face to face and online PD. Although these
previous findings show that online PD activities can be as effective as trainings in face to face situations, one needs to consider other factors, cost, location, time, or content, that might affect teachers’ preference of two different modalities (Dede, Ketelhut, Whitehouse, & McCloskey, 2009; Fishman et al., 2013). Last but not least, carefully designed and thoughtfully delivered PD will always have significant costs associated with it, no matter of the delivery medium (Fishman et al., 2013).

Self-Efficacy and Technology Use

Many scholars have investigated the self-efficacy beliefs of teachers using ICT in a variety of subjects. Celik and Yesilyurt (2013) explored the influence of computer self-efficacy on pre-service teachers’ attitudes toward technology implementation in their future teaching. They found that computer self-efficacy positively and significantly affects attitudes toward implementing computer-mediated education (Celik & Yesilyurt, 2013). Later, Mai (2015) investigated if self-efficacy impacts science teachers' perceptions and their attitudes to adopting technology-based learning. He found that science teachers' attitudes were significantly predicted by their ICT self-efficacy (Mai, 2015).

Similarly, Pan and Franklin (2011) conducted a survey of 559 in-service teachers. They investigated the relationship between in-service teachers’ self-efficacy and the integration of Web 2.0 tools (e.g., blogs, wikis, podcasts, social networking sites, image/photo sharing sites, and course management systems). The results revealed that in-service teachers’ self-efficacy was a significant predictor for the integration of Web 2.0 tools into teaching (Pan & Franklin, 2011). Eventually, in an earlier survey study, Thomas (1996) found that lack of confidence was a significant barrier inhibiting mathematics teachers’ technology use. Ten years later Thomas (2006) administered a similar survey to determine whether teacher confidence and patterns of
use had changed. Teacher confidence in using computer technologies still was a significant factor influencing the use. Recent studies support these previous findings that teachers’ self-efficacy positively influenced their intention to use ICT in the classrooms (Banas & York, 2014; Joo, Park, & Lim, 2018).

**Relationships between PD and Self-efficacy, and Teachers’ ICT Implementation**

Scholars have explored the connections between classroom technology implementation and teachers’ PD and self-efficacy beliefs for integrating ICT. While Ertmer (1999) identified low self-efficacy as one of the barriers that limit teachers’ use of instructional technologies, he also proposed professional development as a solution to increase one’s self-efficacy. He suggested that more professional interaction among teachers help increase self-efficacy. And, mathematics teachers with high self-efficacy more likely to integrate technology into classroom instruction (Ertmer, 1999; Wachira & Keengwe, 2011). According to Ertmer (1999), modeling, reflection, and collaboration are three critical types of professional interaction that should occur among teachers. Modeling includes observing other teachers, discussing audio- or video-based case studies, mentoring; reflection includes reflecting on each other’s ideas and practices, publishing/sharing these ideas with others via conferences, journals, newsletters; and finally, collaboration involves ongoing communication and mutual engagement in projects (Ertmer, 1999).

Various scholars have suggested that there may be significant relationships between teachers’ PD and their technology competencies. Serin (2015) used TALIS 2013 data to investigate the relationship between science teachers’ ICT-related PD and their ICT-related classroom practices in Turkey, finding that science teachers’ participation in PD for learning ICT skills was highly associated with their use of technology during classroom instruction (Serin,
Similarly, Brinkerhoff (2006) conducted a case study to look for the effects of PD on teachers’ willingness to make changes in technology used. He found that a long-duration professional development influenced teachers’ technology skills and technology integration practices (Brinkerhoff, 2006). These studies show the important association between PD and teachers’ technology use.

In addition to those studies, there were previous work investigating the relationship between PD, technology use and self-efficacy, Tweed (2013) conducted a survey of 124 teachers from two school districts in the US. The results of the analysis revealed a weak positive (that is, insignificant) relationship between the hours spent in PD and teachers’ classroom use of technology. These results suggest that, even as teachers spend more time in PD learning to integrate technology, their use of technology in the classroom does not significantly increase. On the other hand, he found that the self-efficacy of teachers did show significant positive correlation to their classroom technology use (Tweed, 2013). That is, more confidence leads teachers to greater use of technology. Moreover, using a structural equation modeling (SEM), Chen (2010) investigated the mediator role of technology self-efficacy of pre-service teachers in relationship between teacher training and student-centered technology use during instruction. He found that perceived self-efficacy was a significant mediator that shape how teachers’ training is enacted in their decisions on technology use (Chen, 2010).

**Country Background**

**Educational System in Turkey**

Turkish formal education includes pre-primary, primary, lower secondary, upper secondary, and higher education institutions. Compulsory education was increased from five to eight years, including both primary and lower secondary schools, in 1997 and was then increased
from eight to twelve years in 2012. The new compulsory structure consists of four years each of primary, lower secondary, and upper secondary school (4+4+4).

The Ministry of National Education (MoNE) administers all stages and types of pre-tertiary education, while the Higher Education Council (HEC) is responsible for the administration of universities and the planning for undergraduate curricula (Clark & Mihael, 2012). Currently, there are 193 (117 public and 76 private) universities in Turkey, with 96 (20 private and 76 public) having faculties of education. Most of these faculties offer programs in regular daytime and evening hours.

**Technology in Turkish Schooling System**

Since its foundation in 1923, the Turkish Republic has progressed considerably. With historically good economic growth, Turkey is now the 17th largest economy in the world (The World Bank, 2016). It is also a candidate for membership in the European Union. According to the Tenth Development Plan 2014-2018 prepared by the State Planning Organization, Turkey seeks to be a country that has “Qualified People, Strong Society” by 2018 (The State Planning Organization, 2014, p. 29). To reach that goal, quality education becomes one of the most important pieces of development. Given the advances in science and technology, necessary investments will be pursued for sustaining innovation in education (The State Planning Organization, 2014).

In the 1990s, Turkey did not make a large investment in ICT use and development due to its economic situation (Akcaoglu, Gumus, Bellibas, & Boyer, 2014). That is to say, in 1995 per capita income was approximately $2,896 per year, while it was $10,515 in 2014. As the government sees technology as a way to prepare the nation for more competitive situations in a global economy, it has extensively invested in spending on instructional technology in schools,
especially during last two decades (Gumus, 2013). For example, the Movement to Increase Opportunities and Improve Technology, or FATIH Project, is the most recent and largest technology initiative in Turkey with a budget of approximately 8 billion dollars. The MoNE launched the FATIH Project to enhance ICT use in teaching and learning in schools and to develop equal opportunities by providing interactive whiteboards (IWBs), tablet computers, and Internet network infrastructure to all schools in basic education (Curaoglu et al., 2015; Ekici & Yılmaz, 2013). FATIH was designed to set up ICT hardware in 40,000 schools and 620,000 classrooms across Turkey. The project, which was initially launched in secondary schools but was eventually to reach all grade levels by 2019, has five main goals as cited in Pouzevvara et al. (2003, p. 6): (i) Equipping the necessary hardware and software infrastructure in schools; (ii) Providing educational e-content and management thereof; (iii) Promoting effective use of the ICT in teaching programs; (iv) Delivering conscious, reliable, and measurable ICT and internet usage; and (v) Providing in-service training for teachers to learn how to use ICT tools in the classrooms. With the aim of training 600,000 teachers, both face-to-face and online trainings are being conducted to support teachers better use new technological devices. The following list shows the specific number of hours of professional learning teachers have to complete thorough the FATIH Project (Akdur, 2017, p.18):

1) Technology Usage in Education (compulsory): 30 hours length, (face to face).

2) Safe and Conscious Internet Use (elective):10 hours length, (face to face).

3) FATIH Project Introduction Seminars (compulsory): 8 hours length, (face to face).

4) Web Infrastructure Seminars: face to face and online seminars. According to MoNE, the trainings had reached more than 120,000 teachers as of April 2013. MoNE has also founded 110
distance-learning centers in 81 provinces, as a way to ease teacher access to professional development activities.

**Conclusion**

In the literature, many researchers have provided clear categorizations of teachers’ PD and identified common characteristics of effective PD activities. For instance, Corcoran (1995) categorized PD as covering traditional in-service programs (offered by state education departments, universities, etc.), in-house district activities, and school-based staff development. Another classification proposed by Garet et al. (2001) includes non-reform types of PD (workshop, conference, course, training) vs. reform types (mentorship, study groups). In a more recent study, Harris (2008b) identifies five groups of PDs, namely, (i) instructor-organized sessions; (ii) individualized learning; (iii) development of materials; (iv) data-based inquiry; and (v) collaborative learning. Finally, teacher collaboration for learning has been categorized in four patterns: collaborator, weakly social, inquirer, and counselor (Ryymin et al., 2008). However, there has been little research analyzing the relationship between different categories of PD and various types of mathematics teachers’ instructional ICT uses. Specifically, I focus on three types of PD (course and training-based model, ICT-mediated learning, and collaboration for ICT), as technology’s role in professional learning varies from being the subject itself to being a mediator for learning. Moreover, in the previous studies investigating the relationship between PD and mathematics teachers’ use of technology, the technology implementation has been taken as a construct that is not specific to what types of usage occur. This study will analyze three types of classroom technology implementation occurring after detailed analysis of literature.

When it comes to ICT self-efficacy, previous studies investigated the relationship between ICT self-efficacy and technology implementation among pre-service teachers (Celik &
Martin Yesilyurt, 2013) and in-service teachers (Mai, 2015; Pan & Franklin, 2011). This study will focus on eighth-grade mathematics teachers. The ICT self-efficacy scale, which is very recent and not cited enough in the literature, was initially created for the ICILS data collection purposes. Indeed, there have been several studies using the ICILS dataset. However, those studies focused on investigating either factors that affect student computer literacy scores (Lorenz, Eickelmann, & Gerick, 2015; Siddiq, Scherer, & Tondeur, 2016) or the influence of teacher attitudes and background characteristics on teacher ICT implementation in a cross-cultural context European countries (Drossel, Eickelmann, & Gerick, 2016; Scherer et al., 2015). Using the ICILS data, this study will uniquely investigate the association of mathematics teacher PD types and ICT self-efficacy with mathematics teacher classroom ICT use focusing on Turkey. Using the ICILS data, this study will also investigate those associations on a nationally representative sample of eighth-grade mathematics teachers in Turkey.
CHAPTER III: RESEARCH DESIGN AND METHODS

The purpose of this study is to determine eighth grade mathematics teachers’ ability to integrate technological tools into instructional activities in ways that support direct instruction, dialogic instruction, and assessment. In addition, the study will examine mathematics teachers’ perceived level of technology implementation and how teachers’ ICT implementation in classroom instruction is related to their participation in professional development activities and ICT self-efficacy.

The following research questions will be addressed in this study:

1. How does eighth grade mathematics teacher ICT implementation occur through (i) dialogic instruction, (ii) direct instruction, and (iii) assessment?

2. Is there any significant impact of ICT professional development and ICT self-efficacy on eighth grade mathematics teachers’ classroom ICT implementation?

3. To what extend does ICT self-efficacy mediate the relationship between ICT professional development and eighth grade mathematics teachers’ classroom ICT implementation?

Based on the cited literature, I hypothesize that there is a significant positive relationship between different types of professional development, ICT self-efficacy, and eighth grade mathematics teachers’ ICT implementation during classroom instruction. I also hypothesize that ICT self-efficacy will mediate the relationship between professional development and eighth grade mathematics teachers’ ICT usage.

Data

This study will use the 2013 data from the International Computer and Information Literacy Study (ICILS). ICILS was the first assessment in the series of studies done by the
International Association for the Evaluation of Educational Achievement (IEA) to measure trends in students’ computer and literacy achievement and teachers’ ICT readiness. ICILS researchers gathered the data from approximately 60,000 Grade 8 (or equivalent) students and almost 35,000 teachers, school ICT-coordinators, and principals in more than 3,300 schools from 21 countries. The participating countries were Argentina (Buenos Aires), Australia, Canada (Newfoundland, Labrador, and Ontario), Chile, Croatia, Czech Republic, Denmark, Germany, Hong Kong SAR, Korea, Lithuania, Netherlands, Norway, Poland, Russian Federation, Slovak Republic, Slovenia, Switzerland, Thailand, and Turkey.

The ICILS 2013 survey focused on two target populations. The first target population comprised eighth-grade students, while the second included teachers who taught regular school subjects such as science, mathematics, language, and others to the target grade during the testing implementation in the 2012-2013 academic year.

The ICILS 2013 country representatives administered questionnaires to students, teachers, school principals, and ICT coordinators in the participating countries. The teachers’ questionnaire consisted of constructs about teachers’ backgrounds, their personal and professional use of ICT, their attitudes towards the use of ICT in teaching, ICT self-efficacy, ICT-related professional development activities, and others (Fraillon, Ainley, Schulz, Friedman, & Gebhardt, 2014).

**Target Population and Sample Design**

The IEA Data Processing and Research Center (DPC) used a systematic random sampling approach consisting of multiple sampling stages, clustering, and stratification for teacher target populations (Fraillon, Schulz, Friedman, Ainley, & Gebhardt, 2015). The samples were designed as two-stage cluster samples: “During the first stage of the sampling, schools were
chosen systematically with probabilities proportional to their size (PPS) as measured by the total
number of enrolled target-grade students” (Fraillon et al., 2015, p. 73). Each country was
encouraged to provide a minimum sample size of 150 schools. During the second stage of the
sampling, 15 teachers were randomly selected from all those teaching the target grade in schools
with 21 or more teachers of that grade. In schools with 20 or fewer such teachers, all teachers
were invited to participate.

Originally, 1887 Turkish teachers from 150 schools participated in the survey. 297 of
those teachers were mathematics teachers. In the questionnaire, however, there was a filter
question asking teachers if they ever used ICT in the teaching and learning activities of the
referenced class. Because of this filter question, more than half of the math teachers (54%) could
not be included in the sample since they reported no use of ICT (N=161). Only those who
responded “Yes” to the filter question were counted in the sample for the analysis. Therefore, the
sample used in the study was 136 mathematics teachers (See Table 1). As a rule of thumb, the 10
cases per variable was considered enough for SEM analysis (Wolf, Harrington, Clark, & Miller,
2013). Because there were 7 variables in this study, the sample size of 136 considered to be
appropriate for SEM analysis with no latent variables.

Table 1

*Characteristics of the Study Sample*

<table>
<thead>
<tr>
<th>Mathematics teachers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey data (All participating teachers)</td>
<td>297 (100%)</td>
</tr>
<tr>
<td>Sample of the study (Only ICT users)</td>
<td>136 (46%)</td>
</tr>
</tbody>
</table>
Weights

Weights compensate for unequal selection probabilities at various sampling stages and non-response patterns within each participating country (Fraillon et al., 2015). Sampling weights help researchers make sure that the sample of the data used for analysis reflects the population from which it was drawn. The weights provided with the ICILS data were calculated using information from the sampling design and the non-response rate of schools, and teachers. As indicated earlier, ICILS employed a stratified two-stage cluster sampling procedure, wherein the schools were sampled first and then the in-service teachers. The final primary teacher weight, TOTWGTT, was calculated as a product of several weight components: School-base weight (WGTFAC1), school nonresponse adjustment (WGTADJ1T), teacher-base weight (WGTFAC2T), teacher nonresponse adjustment (WGTADJ2T), and teacher multiplicity factor (WGTFAC3T) (Fraillon et al., 2015). Analyses was performed using the final primary teacher weight (TOTWGTT) and replication weights to provide accurate standard errors.

Variables in the Study

Dependent Variable

The learning outcomes considered in this study were based on the frequency of teachers’ ICT use during classroom instruction. This frequency included teachers’ ICT use through direct instruction, dialogic instruction, and assessment in mathematics classrooms.

Technology use during mathematics instruction. The in-service teachers were asked to respond to questions about their ICT use during classroom instruction. The response options were given on an ordinal scale of “never, sometimes, and often.” These responses were assigned numerical values from one through three, respectively. The items for teachers’ technology use were categorized based on the existing literature. Three categories emerged: ICT use supporting
direct instruction, ICT use supporting dialogic instruction, and ICT use through assessment. The categorization of ICT use as direct and dialogic instruction was informed by Munter et al. (2015). ICT use for assessment was included in the study because this type of implementation is a fundamental in mathematics instruction (NCTM, 2014; Van den Heuvel-Panhuizen et al., 2011).

Each category representing mathematics teachers’ ICT integration was measured creating a composite variable. First, a composite variable consisting of all the responses that represented teacher ICT use for direct instruction was created and named as “ICT use supporting direct mathematics instruction.” A composite variable including the items that were dialogic instruction was used as the outcome variable “ICT use supporting dialogic mathematics instruction.” Likewise, the final composite of assessment items was used as the outcome variable “ICT use for mathematics assessment.” The composites were computed by summing the appropriate items on Stata. Simple averaging is the most commonly used approach to creating a composite variable when original variables are continuous (Song, Lin, Ward, & Fine, 2013). The survey questions of this study were mainly either ordinal or dichotomous (yes/no). Therefore, calculating the sum scores were preferred for more meaningful interpretation. The correspondence between questions asked in the ICILS instrument and teacher technology use that was described in the literature are shown in Table 2.
Table 2

A Description of Dependent Variables

<table>
<thead>
<tr>
<th>Main Variable</th>
<th>Variables (Type &amp; Items)</th>
<th>Description</th>
</tr>
</thead>
</table>
| Types of Technology Use | *ICT use supporting direct instruction*  
(Continuous: composed of IT1G11A, IT1G11F) | Teachers reported how often they use ICT in classroom practices: (i) Presenting information through direct class instruction; (ii) Reinforcing learning of skills through repetition of examples |
| | *ICT use supporting dialogic instruction*  
(Continuous: composed of IT1G11C, IT1G11G, IT1G11I, IT1G11K) | (i) Enabling student-led whole-class discussions and presentations; (ii) Supporting collaboration among students; (iii) Enabling students to collaborate with other students (within or outside school); (iv) Supporting inquiry learning |
| | *ICT use through assessment*  
(Continuous: composed of IT1G11B, IT1G11D, IT1G11E) | (i) Providing remedial or enrichment support to individual students or small groups of students; (ii) Assessing students’ learning through tests; (iii) Providing feedback to students |

Adapted from the ICILS 2013 user guide for the international database page 139

Independent Variables

There are four primary independent variables that will be used in this study: Three types of teacher ICT related professional development and ICT self-efficacy.

**Types of professional development.** The questionnaire included questions about teachers’ participation to ICT related professional development activities. The questions were designed to ask teacher participation in a list of PDs during the last two years. Based on the existing literature and the type of learning occurred, the list of PD activities was divided into three categories: (i) *course-based ICT learning*, (ii) *ICT-mediated collaboration for learning*, and (iii) *collaboration for ICT-related information*. A summary of the PD activities items selected from the ICILS 2013 database is shown in Table 3.

**Course-based ICT learning.** In this study, course-based learning was operationalized as any professional development course or training that offers instruction for teachers about
classroom uses of information and computer technologies (See Table 3). The teachers rated questionnaire items related to course-based learning on a dichotomous scale. The scale had two response options: “Yes” or “No.” Originally, these responses were assigned numeric values, one and two, respectively. For the current analysis, reserve coding was applied and new values for “Yes” and “No” were two and one, respectively. The composite variable, Course-based ICT learning, was computed by summing those available items on Stata.

**ICT-mediated collaboration for learning.** ICT-mediated collaboration for learning was operationalized as collaborative professional development that occurs in virtual spaces, such as discussion boards, forums, or collaborative workspaces to exchange ideas about teaching and learning (See Table 3). The items available for this type of learning were on a dichotomous scale. Teachers were required to select “Yes” or “No” in order to respond. Originally, these responses were assigned numeric values, one and two, respectively. For the current analysis, reserve coding was applied and new values for “Yes” and “No” were two and one, respectively. A composite variable was created by calculating the sum value for the appropriate items and named as ICT-mediated collaboration for learning for the purpose of this study.

**Collaboration for ICT-related information.** The third category of technology PD was about collaboration between teachers in using ICT. It was operationalized as PD activity that requires in-school teacher collaboration. Teacher collaboration includes creating ICT-based lessons and materials, classrooms visits to observe others’ use of ICT in classrooms and sharing best practices (See Table 3). It was measured by a subscale that was already available in the dataset with an average reliability of 0.79 (Fraillon et al., 2015, p.209). The higher scale values represent more collaboration between teachers.
The proposed classification of PD activities for learning instructional uses of ICT tools corresponds fairly well to the literature cited. Course based model was introduced in several previous studies as shown below whereas the collaborator and inquirer teacher-networking patterns were defined by Ryymin, Palonen, and Hakkarainen (2008):

- Course- and training-based model (Corcoran, 1995; Garet et al., 2001)
- The Collaborator who engages in collaborative efforts of web-based learning by using several media (Bates, Phalen, & Moran, 2016; Duncan-Howell, 2010; Tinker, 2001)
- The Inquirer who is an active seeker of ICT-related information and prefers face-to-face contacts (Borko, 2004; Carlson & Gadio, 2002)

**Teachers’ ICT self-efficacy.** Teachers’ ICT self-efficacy was operationalized as teachers’ confidence about how well they can use computer technologies for teaching and learning by themselves. ICT self-efficacy is a continuous variable in this study. ICT self-efficacy was measured by a subscale that was already available in the dataset as a composite of 14 items. The data providers had previously conducted a confirmatory FA for the scale reliability (14 items; Cronbach’s alpha=0.87; see Appendix B). The scale ranges as follows: Disagree a lot, disagree, agree, and agree a lot.
### Table 3

**A Description of Independent Variables**

<table>
<thead>
<tr>
<th>Main Variable</th>
<th>Variables (Type &amp; Items)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Types of PD Activities</strong></td>
<td><em>Course and training based model</em> (Continuous: composed of IT1G15A, IT1G15B, IT1G15C, IT1G15D, IT1G15E, IT1G15H, IT1G15I, IT1G15F)</td>
<td>Teachers reported if they participated in any of the following courses or trainings in the past two years: (i) Introductory course on general applications (e.g., basic word processing, spreadsheets, databases); (ii) Advanced course on general applications (e.g., advanced word processing, spreadsheets, databases); (iii) Introductory course on Internet use (e.g., compiling Internet searches, digital resources); (iv) Advanced course on Internet use (e.g., creating websites, building web-based resources); (v) Course on integrating ICT into teaching and learning; (vi) Training on subject-specific software; (vii) Course on multimedia involving use of digital video/audio equipment; and (viii) Course on subject-specific digital resources</td>
</tr>
<tr>
<td><strong>ICT-mediated collaborative learning</strong></td>
<td><em>ITU1G15J, ITU1G15K</em></td>
<td>Teachers reported if they participated in any of the following PD activities in the past two years: (i) An ICT-mediated discussion or forum on teaching and learning; or (ii) Sharing and evaluating digital resources with others using a collaborative workspace</td>
</tr>
<tr>
<td><strong>Collaboration between teachers on learning to use ICT</strong></td>
<td><em>ITU1G16A, ITU1G16B, ITU1G16C, ITU1G16D, ITU1G16E</em></td>
<td>Teachers reported to what extent they agreed or disagreed that they (i) work together with other teachers on improving the use of ICT in classroom teaching; (ii) have a common set of rules in the school about how ICT should be used in classrooms; (iii) systematically collaborate with colleagues to develop ICT-based lessons based on the curriculum; (iv) observe how other teachers use ICT in teaching; and (v) have a common set of expectations in the school about what students will learn about ICT.</td>
</tr>
<tr>
<td><strong>ICT-Self efficacy</strong></td>
<td><em>(Continuous: composed of 14 items, IT1G107A through N)</em></td>
<td>Teachers reported how well they can do these tasks on a computer by themselves: (i) Producing a letter using a word-processing program; (ii) Emailing a file as an attachment; (iii) Storing digital photos on a computer; (iv) Filing digital documents in folders and sub-folders for monitoring students’ progress; (v) Using a spreadsheet program for keeping records or analyzing data; (vi) Contributing to a discussion forum/user group on the Internet (e.g., a wiki or blog); (vii) Producing presentations with simple animation functions; (viii) Using the Internet for online purchases and payments; (ix) Preparing lessons that involve the use of ICT by students; (x) Finding useful teaching resources on the Internet; (xi) Assessing student learning; and (xii) Collaborating with others using shared resources; Installing software</td>
</tr>
</tbody>
</table>

Adapted from the ICILS 2013 user guide for the international database pages 143-144
Data Analysis Approaches

In most participating countries including Turkey, a significant number of schools has smaller cluster sizes (close to 10). In this case, “single-level analysis may be preferable in order to obtain more reliable results, because conducting multilevel analysis with teacher data is unlikely to result in precise Level 1 estimates” (Jung & Carstens, 2015, p. 40). Therefore, single-level analysis will be preferred in necessary cases.

For the first research question, which examines the differences in mathematics teacher perceptions of classroom ICT implementation with regard to types occurred, descriptive analyses were carried out using percentages and presented in the form of bar graphs.

For the second and third research questions, which examine the relationship between ICT professional development activities, ICT self-efficacy, and outcome variables, structural equation modeling (SEM) was performed. There are several reasons why SEM is an appropriate approach to examining this research question. First, SEM allows the examination of associations between multiple outcomes instead of just estimating separate equations for each single outcome. This study had three dependent variables that were moderately correlated. This moderate correlation led the researcher use SEM rather than a separate multiple regression for each dependent variable. Second, this study aimed to investigate the mediator role ICT self-efficacy between PD types and teachers’ ICT implementation. SEM was also appropriate to successfully evaluate the mediating effects of ICT self-efficacy.

Stata SE 14 was used as statistical software for the analysis because it allowed for the inclusion of appropriate sampling weights to provide accurate standard errors and population estimates. In order to adjust for complex sample design and sample representative, the data were weighted using the ‘Svy’ procedures in Stata to incorporate the weights and replicate weights.
provided by ICILS. All descriptive analyses, assumptions, and SEM were conducted using the weighted sample. SPSS software package was not appropriate to use for the analysis because it does not handle jackknife replication for estimating sampling errors, which was the technique used for ICILS 2013.

There were important assumptions that had to be taken into consideration before employing SEM approach. Those assumptions were normality, linearity, independence of residuals, and homoscedacity. After all assumptions met, it was appropriate to run the analysis.

In the predictive models, professional development types included the following three: Course and training-based model, ICT-mediated collaborative learning, and collaboration between teachers for learning to use ICT. Furthermore, mathematics teachers’ technology use had three categories involving ICT use supporting dialogic instruction, ICT use supporting direct instruction, and the ICT use for assessment. The results of these analyses will lead us to recognize in what ways ICT tools support mathematics teaching and learning. The results will also inform us whether the predictor variables of technology professional development and ICT self-efficacy can predict various types of technology use. Especially, they will prove if collaboration aspect of PD would be helpful for teachers’ meaningful integration of information and computer technologies into mathematics classrooms. Finally, the findings will be important to determine the mediating role of ICT self-efficacy in the relationship between professional development and technology implementation. The results of this study will be presented in the following chapter.
CHAPTER IV: RESULTS

This study aimed to explore the relationship between professional development (course-based PD, collaboration, and online collaboration) and the type of technology implementation occurred in classrooms. It also aimed to investigate mediating role of self-efficacy in this relationship. The first goal was to describe how eighth grade mathematics teachers use information and computer technologies during classroom instruction in ways that support direct instruction, dialogic instruction, and assessment. The second primary purpose was to investigate if the mathematics teachers’ perceived level of technology implementation is related to their participation in professional development activities and ICT self-efficacy. Finally, the study aimed to examine how ICT self-efficacy mediates the relationship between professional development and technology implementation. The data used in this study were obtained from the ICILS 2013 existing database. This study focused on the eighth-grade mathematics teachers from Turkish schools who currently used the technology during the academic year of 2012-2013.

The ICILS survey instruments assessed teachers’ perceptions of technology implementation, ICT self-efficacy, and ICT related professional development participation. The independent variables were composite scores of ICT self-efficacy, and three types of professional development (ICT use through direct instruction, ICT use through dialogic instruction, and ICT use for assessment). The dependent variables were the composite scores of technology implementation types including ICT use during direct instruction, dialogic instruction, and assessment. In this paragraph you can remind the reader on the variables making the composite measure.

For the first research question descriptive analysis was used to display the distribution of the teachers’ technology uses in various instructional models. For second and third research
questions, a structural equation modeling (SEM) analyses approach with mediation analysis were used to determine 1) the direct effects of the independent variables (ICT self-efficacy, three types of PD) on various types of technology implementation; 2) indirect effect of PD on technology implementation when mediated by ICT self-efficacy. SEM analysis was preferred because of the moderate correlation between dependent variables. This chapter, therefore, provides information on the present participant demographics, descriptive statistics in the form of histograms, and predictive results from SEM. The analyses described were done utilizing statistical software Stata SE 14.2.

**Participant Demographics**

The first portion of the existing survey collected demographic characteristics of the respondents and their general experience with technology. Mathematics teachers who used technological tools during classroom instruction were selected as the focus of the study.

Of the 136 respondents, 66 were female (48.5%) and the others were male (51.5%). In regard to age, a total of 11 were less than 25 (8.1%), 47 between the age of 25 and 29 (34.6%), 51 between the age of 30 and 39 (37.5%), 16 between the age of 40 and 49 (11.8%), 10 between the age of 50 and 59 (7.4%), and only 1 between the age of 50 and 59 (.7%) (see Table 4).

The respondents were asked to report how long they have been using ICT for teaching purposes. Of the 136 respondents, 11 reported less than two-years’ experience with information and computer technologies (8.1%) while 125 reported two years or more experience (25%) (see Table 4).
Table 4

Respondents’ Demographics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>66</td>
<td>48.5</td>
</tr>
<tr>
<td>Male</td>
<td>70</td>
<td>51.5</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 25</td>
<td>11</td>
<td>8.1</td>
</tr>
<tr>
<td>25-29</td>
<td>47</td>
<td>34.6</td>
</tr>
<tr>
<td>30-39</td>
<td>51</td>
<td>37.5</td>
</tr>
<tr>
<td>40-49</td>
<td>16</td>
<td>11.8</td>
</tr>
<tr>
<td>50-59</td>
<td>10</td>
<td>7.4</td>
</tr>
<tr>
<td>60 and over</td>
<td>1</td>
<td>.7</td>
</tr>
<tr>
<td>Technology Experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than two years</td>
<td>11</td>
<td>8.1</td>
</tr>
<tr>
<td>Two years or more</td>
<td>125</td>
<td>91.9</td>
</tr>
</tbody>
</table>

Handling Missing Values and Outliers

Data were first screened for missing data and outliers. Eight missing values were detected. In order to check if the missing values are missing completely at random, independent sample t-tests were performed. In each independent variable with missing values, missing values were assigned to 1 as others 0. Testing if the two resulting groups (one with 0s on scores and the other with 1s on it) differ significantly on all variables. Since there was no significant difference in the results, it can be concluded that the missing values were missing completely at random. As Lagnkamp, Lehman, and Lemeshow (2010) suggested, when analyzing survey data with 10% or less of the values missing, list-wise deletion would be preferable since it may only cause a slight bias that are not severe. Because the number of missing values were 5% of the sample size (n=136), the list-wise deletion method was used to handle the missing values. Outliers are cases that have data values that differ substantially from the data values for the majority of cases in the data set. Outliers are important because they can change the results of the data analysis. Before
the analysis, univariate outliers first were detected. One way to identify univariate outliers is to convert all of the scores for a variable to standard scores. The presence of the univariate outliers was examined by computing standardized residuals for the variables of interest and observing if any of those standardized residuals fell below -3.29 and/or above 3.29 (Tabachnick & Fidell, 2001). No standardized residuals out of the range were found. Second, Cook’s distance and DFBeta measures were utilized to test if there is any influential case that exerts undue influence over the regression models. Cook’s distance is a measure of the overall effect of a single case on the model and the values greater than 1 may be cause for concern (Field, 2013, p. 306). No values were detected as influential case. DFBeta values found to be smaller than 1 as well. For detecting multivariate outliers, mahalanobis distances were calculated. These distances have a chi-square distribution with degrees of freedom equal to the number of predictors. With four predictors, a distance greater than 9.49 (p=.05) would be cause for concern (Field, 2013). No values that are greater than this cut-off value was found. Consequently, no outliers and/or influential cases were found in the dataset.

**Testing Assumptions**

Assumptions are important to consider as they are helpful to determine if a researcher can correctly draw conclusions from the results of their analysis. Before conducting statistics analyses for this study, data were tested for assumptions. Tests for assumptions included multicollinearity, independence of the residuals, normality, linearity, and homoscedasticity.

Multicollinearity occurs when you have two or more independent variables that are highly correlated with each other. Two procedures were followed to test for multicollinearity. First, bivariate correlations among the four predictors were analyzed. Highly correlated predictors generate a concern because it leads to problems with understanding unique
contributions of independent variables to the variance explained in the dependent variable. Any two predictors with a correlation larger than .80, raise a concern (Field, 2013). The correlations for each pair of independent variables were smaller than .80, which indicated there might be no potential multicollinearity problems. (See Table A1 in the appendix)

Second, tolerance and variance inflation factor (VIF) statistics were analyzed for each independent variable to check the multicollinearity. When the tolerance values less than .10 and VIF is more than 10, there may be a multicollinearity problem. VIF and Tolerance values for each predictor with each outcome variable were examined and found to be in range. It was therefore determined that multicollinearity was not an issue.

Next, in order to understand if the residual terms were uncorrelated, independence of the residuals test was measured using the Durbin-Watson value. The Durbin-Watson value can range from 0 to 4. When the residuals are uncorrelated, the value will be approximately equal to 2 (Field, 2013). Analysis found the Durbin-Watson value to be equal to 1.76 for model 1 (direct instruction as dependent variable), 1.82 for model 2 (dialogic instruction as dependent variable), and 1.51 for model 3 (assessment as dependent variable) suggesting that the residual terms are uncorrelated.

Normality was assessed through the analysis of skewness and kurtosis. Skewness is the measure of whether a distribution trails of in one direction or another, and kurtosis is the measure of the thickness of the tails of a distribution (Acock, 2012, p. 259). ICT use through direct instruction was positively distributed with a skewness of .204 (SE=.214) and kurtosis of -1.039 (SE=.425). ICT use through dialogic instruction was positively distributed with a skewness of .382 (SE=.214) and kurtosis of -.498 (SE=.425) while ICT use for assessment was negatively distributed with a skewness of -.029 (SE=.214) and kurtosis of -.573 (SE=.425). Score for
collaboration between teachers in using ICT was distributed with a skewness of .459 (SE=.214) and kurtosis of -.171 (SE=.425). Scores for online collaboration were also positively distributed with skewness of 1.690 (.214) and kurtosis of 1.964 (SE=.425). Finally, Course based professional development was distributed with a skewness of 1.221 (SE=.214) and kurtosis of -.200 (SE=.425) whereas the score for ICT self-efficacy was negatively distributed with a skewness of -.588 (SE=.214) and kurtosis of .185 (SE=.425). The values for skewness and kurtosis between -2 and +2 are considered acceptable in order to prove normal distribution (Field, 2013). Therefore, with the skewness values ranging from -1.663 to .413, and kurtosis values ranging from -.991 to 1.874, the data can be considered to be reasonably normally distributed.

Linearity was assessed using a P-P plot of standardized residuals. Visual inspection of the normal P-P plot indicated that the points were close to the line, establishing linearity as shown in Figure A1 with direct instruction as dependent variable, Figure A2 with dialogic instruction as dependent variable, and Figure A3 with assessment as dependent variable. (See Appendix A)

Homoscedasticity was assessed by visual inspection of a scatterplot of standardized residuals versus standardized predicted values. Homoscedasticity is an assumption related to dependency between variables (Hair, Anderson, Tatham, & Black, 1998). If there is homoscedasticity, there should be no pattern to the residuals plotted against the fitted values. The generally consistent spread as shown in Figure A4, Figure A5, and Figure A6 indicated that homoscedasticity could be assumed. (See Appendix A)

**Descriptive Information of the Subscales and Reliability Measures**

This section summarizes the average score and reliability information for each scale based on the sample withdrawn from ICILS 2013 existing database summary presented in Table
The mean scores of the four independent variables were self-efficacy (M = 51.52, SD = 9.51), collaboration (M = 55.29, SD = 10.4), followed by course-based PD (M = 9.42, SD = 2.27), and online collaboration (M = 2.47, SD = 0.77). For the dependent variables, the mean score for direct instruction was 4.49 (SD = 1.05), the mean score for dialogic instruction was 7.30 (SD = 2.20), and the mean score for assessment was 6.21 (SD = 1.66).

Reliability scores were analyzed to ensure internal consistency within the survey. Hair et al. (1998) argued that a Cronbach’s alpha of 0.6 and above were considered an effective reliability for judging a scale. Although many researchers recommend a minimum value of 0.7, the generally agreed lower limit for Cronbach’s alpha may decrease to 0.60 in exploratory research (Hair et al., 1998). In this study, the Cronbach's coefficient alpha values for six scales were all larger than 0.7, presenting good reliability for each scale (Hair et al., 1998). Only one scale, direct instruction, had Cronbach’s alpha of .684. Other Cronbach's coefficient alphas were as follows: self-efficacy was .901 with 14 items, dialogic instruction was .811 with 3 items, assessment was .793 with 3 items, collaboration was .816 with 5 items, online collaboration was .799 with 2 items, and course-based PD was .886 with 8 items. For existing subscales, collaboration and self-efficacy, the previous reported cronbach’s alpha values yielded as follows: Collaboration was 0.79 and self-efficacy was .87 (Fraillon et al., 2015) (See Appendix B). Overall, the Cronbach’s alphas ranging from 0.684 to 0.901 for the variables in the questionnaire used for the study implies that the instrument is reliable.

**ICT Implementation in Mathematics Classrooms**

Descriptive analyses were required to address the first research question (given below). Three separate histograms were created to display the differences that exist in eighth grade
mathematics teachers’ frequencies of ICT implementation through (i) dialogic instruction, (ii) direct instruction, and (iii) assessment.

RQ1: How does eighth grade mathematics teacher ICT implementation occur through (i) dialogic instruction, (ii) direct instruction, and (iii) assessment?

ICT implementation through direct instruction

This is a composite measure of the variables (i) presenting information through direct class instruction and (ii) reinforcing learning of skills through repetition of examples when using ICT in classroom practices. A mean score of 6 from the teachers’ reports indicated that they often experienced all the two types of ICT implementation while a score of 2 indicated that the teachers never experienced these practices. Figure 3 is a summary of percentages of the sum scores of the eight grade mathematics teachers’ classroom technology use during direct instruction. It was found that 25 percent of mathematics teachers often implemented ICT during direct instruction. On the other hand, only one percent of teachers never used any information and computer technologies when delivering content through direct instruction.
ICT implementation through direct instruction

ICT implementation through dialogic instruction

ICT implementation through dialogic instruction is a composite measure of the variables including (i) enabling student-led whole-class discussions and presentations; (ii) supporting collaboration among students; (iii) enabling students to collaborate with other students (within or outside school); and (iv) supporting inquiry learning. A sum score of 12 from the teachers’ reports indicated that they often experienced all the four types of ICT implementation while a score of 4 indicated that the teachers never experienced these practices. Figure 4 displays percentages of the eight grade mathematics teachers’ frequency of classroom technology use during direct instruction. The figure shows that only 5 percent of teachers often implemented ICT during dialogic instruction. On the other hand, 11 percent of teachers never used any information and computer technologies when delivering content through dialogic instruction.
**Figure 4.** ICT implementation through dialogic instruction

**ICT implementation for assessment**

This is a composite measure of the variables (i) providing remedial or enrichment support to individual students or small groups of students; (ii) assessing students' learning through tests; and (iii) providing feedback to students. A sum score of 9 from the teachers’ reports indicated that they often experienced all the three types of ICT implementation while a score of 3 indicated that the teachers never experienced these practices. Figure 5 displays percentages of the eight grade mathematics teachers’ frequency of classroom technology use through assessment. It was found that 13 percent of teachers often used information and computer technologies when assessing students’ learning. However, 6 percent of teachers never integrated any instructional technology into assessment practices.
The Relationship between PD, Self-efficacy, and ICT Implementation

To address the second and third research questions given below, a structural equation model with mediation analysis was run to investigate the associations between three types of ICT related professional development, ICT self-efficacy, and three correlated dependent variables.

RQ2: Is there any significant impact of ICT professional development and ICT self-efficacy on eighth grade mathematics teachers’ classroom ICT implementation?

RQ3: To what extend does ICT self-efficacy mediate the relationship between ICT professional development and eighth grade mathematics teachers’ classroom ICT implementation?

A structural equation model (SEM) approach was appropriate because of the existing moderate correlation between dependent variables. SEM model without latent variables was built to address two primary purposes. First, the SEM model addressed the direct relationship between
ICT professional development and ICT self-efficacy with technology use during mathematics instruction. Second, the SEM model included a mediation analysis that seeks to explain the observed relationship between PD and technology implementation via the inclusion of self-efficacy as a mediator variable. Three independent variables were collaboration, online collaboration, and course-based PD. ICT use as dependent variable has also three categories including technology use during direct instruction, dialogic instruction, and assessment.

For the goodness of fit statistics, chi-squared test, the root mean square error of approximation (RMSEA), the standardized root mean squared residual (SRMR), and the coefficient of determination (CD) were reported since they were only available fit measures for SEM analysis with survey weights. According to Hu and Bentler (1999), well-fit models should have a non-significant $\chi^2$, RMSEA smaller than .06, and SRMR smaller than .08. For SEM models with complex survey data, Stata uses four types of criteria to calculate the chi-squared test (Berndt, 1991; Greene, 1993; Judge et al., 1985; McElroy, 1977). Four different chi-squared values corresponding to each criterion were reported with the command r2sem. The selected chi-squared value was $\chi^2(14) = 19.39$, $p = .150$. This non-significant chi-squared value demonstrates a good fit. Chi-square value is sensitive to sample size and not preferred as a goodness of fit statistics recently for especially large samples. This study’s sample size was not considered to be large. So, it was appropriate to report chi-square value in addition to the other evidences for a well-fit model. Next, RMSEA was calculated as 0.053 and SRMR value was zero that corresponds to perfect fit. Finally, the value of coefficient of determination (CD), which is also known as R-squared, was 0.241. This means that the model accounts for 24.1% of the variance.

The mediation hypothesis of self-efficacy was tested using the structural equation modeling without latent variables on Stata statistical software. This procedure estimates total,
direct, and indirect effects of multiple predictors on dependent variables via the mediator. Direct effect is the effect of independent variable on dependent variable that is not mediated by the mediator. Indirect or mediated effects are part of the exposure effect that is mediated through the mediator. Total effects are the sum of the direct and indirect effects.

Results for the direct effects showed that self-efficacy ($p < .001$), collaboration ($p < .001$), and online collaboration ($p < .05$) had a significant association with ICT use through direct instruction. On the other hand, the other type of professional development (course-based PD) played non-significant ($p > .05$) role in increasing ICT use through direct instruction as shown Table 5. Second, having technology use through dialogic instruction as a dependent variable, the direct effects indicated that ICT self-efficacy, collaboration and course-based PD were significant factors ICT use through dialogic instruction ($p < .001$) as seen in Table 5. Finally, the direct effects indicated that ICT self-efficacy ($p < .001$), collaboration ($p < .001$), and course-based PD ($p < .01$) again significantly contributed to more ICT use through assessment. Online collaboration played insignificant ($p > .05$) role in the model as shown Table 5.
Table 5

Direct Effects of Professional Development and Self-efficacy on Technology Use

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>SE</th>
<th>t statistics</th>
<th>[95% Conf. interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct effects of IVs on technology use for direct instruction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>.032***</td>
<td>.002</td>
<td>18.47</td>
<td>.029 .036</td>
</tr>
<tr>
<td>Collaboration</td>
<td>.027***</td>
<td>.002</td>
<td>11.52</td>
<td>.023 .032</td>
</tr>
<tr>
<td>Online collaboration</td>
<td>.063*</td>
<td>.025</td>
<td>2.49</td>
<td>.013 .114</td>
</tr>
<tr>
<td>Course based PD</td>
<td>.029</td>
<td>.020</td>
<td>1.43</td>
<td>-.011 .069</td>
</tr>
<tr>
<td><strong>Direct effects of IVs on technology use for dialogic instruction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>.082***</td>
<td>.004</td>
<td>16.33</td>
<td>.071 .091</td>
</tr>
<tr>
<td>Collaboration</td>
<td>.057***</td>
<td>.005</td>
<td>10.47</td>
<td>.046 .068</td>
</tr>
<tr>
<td>Online collaboration</td>
<td>-.073</td>
<td>.070</td>
<td>-1.04</td>
<td>-.212 .067</td>
</tr>
<tr>
<td>Course based PD</td>
<td>.199***</td>
<td>.034</td>
<td>5.82</td>
<td>.130 .267</td>
</tr>
<tr>
<td><strong>Direct effects of IVs on technology use for assessment</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
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<td>.003</td>
<td>15.44</td>
<td>.051 .067</td>
</tr>
<tr>
<td>Collaboration</td>
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<td>.002</td>
<td>13.45</td>
<td>.030 .041</td>
</tr>
<tr>
<td>Online collaboration</td>
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<td>.043</td>
<td>-0.31</td>
<td>-.100 .073</td>
</tr>
<tr>
<td>Course based PD</td>
<td>.106***</td>
<td>.018</td>
<td>5.91</td>
<td>.070 .142</td>
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<td>.169 .262</td>
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<td>.236</td>
<td>0.43</td>
<td>-.369 .572</td>
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<tr>
<td>Course based PD</td>
<td>.079</td>
<td>.158</td>
<td>0.50</td>
<td>-.236 .395</td>
</tr>
</tbody>
</table>

*p < .05; **p < .01; ***p < .001

Next, the indirect effects of ICT related professional development through self-efficacy on technology uses of mathematics teachers through direct instruction, dialogic instruction, and assessment was evaluated. ICT self-efficacy was a significant mediator of the effects of collaboration on any type of instruction (Table 6). As expected, higher levels of collaboration were associated with higher levels of confidence, which then led to higher uses of technology regardless of instruction type. Online collaboration and course-based PD did not have any significant effect on teachers’ self-efficacy which led to no significant effect on teacher’s ICT implementation during any type of instruction.
Table 6

Mediator Effects of Self-efficacy in the Relationship between Professional Development and Technology Use

<table>
<thead>
<tr>
<th>Indirect effects of IVs on technology use through direct instruction via self-efficacy</th>
<th>Coefficient</th>
<th>SE</th>
<th>t statistics</th>
<th>[95% Conf. interval]</th>
</tr>
</thead>
<tbody>
<tr>
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<td>7.93</td>
<td>.005</td>
</tr>
<tr>
<td>Online collaboration</td>
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<td>.007</td>
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<td>-.011</td>
</tr>
<tr>
<td>Course based PD</td>
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<td>.005</td>
<td>0.50</td>
<td>-.007</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indirect effects of IVs on technology use through dialogic instruction via self-efficacy</th>
<th>Coefficient</th>
<th>SE</th>
<th>t statistics</th>
<th>[95% Conf. interval]</th>
</tr>
</thead>
<tbody>
<tr>
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<td>8.38</td>
<td>.009</td>
</tr>
<tr>
<td>Online collaboration</td>
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<td>.019</td>
<td>0.43</td>
<td>-.029</td>
</tr>
<tr>
<td>Course based PD</td>
<td>.006</td>
<td>.012</td>
<td>0.51</td>
<td>-.018</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indirect effects of IVs on technology use through assessment via self-efficacy</th>
<th>Coefficient</th>
<th>SE</th>
<th>t statistics</th>
<th>[95% Conf. interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration</td>
<td>.013***</td>
<td>.002</td>
<td>8.38</td>
<td>.013</td>
</tr>
<tr>
<td>Online collaboration</td>
<td>.006</td>
<td>.019</td>
<td>0.43</td>
<td>-.029</td>
</tr>
<tr>
<td>Course based PD</td>
<td>.005</td>
<td>.012</td>
<td>0.51</td>
<td>-.018</td>
</tr>
</tbody>
</table>

*p < .05; **p < .01; ***p < .001

As can be seen in Table 7, the total effect estimates confirmed that any collaborative type of professional development are significantly and positively associated to teachers’ technology implementation for direct instruction. Also, in-school collaboration among teachers for ICT learning and course based professional development were significantly and positively associated to teachers’ technology implementation for both dialogic instruction and students’ assessment.
Table 7

**Total Effects of Professional Development on Technology Use**

<table>
<thead>
<tr>
<th>Total effects of IVs on technology use for direct instruction</th>
<th>Coefficient</th>
<th>SE</th>
<th>t statistics</th>
<th>[95% Conf. interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration</td>
<td>.034***</td>
<td>.002</td>
<td>18.47</td>
<td>.029</td>
</tr>
<tr>
<td>Online collaboration</td>
<td>.067*</td>
<td>.025</td>
<td>2.71</td>
<td>.018</td>
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<tr>
<td>Course based PD</td>
<td>.032</td>
<td>.016</td>
<td>1.93</td>
<td>-.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total effects of IVs on technology use for dialogic instruction</th>
<th>Coefficient</th>
<th>SE</th>
<th>t statistics</th>
<th>[95% Conf. interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration</td>
<td>.075***</td>
<td>.005</td>
<td>13.76</td>
<td>.064</td>
</tr>
<tr>
<td>Online collaboration</td>
<td>-.064</td>
<td>.069</td>
<td>-0.94</td>
<td>-.201</td>
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<tr>
<td>Course based PD</td>
<td>.205***</td>
<td>.024</td>
<td>8.45</td>
<td>.157</td>
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<table>
<thead>
<tr>
<th>Total effects of IVs on technology use for assessment</th>
<th>Coefficient</th>
<th>SE</th>
<th>t statistics</th>
<th>[95% Conf. interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration</td>
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<td>14.36</td>
<td>.042</td>
</tr>
<tr>
<td>Online collaboration</td>
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<td>.044</td>
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<td>-.095</td>
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<tr>
<td>Course based PD</td>
<td>.111***</td>
<td>.014</td>
<td>7.95</td>
<td>.083</td>
</tr>
</tbody>
</table>

*p < .05; **p < .01; ***p < .001

**Summary**

This chapter presented the management of missing values and outliers, assumptions check, participants’ demographics, descriptive statistics, and the results and findings of the regression analyses into whether the various ICT-related PD activities and ICT self-efficacy have any relationship with mathematics teachers’ technology use during classroom instruction and whether self-efficacy mediate the relationship between PD and technology use. Descriptive statistics and a structural equation modeling with mediation analysis were utilized to address the three research questions. The independent variables in the SEM model were collaborative PD, virtually collaborative PD, course-based PD whereas the dependent variables were ICT use through direct instruction, dialogic instruction, and assessment. ICT self-efficacy played a role as a mediator in the SEM model. Because the dependent variables were moderately correlated, SEM was preferred.
A total of 136 responses were collected, eight of which were dropped due to missing data. Of the 136 respondents, there was a balanced distribution between female and male participants. In regard to age, the majority of respondents were in their 20s, followed by 30s, followed by 40s, and a small minority were in their 50s. The majority of respondents had two years and more experience with information and computer technologies.

The results showed that self-efficacy, collaboration, and online collaboration had a significant and positive impact on ICT use through direct instruction. Second, the results indicated that ICT self-efficacy, collaboration, and course-based PD were significant factors for ICT use through dialogic instruction and those three factors are also significantly contributed to increasing ICT use through assessment. When ICT self-efficacy mediated the relationship between PD activities and teachers’ technology use in classroom instruction, only collaboration among teachers had a significantly positive impact on teachers’ technology use through any type of instruction.
CHAPTER V: SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Introduction

This chapter provides a review of the results of the study and a discussion of the importance of these results in teaching mathematics with technology. Conclusions drawn from the analyses and the implications of the findings are included. Finally, recommendations for technology teacher professional development programs and effective technology integration, limitations, and future research are discussed.

Summary of Findings

The purpose of the study was to determine whether technology teacher professional development (course-based PD, collaboration, and online collaboration) and ICT self-efficacy had significantly positive association with ICT implementation into classroom instruction (through direct instruction, dialogic instruction, and assessment). This study also investigated the mediating role of self-efficacy in the relationship of professional development and teacher ICT implementation. In the following sections, the researcher discusses the findings, organized by each research question.

Teachers’ ICT Implementation during Mathematics Instruction

In relation to the first research question, the researcher aimed to highlight and compare eighth-grade mathematics teachers’ implementation of ICT tools through different instructional approaches, namely: direct instruction, dialogic instruction, and assessment of learning. The findings show that 25 percent of mathematics teachers often implemented ICT during direct instruction, whereas only 5 percent of teachers did so during dialogic instruction. In addition, 13 percent of teachers reported they often used ICT tools for assessment of students’ learning. On the other hand, only 1 percent of teachers never used ICTs when delivering content through
direct instruction, while 11 percent did not use ICTs when delivering content through dialogic instruction. According to Munter and his colleagues (2015), direct and dialogic models of instruction differ in terms of students’ and teachers’ roles in learning, mathematical creativity, group work, and the role of representations. Lewis (2014) asserted that dialogic instruction provides more opportunities for students to take an active role in their learning by engaging in small-group and whole-class discussions about their ideas, questions, and disagreements. Based on the findings, it seems likely that mathematics teachers tend to integrate technology more through direct instruction than through dialogic instruction and assessment. Therefore, the findings suggest that mathematics teachers tend to use ICT tools more in tasks that do not require collaboration among students. Similarly, Mullins et al. (2011) found that, in such tasks, teachers tended to assign passive roles to students and technology during instruction, a pattern that does not help increase students’ mathematical learning.

**The association of PD and Self-Efficacy with ICT Implementation during Mathematics Instruction**

The results showed that self-efficacy, collaboration, and online collaboration significantly impacted ICT use through direct instruction. The results also indicated that ICT self-efficacy, collaboration, and course-based PD were three significant factors for ICT use in dialogic instruction. Those three factors also significantly contributed to increasing ICT use through assessment.

The findings of the present study highlight the significant relationship between collaborative professional development and mathematics teachers’ ICT use through dialogic instruction and assessment. Based on the findings, it can be concluded that in-school collaboration among teachers on learning to use ICT (e.g., working with other teachers on
improving the use of ICT in classroom teaching, along with using ICT-based lessons centered on the curriculum and observing how other teachers use ICT in teaching) positively influences teachers’ classroom technology use for more rigorous tasks. A previous study with congruent findings investigated the effect of PD programs on science teachers’ ICT competence and integration, suggesting that successful PD programs should first encourage collaboration among teachers in the form of sharing ideas, group work, and the like (Lavonen et al., 2006). Similarly, Harris (2008a) pointed out, “Collaborative learning is a promising model of professional development for teachers that has a growing research base demonstrating its effectiveness. It is the most desired—but unfortunately, also one of the least frequently—practiced” (p. 24). As teachers work with their colleagues on improving the use of ICT in classroom teaching and ICT-based lessons based on the curriculum, and observe how other teachers use ICT in teaching, they are more likely to benefit from using ICT in their own teaching. It is also important to note that schools supporting in-school collaboration among teachers might promote a change in teachers’ technology learning and implementation. Mathematics teachers working in that type of supportive environment may become more open to implementing technology in student-centered collaborative learning tasks. As Putnam and Borko (2000) suggested, teachers learn best in their own classrooms. Once the teachers’ learning is situated directly in classroom practices, teacher change becomes powerful (Putnam & Borko, 2000). Therefore, teacher collaboration during school hours might effectively create a significant change in teachers’ technology learning and implementation.

Our findings showing the significant positive relationship between ICT-mediated collaboration and tech use through direct instruction were similar to those of previous studies. For example, Dalgarno and Colgan (2007) highlighted that, as mathematics teachers engaged in
technology-facilitated learning opportunities to advance their knowledge, their level of technology integration in the classroom might change. However, it is not possible to conclude that the change in instructional practices is automatically effective. The findings in this study showed that ICT-mediated collaboration did not have any significant effect on more rigorous teachers’ technology implementation practices such as dialogic instruction and assessment.

Based on the results, teachers’ ICT self-efficacy was found to be a significant factor for any type of technology implementation during mathematics instruction. This finding mirrors previous research findings. Earlier researchers have linked high levels of in-service teachers’ self-efficacy to their technology implementation into teaching (e.g., Joo et al., 2018; Pan & Franklin, 2011; Sang et al., 2010). This implies that the more confident teachers are about their ability to teach with computers, the more likely they are to be interested in teaching with computers. Only a few studies found that technology self-efficacy was not significantly correlated to teachers’ efficient use of technology (e.g., Fanni et al., 2013).

**Face-to-face vs. online PD.** The findings of this research study highlight an important difference between the impact of face-to-face and online types of PD on teacher growth. Based on the findings, collaborative face-to-face PD had significantly positive contribution for ICT implementation in all types of instruction (direct instruction, dialogic instruction, and assessment). Also, the course-based PD had a significantly positive impact on teachers’ ICT implementation through dialogic instruction and assessment. However, signs of the significance of online collaboration for ICT learning were found only for teachers who used ICT through direct instruction. In other words, there was no significant impact of online collaboration on ICT implementation through dialogic instruction or assessment. This non-significant finding raises
some critical questions for further discussions, since there is an increasing tendency to move from face-to-face PD to online learning communities in teacher education.

Thus, the current findings suggest that teachers prefer face-to-face meetings for professional learning. Previous studies support the current study’s findings that online collaboration among teachers might not be as effective as face-to-face PD practices in terms of changing teachers’ development and classroom practices (McConnell, 2013; Ryymin et al., 2008; Sentance & Humphreys, 2015). Previous research also suggested that online learning communities can become more effective when they are designed as a follow-up support platform for those seeking further guidance and resource sharing after joining a face-to-face PD (McConnell et al., 2013; Sentance & Humphreys, 2015). On the other hand, it is important to note that a previous study found no significant difference between the two types (face-to-face and online), when it compared the impact on teacher learning outcomes, including knowledge, beliefs, and classroom practices (Fishman et al., 2013). Although the earlier literature encompasses varied opinions, the current study agrees that teachers’ face-to-face meetings for professional learning would be more likely to change their classroom practices than online learning.

Based on the findings, this study claims that the modality of PD (online or face-to-face) can make a difference in teachers’ learning outcomes. The researcher concludes that there are some specific factors that might be associated with why online PD was found to be less effective in a given teacher technology-learning context, namely: the content of PD, the time spent during PD, and the cost.

First, the content of PD for this study was learning how to use ICT tools in mathematics classrooms. Learning about new technologies and tools, especially in online settings, could be
difficult for some participants. Teachers, after all, work in a face-to-face environment by the nature of their role, so they tend to be more comfortable with this type of interaction (Sentance & Humphreys, 2015). For teachers who need to grow their knowledge and skills related to technology integration, online learning might require some extra effort; this might well be more easily achieved via a commitment to face-to-face trainings and collaboration. In sum, there are reasons why teachers might prefer face-to-face trainings and collaborations when seeking technology-related information.

The issue of total time spent on PD might be another factor impacting the effectiveness of PD activities on teachers’ learning outcomes. For meaningful change in teacher beliefs and practices to occur, the duration of a professional development activity is important (Hochberg & Desimone, 2010). That is, if the average number of hours teachers spent on online PD was less than the total number of hours spent by teachers in the face-to-face condition, this difference in contact hours might impact teacher learning and, subsequently, classroom practices. Teachers tend to spend less time in online learning spaces, and to use most of their time there in reviewing shared ideas and resources rather than contributing to the discussion (Fishman et al., 2013). Therefore, time spent and the quality use of that time might be other factors that reduce the effectiveness of online PD practices.

The idea that online PD is more cost-effective than face-to-face training is widely held among policymakers and school leaders (Dede et al., 2009). However, previous research also suggests that the cost of both modalities of PD is similar in designing and delivering, as well as highly dependent on context (Fishman et al., 2013). In this study, for example, face-to-face collaboration occurred on-site among the teachers who worked at the same school, thereby reducing the cost spent when compared to other face-to-face trainings that requires travel and
time. Therefore, depending on the design of PD, face-to-face PD activities would be equally cost-effective as compared to online PD. Overall, it is important to keep in mind that carefully designed and thoughtfully delivered PD will always have significant costs associated with it, no matter what the delivery medium (Fishman et al., 2013).

Self-Efficacy as a Mediator in the Relationship between PD and ICT Implementation during Mathematics Instruction

With this question, the researcher aimed to investigate the potential of a mediating relationship for ICT self-efficacy between several PD and ICT use-related variables among eighth-grade mathematics teachers in Turkey. The rationale for selecting self-efficacy as a mediator lay in the fact that teacher beliefs have been suggested as a potential mediator between professional development and teacher classroom practices (e.g., Desimone, 2009; Kang et al., 2013). There is also an emerging need in the literature to investigate the mediating roles of beliefs, satisfaction, and efficacy in the relationship between PD and teaching practice (Kang et al., 2013).

The results from the mediation analyses revealed that, when ICT self-efficacy mediated the hypothesized relationship, only collaboration among teachers had a significantly positive influence on teachers’ technology use through any type of instruction. When teachers are exposed to collaborative in-service education, they are more likely to have high confidence in using technology and then providing quality instruction for students (Desimone, 2009; Yuksel, 2012). According to Desimone (2009), there are three core features of a quality in-service education: 1) applying active learning strategies; 2) supporting interaction among teachers from the same department (e.g., math); 3) being content-focused. Therefore, as mathematics teachers interact with each other in attempting to improve content-specific teaching and learning, they are
more likely to have high self-efficacy and then increase technology integration as the result of direct instruction, dialogic instruction, and assessment. Ertmer (1999) also proposed professional development as a solution to overcome the low self-efficacy barrier that limits teachers’ technology integration, suggesting that more professional development interaction among teachers in the form of modeling, reflection, and collaboration helps increase self-efficacy. It turns out that mathematics teachers with high self-efficacy more likely to integrate technology (Ertmer, 1999; Wachira & Keengwe, 2011). Some examples of effective professional development activities that could increase self-efficacy are the following: observing other teachers, reflecting on each other’s ideas and practices, publishing/sharing these ideas with others, ongoing communication, mentoring, mutual engagement in projects, and discussion about case-studies (Ertmer, 1999). Participation in these professional learning opportunities could eventually encourage teachers to become more innovative, as they become more confident. As a result, these changes in teaching modalities could lead to better student learning in mathematics and greater proficiency in fundamental 21st-century skills.

**Recommendations for Future Research**

The study data were collected during the academic year 2012-2013. The first recommendation for future analyses is that researchers replicate this study using the ICILS 2018 dataset, which will be available by the end of 2020. Because ICILS 2018 will be linked directly to ICILS 2013, this could allow participating countries to monitor changes over time in the contexts of teaching and learning.

Second, a single-level structural equation modeling was performed, based on the teachers’ self-report survey items, due to the small cluster sizes of schools that participated in the study. Future researchers could include data from the principals’ and ICT coordinators’ surveys
to provide more detailed information about professional development activities and teachers’ classroom practices from the perspectives of other professionals.

Third, given that this study conducted a secondary data analysis on an existing survey study, the results might be limited to participants’ perceptions in nature. For future research, interviews and observations should be included to allow a more triangulated study on what is happening in technology-integrated classrooms and professional development activities.

Next, this study utilized Desimone’s framework to investigate the relationships among PD, self-efficacy, and classroom practices, describing the mediator role of self-efficacy in the relationship between PD and classroom practices. Initially, Desimone’s framework included a final step, which is student learning, suggesting that researchers follow this path when examining the associations among PD, knowledge and beliefs, changes in instruction, and student learning. For future research, it would be desirable to include that final path—student learning—and investigate how the change in PD, teacher knowledge and beliefs, and, finally, change in classroom instruction affects student achievement. Also, future researchers might consider studying the mediating roles of teachers’ knowledge, attitudes, and beliefs toward ICT and ICT-related classroom practices in the path from professional development through student learning.

Finally, the further applications of future research recommendations should be considered in the faculty development field. The investigation of how different forms of support and training programs facilitate faculty use of technology into pedagogical practices is a growing and increasingly important area of research in higher education (Baran, 2016). Previous research conducted on the barriers of effective technology integration in higher education found the most frequent obstacles being faculty beliefs, lack of knowledge, limited institutional support, and lack of self-efficacy (Kopcha 2008). Therefore, investigating the role of those barriers in the
relationship between PD and technology use might have the potential to promote solutions for the adoption and dissemination of technology integration practices throughout higher education.

**Limitations**

As mentioned before, there were several limitations to this study, which may have affected the results. In the ICILS 2013 study, a significant number of schools in Turkey had smaller cluster sizes (close to 10). The researcher, therefore, conducted a single-level analysis to obtain more reliable results, because conducting a multilevel analysis with teacher data was unlikely to result in precise Level 1 estimates (Jung & Carstens, 2015). In other words, only teacher-level survey data were taken into account for this study. However, other professionals from each school, including principals and ICT coordinators, were also participants in the ICILS 2013 survey, and they were sampled at the school level. Although it was not appropriate to include those individuals in this study, their responses should be important in order to provide more detailed information about professional development activities and teachers’ classroom practices from the perspectives of other professionals. The analysis was also limited to the teachers’ self-reports, as survey studies by nature are focused on participants’ perceptions. Interviews and observations should be included in future research in order to allow a deeper look into what is occurring during technology-integrated classrooms and professional development activities.

Another limitation was that data were collected during the academic year 2012-2013. Teachers’ participation in technology professional development, teachers’ beliefs, and the level of teachers’ technology implementation in Turkey might be different now, based on changing experiences over the years. However, this study is still critical, because the time for data collection occurred a few years after the FATIH project was launched in 2010. This study,
therefore, should help researchers understand the occurrence of teacher-related factors at a time when middle-level teachers were not yet exposed to any PD activities through the FATIH project, which initially began at the secondary level in 2010. Ultimately, it was expected to dramatically alter the presence of ICT in the classrooms and teacher trainings, as it aimed eventually to reach students and teachers at all grade levels (K-12) between 2011 and 2019. Current results would ideally be used in comparison with the next ICILS study. Clearly, it would be beneficial to see how the project supported student and teacher growth over the years. Also, instructional technology is always working to improve, which means it is important to note this ever-changing situation when considering the present and when making recommendations for the future. Yet those changes need not affect the associations between types of technology and professional development, teacher self-efficacy, and teacher classroom technology uses, which are at the center of this study.

Based on the teachers’ survey, this researcher acquired sufficient information about the content of PD activities, including the type of activities and interactions that occurred among the teachers in all three PD forms (course-based trainings, face-to-face collaboration, and online collaboration). However, it is not possible to know the duration of each PD form. This is another limitation, as time spent on any PD can be critical to changing teacher outcomes, in addition to other factors (Hochberg & Desimone, 2010). Finally, one of the composite variables in the study, online collaboration, was constructed based on two survey items. This could be considered as a potential limitation.
Implications for Practice and Conclusion

The recommendations that came out of this study can be used as a guide in mathematics teachers’ professional development programs in and out of schools. The results of this study can provide a framework (e.g., effective technology-related PD programs) and ways that mathematics teachers can use to encourage eighth-grade students to use technology to support their mathematics learning. While this study focused on only the content area of mathematics, the results of the study have the potential to guide other content area teachers (e.g., lessons in any subject or education level) in regard to preparing them to incorporate technology into instruction in ways that support students’ learning. It is important to train teachers to use ICT tools in ways that support students’ active learning through discussions and collaboration in any content-area. Professional development providers and school leaders should be aware of the importance of attending to collaboration aspect of instructional technology when using it as a teaching and learning tool, and train teachers based on this goal.

The technology integration is not intended to take the teacher’s place in the classroom. However, the teachers can utilize from appropriate technologies to develop educational materials and engage students in learning the content. MoNE of Turkey supported teachers to use technological tools by either developing or purchasing a variety of e-content software, tutorials, encyclopedias, animations, simulations, games and so on for students, for use both within and outside of the classroom (Curaoglu et al., 2013). Gaining a better understanding of how to effectively integrate technology into the classroom to enrich students’ knowledge should be the goal of all educators. To help teachers achieve this goal, teachers are offered with on-going face-to-face and online trainings to better use new technological devices in teaching. The FATIH
Project required educators in Turkey complete a specific number of hours of professional learning as follows (Akdur, 2017, p.18):

1) Technology Usage in Education (compulsory): 30 hours length, (face to face).

2) Safe and Conscious Internet Use (elective):10 hours length, (face to face).

3) FATIH Project Introduction Seminars (compulsory): 8 hours length, (face to face).

4) Web Infrastructure Seminars: face to face and online seminars.

Although there are no standards for teachers’ technology professional growth and leadership in Turkey yet, recent initiatives and programs by MoNE in Turkey encourage educators to re-think how to teach in the 21st century. This study also helps teachers understand the role of effective PD activities for adapting their teaching for 21st century learning. In details, this study suggests teachers to engage in the professional development practices that would teach them effective uses of technologies for active learning and collaboration in the classroom.

The data showed a significant relationship between professional development and technology use in the mathematics classroom, more importantly, this association depended on the structure of PD and level of classroom technology uses. To be more explicit, the mathematics teachers who attended the on-site collaborative PD activities on technology were possibly looking for new and more rigorous ways to integrate technology into the classroom. Teachers seemed to utilize from face-to-face PD activities rather than online learning communities. Especially, during school hours, teachers should be encouraged to collaborate with other teachers on improving the ICT use in classroom teaching.

The data also showed ICT self-efficacy has a significant influence on teachers’ classroom technology use. This finding agrees with Bandura’s (1986) theory of self-efficacy stating that as teacher self-efficacy is advanced, the level of integration in the classroom will likely
correspondingly increase. This study also found a significant role of self-efficacy as a mediator between on-site collaboration and classroom technology practices. This finding indicated that participation in on-site collaborative PD leads to higher ICT self-efficacy, which supports mathematics teachers for technology integration into classroom instruction. This finding was supported by previous literature as well (Bandura, 1982; Desimone, 2009). According to Bandura (1982), an increase in teachers’ collaboration for technology learning might lead an increase in the sources of their self-efficacy such as mastery experiences, vicarious experiences, and social persuasion which would effectively increase teachers’ technology integration. For example, vicarious experiences originate from the observation of peer teachers/colleagues which is one of the in-school professional activities considered when operationally defining the collaboration type of PD for the purpose of the current study. Successful performance of the observed peers on a task may lead an increase in the observer teacher’s self-efficacy (Fanni et al., 2013). More successful vicarious experiences might result in higher social persuasion and more mastery experiences as they all related sources of self-efficacy. Therefore, teachers’ interaction and collaboration with colleagues on effective practices allow them gain peers’ encouragement, positive feedback on practices, and prior successful experiences concerning technology. And, this would lead higher levels of self-efficacy and then higher use of technology in classroom instruction, which would be desirable to showcase the successes of current initiatives in Turkey.

In conclusion, teachers should be offered with greater amounts and greater varieties of technology professional development, including a blend of professional development courses depending on individual needs and individualized learning opportunities providing face to face and online collaborations. Policy makers and schools should note that face-to-face collaboration among teachers were more effective than online professional interactions to make a change in
teacher practices. Online learning communities should be encouraged for teachers who seek further guidance and resources sharing after joining a face-to-face training (McConnell et al., 2013; Sentence & Humphreys, 2015). Therefore, teachers should collaborate more in person to observe each other, work together, and learn from each other’s experiences, and then use online platforms for further communication and resource sharing.

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## Appendix A: Testing Assumptions

### Table A1

**Correlations among Variables**

<table>
<thead>
<tr>
<th></th>
<th>Online Collaboration</th>
<th>Course based PD</th>
<th>Collabo.</th>
<th>ICT self-efficacy</th>
<th>DirectIns</th>
<th>DialogicIns</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online Collaboration</td>
<td>-</td>
<td>.554*</td>
<td>.249**</td>
<td>.060</td>
<td>.105</td>
<td>.177*</td>
<td>.129</td>
</tr>
<tr>
<td>Course based PD</td>
<td>.554*</td>
<td>-</td>
<td>.315*</td>
<td>.110</td>
<td>.084</td>
<td>.249*</td>
<td>.173</td>
</tr>
<tr>
<td>Collaboration</td>
<td>.249*</td>
<td>.315*</td>
<td>-</td>
<td>.233*</td>
<td>.263*</td>
<td>.358*</td>
<td>.286*</td>
</tr>
<tr>
<td>ICT self-efficacy</td>
<td>.060</td>
<td>.110</td>
<td>.233*</td>
<td>-</td>
<td>.292*</td>
<td>.428*</td>
<td>.351*</td>
</tr>
<tr>
<td>DirectInstruction</td>
<td>.105</td>
<td>.084</td>
<td>.263*</td>
<td>.292*</td>
<td>-</td>
<td>.572*</td>
<td>.737*</td>
</tr>
<tr>
<td>DialogicIns</td>
<td>.177*</td>
<td>.249*</td>
<td>.358*</td>
<td>.428*</td>
<td>.572*</td>
<td>-</td>
<td>.698*</td>
</tr>
<tr>
<td>Assessment</td>
<td>.129</td>
<td>.173</td>
<td>.286*</td>
<td>.351*</td>
<td>.737*</td>
<td>.698*</td>
<td>-</td>
</tr>
</tbody>
</table>

**p < .05**

### Table A2

**Average Score and Reliability Information for Each Composite**

<table>
<thead>
<tr>
<th>Subscales</th>
<th>Items</th>
<th>Range (Min-Max)</th>
<th>M</th>
<th>SD</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT use through direct instruction</td>
<td>2</td>
<td>2-6</td>
<td>4.49</td>
<td>1.05</td>
<td>.684</td>
</tr>
<tr>
<td>ICT use through dialogic instruction</td>
<td>3</td>
<td>4-12</td>
<td>7.30</td>
<td>2.20</td>
<td>.811</td>
</tr>
<tr>
<td>ICT use for assessment</td>
<td>3</td>
<td>3-9</td>
<td>6.21</td>
<td>1.66</td>
<td>.793</td>
</tr>
<tr>
<td>Collaboration</td>
<td>5</td>
<td>29.57-75.62</td>
<td>55.12</td>
<td>10.34</td>
<td>.816</td>
</tr>
<tr>
<td>Online collaboration</td>
<td>2</td>
<td>2-4</td>
<td>2.47</td>
<td>0.77</td>
<td>.799</td>
</tr>
<tr>
<td>Course based PD</td>
<td>8</td>
<td>8-16</td>
<td>9.42</td>
<td>2.27</td>
<td>.886</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>14</td>
<td>22.59-64.19</td>
<td>51.52</td>
<td>9.51</td>
<td>.901</td>
</tr>
</tbody>
</table>
Figure A1. Testing for linearity: normal p-p plot of regression standardized residual (direct instruction as dependent variable)

Figure A2. Testing for linearity: normal p-p plot of regression standardized residual (dialogic instruction as dependent variable)
Figure A3. Testing for linearity: normal p-p plot of regression standardized residual (assessment as dependent variable)

Figure A4. Testing for homoscedasticity with direct instruction as a dependent variable
Figure A5. Testing for homoscedasticity with dialogic instruction as a dependent variable

Figure A6. Testing for homoscedasticity with assessment as a dependent variable
Appendix B: CFA for the ICT Self-efficacy Scale

Figure 12.6: Confirmatory factor analysis of items measuring teachers’ ICT self-efficacy

Table 12.9: Item parameters for scale measuring teachers' confidence in computer tasks (self-efficacy)

<table>
<thead>
<tr>
<th>Scale or Item</th>
<th>Question/Item Wording</th>
<th>Delta</th>
<th>Tau(1)</th>
<th>Tau(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_EFF</td>
<td>How well can you do these tasks on a computer by yourself?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT1G07A</td>
<td>Searching for and finding a file on your computer</td>
<td>-1.10</td>
<td>-0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>IT1G07B</td>
<td>Emailing a file as an attachment</td>
<td>-1.06</td>
<td>-0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>IT1G07C</td>
<td>Storing your digital photos on a computer</td>
<td>-0.33</td>
<td>-0.42</td>
<td>0.42</td>
</tr>
<tr>
<td>IT1G07D</td>
<td>Filing digital documents in folders and subfolders</td>
<td>-0.44</td>
<td>-0.36</td>
<td>0.36</td>
</tr>
<tr>
<td>IT1G07E</td>
<td>Monitoring students' progress</td>
<td>0.15</td>
<td>-1.37</td>
<td>1.37</td>
</tr>
<tr>
<td>IT1G07F</td>
<td>Using a spreadsheet program (e.g., Lotus 1 2 3®, Microsoft Excel®) for keeping records or analysing data</td>
<td>0.87</td>
<td>-1.12</td>
<td>1.12</td>
</tr>
<tr>
<td>IT1G07G</td>
<td>Contributing to a discussion forum/user group on the internet (for example, a wiki or blog)</td>
<td>0.76</td>
<td>-1.22</td>
<td>1.22</td>
</tr>
<tr>
<td>IT1G07H</td>
<td>Producing presentations (for example, [PowerPoint® or a similar program]), with simple animation functions</td>
<td>0.09</td>
<td>-0.61</td>
<td>0.61</td>
</tr>
<tr>
<td>IT1G07I</td>
<td>Using the internet for online purchases and payments</td>
<td>-0.18</td>
<td>-0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>IT1G07J</td>
<td>Preparing lessons that involve the use of ICT by students</td>
<td>-0.05</td>
<td>-1.07</td>
<td>1.07</td>
</tr>
<tr>
<td>IT1G07K</td>
<td>Finding useful teaching resources on the internet</td>
<td>-1.66</td>
<td>-0.46</td>
<td>0.46</td>
</tr>
<tr>
<td>IT1G07L</td>
<td>Assessing student learning</td>
<td>-0.13</td>
<td>-1.27</td>
<td>1.27</td>
</tr>
<tr>
<td>IT1G07M</td>
<td>Collaborating with others using shared resources such as [Google Docs®]</td>
<td>1.32</td>
<td>-1.52</td>
<td>1.52</td>
</tr>
<tr>
<td>IT1G07N</td>
<td>Installing software</td>
<td>1.76</td>
<td>-0.70</td>
<td>0.70</td>
</tr>
</tbody>
</table>

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