2014

Teachers' Perceived Influences on Technology Integration Decisions: A Grounded Theory on Instructional Decisions after Professional Development

Karen Larsen Greenhaus
College of William & Mary - School of Education

Recommended Citation

Greenhaus, Karen Larsen, "Teachers' Perceived Influences on Technology Integration Decisions: A Grounded Theory on Instructional Decisions after Professional Development" (2014). *Dissertations, Theses, and Masters Projects.* Paper 1539618733.
https://dx.doi.org/doi:10.25774/w4-xwce-nx22

Teachers' Perceived Influences on Technology Integration Decisions:

A Grounded Theory on Instructional Decisions after Professional Development

A Dissertation

Presented to

The Faculty of the School of Education

The College of William and Mary

In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Education

by
Karen Larsen Greenhaus
April 2014

Teachers' Perceived Influences on Technology Integration Decisions: A Grounded Theory on Instructional Decisions after Professional Development

by

Karen Larsen Greenhaus

Approved April 2014 by

Mark J. Hofer, Ph. D.
Chairperson of Doctoral Committee

Michael F. DiPaola, Ed. D.

Judith B. Harris, Ph. D.

DEDICATION

This dissertation is dedicated to my wonderful, supportive, loving husband, Dan, my two amazing daughters, Shannon and Quinn, and my parents, Kris and Eileen Larsen. My parents instilled in me the belief that I could do and be anything I wanted, and provided the encouragement and support to dream big. My husband has sacrificed and supported me through this long process, providing a never-ending source of strength and belief in my abilities to succeed. My daughters, who may not have realized how inspirational they were to me, have provided me with encouragement and understanding and the motivation to not give up. Thank you all for believing in me, putting up with my scattered-brain and ultra-focus on writing and studying all these years!

Table of Contents

Acknowledgements

This has been a very long journey, and there are so many people that have supported me throughout the entire process. I would like to acknowledge and thank my committee chairperson, Mark Hofer, for all his advice, support and understanding throughout the years. I know it was rough there at times, but I appreciate you standing by and talking me through things and helping me get past those rough spots.

I want to also thank the other members of my committee, Dr. Judi Harris and Dr. Mike DiPaola, for their wisdom and advice in steering me in a direction I may not have seen at first, but one that ultimately was the right path. In addition, I want to thank Judi and Mark, as the leaders of the CET program, and The College of William and Mary, for the willingness and efforts to help create a non-traditional path for me to complete my doctorate. When life and location changes interfered with program completion plans, with their help and creativity, I was able to forge a different path to finish my coursework and dissertation. Thank goodness for online learning, independent study approaches and accommodating professors!

There are too many friends and family members to list who gave me support, understanding, and encouragement throughout the years. You know who you are and you know how much you all mean to me. Thank you for always giving me those words of encouragement, listening to my complaints, and boosting me up with your never-ending belief in my ability to do this. Without you, I would have given up a long time ago!

Finally, I would like to acknowledge the principals, teachers, and students who I have learned from, worked with, and taught over the course of my career. My journey to this point is a result of what I have learned from you and with you. You inspired me to start this journey and continue to inspire me every day to keep learning and being the best educator I can be.

List of Tables

List of Figures

Abstract

TEACHERS' PERCEIVED INFLUENCES ON TECHNOLOGY INTEGRATION: A GROUNDED THEORY ON INSTRUCTIONAL DECISIONS AFTER PROFESSIONAL DEVELOPMENT

Karen L. Greenhaus, Ed. D., Curriculum and Educational Technology, The College of William and Mary in Virginia, 2014. Chairperson: Mark J. Hofer, Ph. D.

This qualitative grounded theory study explored teachers' instructional decisions around planning and practice for technology integration after participation in professional development. The purpose of this study was to determine how a long-term hybrid professional development experience influenced, if at all, math teachers' instructional decisions to integrate *The Geometer's Sketchpad* into their planning and classroom practice. There are several components for effective professional development suggested in the research literature. Professional development that is sustained over long periods of time, connected to teachers' practice, and provides active engagement in learning by participating teachers' is more likely to result in effective implementation of new skills and pedagogical practices (Darling-Hammond & McLaughlin, 1995; Polly & Hannafin, 2010). The seven participants in this study all experienced a seven-month hybrid professional development that was designed using these research-recommended components. The study took place ten months after the professional development. Sources of data included classroom observations, one-on-one interviews, and written lesson plans. Data generation occurred over a three-month span of time. Data were analyzed using constant-comparative methods. A theory grounded in the data found four perceived influences on teachers' instructional decisions around planning and practice for technology integration: curriculum and district expectations; professional development; teaching practices; and internal and external factors. These four influences work together, with curriculum and district expectations being the central influence. The findings from this study have implications for educational leaders around their decisions for technology acquisitions, use expectations and design of technology-focused professional development.

Teachers' Perceived Influences on Technology Integration Decisions:

A Grounded Theory on Instructional Decisions after Professional Development

Chapter 1

Introduction

Picture a computer lab into which a high school algebra teacher, whom we will call Jeanne, has brought her students to learn about slope using new math software. The students are all sitting at computers; Jeanne has them open the math software, gives them a worksheet on slope and tells the students to follow the directions printed on the worksheet that walks them through both the steps for using the software as well as the math lesson. The students have not seen the software before and become confused about the steps they are to follow. Jeanne is confronted with numerous questions and frustration from the students. Most of the available class time is spent answering questions about how to operate the software, rather than learning the math content of the lesson. At the end of class, Jeanne determines the software is not going to be a useful learning tool for her and her students, and will probably not use the software again.

In the computer lab next door, another teacher whom we will call Sara is working with her geometry students on quadrilateral properties using the same math software. Sara's students are also using a worksheet that steps them through the use of the software tool as they are guided through quadrilateral constructions and explorations. Sara's students are more comfortable with the software, and she is able to walk around and help various students as needed, with most students engaged in the math lesson. This is the second day in the lab for Sara's students; they spent a day the previous week simply learning to use the software as preparation for this first math lesson using *Sketchpad*. This preliminary day of software exploration has allowed Sara and her students to focus today on the math content rather than the software. Sara is pleased with how her students are using the software to create examples of many quadrilaterals. She is already making plans for the next lesson, during which she will incorporate further use of the new software.

Both of these teachers taught in a district where I served as a math specialist. They both participated in the same two-day software training session that took place two weeks prior to them teaching these math lessons. The professional development sessions were focused on learning the skills necessary to operate the new math software, with an emphasis on how the software could be used to support the teaching of math content. The professional development involved modeling appropriate pedagogical strategies for using the new software with students and specific software skills training. Jeanne and Sara experienced hands-on, content-focused learning activities. These activities included lesson plan notes to support teachers' pedagogical strategies and student worksheets to support students' hands-on learning. These activities simultaneously scaffold the learning of the software along with the learning of the mathematics content.

In each classroom example, Jeanne and Sara used the same activities they were introduced to in the professional development session with their own students. Jeanne did not introduce the software prior to her students engaging in the mathematics learning activity, even though this was how she herself was introduced to the software. Providing students with an opportunity to learn the software in advance was also one of the pedagogical strategies suggested in the training. Jeanne's instructional implementation did not follow what was modeled in the professional development; it is unclear why she made those instructional decisions. Jeanne's students were frustrated with the software and unable to focus on the math lesson.

Sara's instructional decisions seemed to follow what was modeled in the professional development experience. She provided a day of focusing on the operation of the software with her students prior to having them use the software to do a focused lesson on math. The previous experience with the software increased her students' comfort level with the software, allowing them to focus on the learning of the mathematics, not the software, during the next lesson.

The instructional decisions made by Sara and Jeanne around integrating the math software into their math instruction seemed to indicate that the same professional development session content was understood and appropriated differently by the two teachers. This raises the question about what teachers actually internalize after participating in a professional development experience and how, if at all, that knowledge transfers to their instructional practice. The purpose of this study was to examine, after an extended professional development experience, how and why teachers made the instructional decisions they did related to the focus of the professional development. Are there other contextual factors that contributed to their instructional decisions not related to the intended learning outcomes from professional development?

Professional Development

Professional development, as defined by the National Staff Development Council [NSDC] (2012a), is "a comprehensive, sustained, and intensive approach to improving teachers' and principals' effectiveness in raising student achievement" (para. 34). NSDC promotes a "collective effort" (para. 34A) approach to professional learning. This approach focuses on the idea that professional learning is a continuous, ongoing effort, where teams of educators are constantly looking at student and educator needs and goals to revise, assess, and provide the necessary support and resources for new skills and strategies. Professional development can be structured in a variety of ways, which includes workshops and conferences. No matter the structure of the professional development experience, the focus should always be centered on the learning goals and how the professional development activities and resources will enhance and support student achievement. The NSDC (2012b) lists several components that should be present in quality professional development: learning communities; leadership; resources; data; learning designs; implementation; and outcomes. These components should be included when designing professional development to improve student achievement.

If the goal of professional development for teachers is to enhance their pedagogical content knowledge and introduce new resources and practices in order to improve student achievement (Darling-Hammond & McLaughlin, 1995), how do we know that the professional development is, in fact, increasing teacher knowledge and whether this knowledge is informing participants' later instructional practice? Considerable time and money is regularly invested by school districts to provide teachers with professional development opportunities, with the anticipated outcome of improving teachers' instructional practice in order to improve students' learning (Darling-Hammond & McLaughlin, 1995; Garet, Porter, Desimone, Birman & Yoon, 2001). Typical professional development for teachers consists of one to two days of training, with about 16 hours each year in total spent on specific content-focused learning (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009, p. 20). However, this traditional "workshop approach" is not effective for sustained teacher change because of its limited duration, focus, and lack of active engagement of teachers (Birman, Desimone, Porter, & Garet, 2000; Garet et al., 2001; Quick, Holtzman, & Chaney, 2009).

There are several key components necessary for professional development to be effective. The curriculum content focus of professional development is crucial for optimal learning, implementation and adoption of the resources and strategies introduced (Darling-Hammond & Mclaughlin, 1995; Garet et al., 2001). To be effective, the teachers must perceive a direct connection between professional development content and what they teach and how they work with their students (Darling-Hammond & McLaughlin, 1995; Duncan-Howell, 2010; Garet et al., 2001; Macleod, 2010). Teachers also need to relate knowledge learned during professional development to perceived needs in their own teaching (Colbert, Thomas, Carolina, Colbert, Brown, & Choi, 2008). Professional learning experiences should provide either new skills or updates to current skills that will support positive changes in teaching practice and improvement of student achievement (Duncan-Howell, 2010).

Directly related to providing relevant content in professional development is the use of activities that involve hands-on, active learning (Garet et al., 2001; Ingvarson, Meiers, & Beavis, 2005; Yoon, Duncan, Lee, Scarloss & Shapley, 2007) and provide opportunities for teachers to engage in tasks that are related and relevant to their teaching practice (Darling-Hammond & McLaughlin, 1995). This includes the opportunity to collaborate with others, experiment with new skills or content, share and reflect on both content and strategies, and generally be connected to the reality of teachers' work, the workplace and students (Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Macleod, 2010).

Professional development should be sustained over longer periods of time than the traditional one- or two-day or even week-long trainings, and should provide continued support and collaboration for effective implementation of new skills and pedagogical practices to occur (Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Polly & Hannafin, 2010; Yoon et al., 2007). The duration of these longer-term professional development experiences varies, but should be sustained, intensive, and connected to teacher practice (Darling-Hammond et al., 2009). It should allow for discussions of curriculum content and student learning, and provide time for active engagement in learning by participating teachers (Darling-Hammond, et al., 1995; Garet et al., 2001; Polly & Hannafin, 2010; Quick, Holtzman & Chaney, 2009; Yoon et al., 2007). Research has demonstrated that an average of 49 hours of professional development for teachers in a given area is required for it to have any effect on student achievement (Darling-Hammond et al., 2009, p. 9; Yoon et al., 2007), which further suggests that participation in stand-alone one- to two-day workshops or conferences may not be as effective, as illustrated in the scenarios shared earlier in this chapter.

Providing effective professional development that is characterized by a focus upon curriculum content, active learning, collaboration, and reflection over a sustained period of time is difficult for districts, in large part due to financial limitations (Duncan-Howell, 2010; Garet et al., 2001) as well as time and opportunity constraints (Darling-Hammond et. al., 2009). Financial constraints are often cited as the primary reason for shorter duration professional development that is typically provided (Duncan-Howell, 2010). Providing professional development for a large number of teachers often leads to cost-saving decisions that affect the amount of time, content, and type of learning experience that can be offered (Garet et al., 2001). These financial constraints often deny teachers the chance to participate in appropriate or relevant professional development (DiPaola & Hoy, 2008). It is estimated that it costs $512 per year, on average, to provide a teacher with high-quality professional development, which is double what districts typically spend (Birman, et al., 2000). The extended duration, which includes planning coherent, content-focused activities relevant to teachers' classroom practice, time for collaboration, time for planning, and time for reflection on practice (Birman, et al., 2000; Corcoran, 1995; Garet, et al., 2001; Polly & Hannafin, 2010) makes the professional development experience more costly and less likely to be provided. Despite both the cost and time challenges of providing effective professional development for teachers, it is important to find ways to provide relevant learning experiences if the ultimate goal is to improve classroom practice and increase student achievement (Corcoran, 1995; Darling-Hammond & McLaughlin, 1995; Garet, et al., 2001).

Online Professional Development

Online professional development (OPD) is becoming a viable cost-saving alternative to traditional face-to-face professional development, in part because of its ability to provide the components of effective professional learning in a more convenient and cost-effective format and structure (Carey, Kleiman, Russell, Venable & Louie, 2008; Coffman, 2004). OPD makes it possible for teachers to engage in long-term learning on specific content and skills (Boling, 2002; Macleod, 2010). Due to the online nature of OPD, teachers can access content and resources at times and locations that are more convenient in their lives, making the professional development experience more flexible and accessible (Chambers, 2005; Coffman, 2004). OPD can provide access and ongoing support to resources that may not typically be available to teachers (Dede, Breit, Ketelhut, McCloskey & Whitehouse, 2005).

There are both synchronous (where all participants are online at the same time) and asynchronous (where participants are online at different times) models of OPD, as well as hybrid models that combine face-to-face and online components, that can overcome the various time constraints and limitations teachers often experience with solely face-to-face professional development. In addition, OPD models provide multiple resources for teachers to explore and learn about specific content and strategies (Coffman, 2004; Gray, 2004). OPD options provide numerous ways for teachers to interact and learn using many different types of media, including video, Web links, and written documents (Carey et al., 2008). One important component of many OPD offerings is an online community, within which teachers can interact in discussion forums and/or live chats, share documents, and email each other (Holmes, Signer & Macleod, 2010). These online communications can offer teachers' opportunities to share ideas and challenges, collaborate, and reflect on their learning and experiences (Boling, 2002; Chambers, 2005; Coffman, 2004; Silverman, 2012). Using these online communication options, teachers are able to stay up-to-date on the information they are learning and receive support and assistance with applying that information in practice (Coffman, 2004). Online communities provide options for professional learning that are relevant to topics of interest for its members and available as needed (Duncan-Howell, 2009). Additionally, the online communications allow for artifacts and discussions to be saved, which can contribute to ongoing discussion, collaboration and learning (Silverman, 2012). The flexibility that various OPD models provide allows teachers to participate in their own time and at their own pace, practicing what they learn in their own classrooms, and then reflecting upon those experiences and receiving ongoing support from their online community (Boling, 2002; Carey et al., 2008). Many OPD environments include a virtual place for teachers to express not only their learning, but also their emotions and beliefs as they try new things, which has been shown to support effective classroom implementation (Boling, 2002; Carey et al., 2008; Coffman, 2004). Interactions within online communities can provide insight and meaning to the content being learned, connections to others in the field, and skill development (Chamberlin, 2009; Gray, 2004; Macleod, 2010; Silverman, 2012).

Due to the consistent availability of the Internet, OPD models and resources are always available to teachers, providing opportunities for longer-duration learning experiences for teachers, which are recommended for effecting sustainable change in teacher practice (Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Dede et al., 2005). It seems logical to assume that OPD could become a more effective option than face-to-face for continuing education for teachers. Like any professional development experience, however, it is important to examine how these OPD models provide teachers with opportunities to develop their knowledge for technology integration and then explore how participants integrate this knowledge in their classroom practice after the OPD has concluded (Dede et al., 2005). As we saw with the math teachers who participated in a two-day face-to-face professional development workshop, teachers do not always draw on the knowledge they have developed, or do so differently than the instructional practices modeled in the professional development.

Teacher knowledge development in online professional development. There is evidence, mostly from self-reports by teacher participants, that there can be development, transfer and continued use of the knowledge, skills, pedagogies and content learned in OPD (Carey et al., 2008; Chamberlin, 2009; Garet et al., 2001; Morrow, 2002; Russell, Kleiman, Carey & Douglas, 2009; Silverman, 2012) to classroom practice. Much of this transfer and continued implementation is more common in the efforts that feature longer duration experiences, opportunities for collaboration, and community support (Coffman, 2004; Frey, 2009; Ingvarson et al., 2005; Norris, 2008). OPD experiences have the potential to provide a longer time for learning and practice, which help increase teacher skill level and confidence in both using and integrating the technology into classroom instruction (Dash, Magidin de Kramer, O'Dwyer, Masters & Russell, 2012; Dove, 2011; Furges, 2011). The collaboration and community support aspects of OPD, through discussion forums, reflections and sharing of work and ideas, help to create a supportive, shared learning environment and confidence to refine teaching and incorporate strategies (Bryan, 2008; Bryant, 2008; Crockett, 2010; Dove, 2011; Silverman, 2012).

The teachers' perceived benefits about technology integration, the OPD content, and its relevance and value in supporting their instructional beliefs all play a large role in determining how the content of the OPD is learned and integrated in participants' classrooms (Crockett, 2010; Hughes, 2005; Turner et al., 2010). If teachers see the relative advantage of the content and strategies in the OPD to their own teaching practice, they are more likely to use them in their classrooms and continue this use after the OPD

(Bryant, 2008; Dove, 2011; Furges, 2011). Teachers also demonstrate improved attitudes over the course of the OPD experience towards the use of content and pedagogies taught in the OPD (Carey et al., 2008; Coffman, 2004; Frey, 2009; Russell et al., 2009). They were more willing to try strategies, integrate what they learned into their instructional practice, and continue to improve (Bryan, 2008; Bryant, 2008; Dash et al., 2012; Dove, 2011; Furges, 2011). This change in attitude, using pre- and post-survey results, occurred in various types of OPD, including participation in virtual online communities (Coffman, 2004; Gray, 2004), online project-based professional development (Frey, 2009), and self-paced online courses (Carey et al., 2008). The findings from OPD studies seem to support that following the same guidelines for effective face-to-face professional development, as described by Darling-Hammond et al. (2009) and Garet et al. (2001), shows similar benefits as face-to-face professional development efforts on teacher attitude and integration of knowledge into instructional practice (Dash et al., 2012; Carey et al., 2008; Frey, 2009; Ingvarson et al., 2005; Norris, 2008; Russell et al., 2009).

The evidence that OPD can be effective in addressing the requirements of quality professional development comes in large part from follow-up surveys, questionnaires, and interviews with teacher participants (Beatty, 2003; Bryan, 2008; Bryant, 2008; Carey et al., 2008; Chamberlin, 2009; Chambers, 2005; Crockett, 2010; Dash et al., 2012; Dove, 2011; Frey, 2009; Furges, 2011; Russell et al., 2009). Based on this self-reported data, teachers do implement content and strategies from OPD in their instruction, but to varying degrees and for varying reasons (Hughes, 2005; Klein & Riordan, 2009; Polly, 2011; Turner, Warzon, & Christensen, 2010). Each teacher gleans different knowledge and understanding from a specific OPD experience. How they implement their OPD-based learning differs, due to each teacher's unique experiences, beliefs about teaching, and ideas about the nature of learning and students' abilities (Klein, 2009; Turner et al., 2010). Additionally, some findings suggest that support from school leaders and the nature of a school's structure influences what and how components of OPD are implemented into the classroom (Bryan, 2008; Bryant, 2008; Crockett, 2010; Polly, 2011; Turner et al., 2010).

OPD models appear to be effective when the learning experiences offered are content-focused, support teachers' instructional practice directly (Garet et al., 2001; Hughes, 2005; Ingvarson et al., 2005; Silverman, 2012), and provide time and continued support from both colleagues and administration (Bryan, 2008; Bryant, 2008; Crockett, 2010; Dove, 2011; Furges, 2011). Since these findings come largely from teacher self-reports, it is difficult to know the true nature of teachers' understandings and technology integration following OPD (Dede et al., 2005). According to a synthesis of 40 empirical studies on online teacher professional development done by Dede et al. (2005), few studies attempted to measure observable changes in teachers' knowledge or skill after online professional development. There is a need for research studies of professional development that goes beyond self-reported data to determine how, if at all, teachers integrate the content and strategies they develop in OPD in their classroom practice (Dede et al., 2005; Lawless and Pellegrino, 2007).

Study Focus: Assessing Teacher Technology Integration after Hybrid Professional Development

Well-documented recommendations exist for what constitutes quality professional development, including online professional development (Darling-Hammond &

McLaughlin, 1995; Duncan-Howell, 2010; NSDC, 2012b). There is research evidence to suggest that some instances of OPD have resulted in teachers implementing what they learned during professional development (e.g., Bryan, 2008; Bryant, 2008; Crockett, 2010; Dash et al., 2012; Dove, 2011; Furges, 2011; Hughes, 2005; Klein & Riordan, 2009; Polly, 2011; Russell et al., 2009). What is missing is evidence that knowledge of new pedagogies, technologies, and content learned in OPD is sustained over time, as well as how and why knowledge developed in OPD influences instructional decisions (Chamberlin, 2009; Dede et al., 2005; Pierson & Borthwick, 2010).

This grounded theory study focused on understanding the influences on teachers' instructional decisions and practices related to *Sketchpad* integration in their mathematics classrooms after they had participated in a seven-month hybrid online professional development course, conducted mostly online, but with periodic face-to-face meetings. Prior to participating in the study, the teachers spent seven months learning to use and teach mathematics content with *The Geometer's Sketchpad®* [*Sketchpad*] (KCP Technologies, 2011) mathematics software through a scaffolded OPD approach to learning and implementing the software into mathematical instruction. The design of the OPD was structured according to recommended components of quality professional development such as embedded instructional practice and reflection, collaboration with peers, feedback and reflection. The OPD and face-to-face components were designed to help teachers integrate the software into focused, content-based mathematics instruction using research-based pedagogical approaches.

The Technology, Pedagogy, and Content Knowledge (TPACK) construct (Mishra & Koehler, 2006) provides a coherent way of thinking about technology integration and the relationship between teaching and technology that "can transform the conceptualization and the practice of teacher education, teacher training, and teachers' professional development" (p. 1019). Rather than treating technology knowledge, pedagogical knowledge, and content knowledge as separate, where teachers learn and use the skills of each type of knowledge in isolation, the focus is on how these three types of knowledge intersect in teaching practice. Designing learning experiences for teachers in order to help them integrate technology into their instructional practice must incorporate strategies that assist teachers in understanding how the technology fits and supports the content, and what pedagogical strategies are most appropriate for the content and technology. The OPD teachers participated in prior to this study was designed with a TPACK-based, integrated approach, providing constant connections between the software, math content, and instructional strategies and how each one of these influenced the choices and use of the others. Understanding teachers' instructional decisions for planning and practice around the integration of technology, pedagogy and content into mathematics instruction after an OPD experience was the focus of this qualitative research study.

Lawless and Pellegrino (2007) found in their study of educational technology professional development that there is little evidence in the research literature to date of sustained and effective implementation of strategies and tools as a result of professional development. According to Lawless & Pellegrino (2007), much more than just self-reported data on technology integration professional development outcomes is needed to assess their efficacy. If the intended outcomes of OPD are pedagogical practices that demonstrate knowledge and integration of technology that ultimately improve students' learning, it is important to conduct long-term investigations into how and why, if at all, teachers implement what they learned in OPD, and if there is documentable, sustained application of knowledge learned about technology integration in teacher practice as a result of participating in OPD.

The grounded theory approach used in this study provided what Merriam (1998) describes as substantive theory, where categories and properties that define those categories were used to conceptualize a theory. This study categorized and found patterns related to teachers' implementation of technology in participants' mathematics classrooms after an OPD experience. These patterns provide insight into what teachers actually took from the OPD experience, how they integrated technology into their instructional practice, and what perceived factors, including the OPD experience, influenced their instructional decisions. The study was not an evaluation of the OPD itself, but rather an investigation into what factors influence teachers' perceive as influencing their technology integration decisions, which may or may not include elements from the OPD experience. These insights inform the design of future technology OPD to support teachers' technology integration into instructional practice.

The research questions that guided this study were:

1) How, if at all, did experiences in a TPACK-based OPD influence participants' instructional decisions when planning for technology-integrated lessons using *Sketchpad*?

2) How, if at all, did the participants draw on their experiences from OPD about integrating *Sketchpad* software in mathematics classroom instruction after participating in a seven-month hybrid online professional development program?

3) What, if any, other factors influenced teachers' instructional decisions regarding their integration of *Sketchpad* that are not related to the OPD experience?

A deliberate convenience sample subset of teachers who participated in an OPD experience participated in this study. Deliberate convenience sample means participants were selected from teachers who volunteered for the study, and then chosen based on their different grade levels and teaching experiences. Through classroom observations, one-on-one interviews, and analysis of written lesson plans, this study documents evidence of how teachers' perceptions about their experiences in technology OPD influenced instructional decisions when planning for and implementing *Sketchpad* into classroom practice, why teachers made those decisions, and what other factors influenced those decisions. The study used constant comparative analysis to develop a grounded theory illuminating the ways in which teachers drew on their experiences during a seven-month OPD experience to inform their instructional decisions for planning and implementing technology integrated lessons, as demonstrated in teacher behavior and practice, and what other contextually situated reasons may have influenced those decisions.

Chapter 2

Literature Review

The purpose of professional development is to provide teachers with either new knowledge and skills or ways to enhance and improve current practices, and ultimately, to increase student achievement (Darling-Hammond et al., 2009). Teaching is a profession, and as with any profession, there is a need to continually update current practices, as well as explore new strategies, technologies, expectations and outcomes introduced to improve and sustain the profession and improve student achievement (Darling-Hammond et al., 2009). The Association for Supervision and Curriculum Development (2002) defines professional development as any activity focused on helping teachers meet student learning needs in order to achieve learning goals. Similarly, the National Staff Development Council (2012a) defines professional development as ongoing, sustained and comprehensive professional learning to improve both principal and teacher effectiveness to increase student achievement. The goal of professional development should be to help teachers understand the context for the strategies and content being introduced, and how these activities will help students achieve learning goals (DiPaola & Hoy, 2008). This requires a long-term, collaborative effort involving teachers and administrators. School leaders must consider how to provide effective professional development and structure it in such a way to ensure that it has an impact on instructional practice and student learning (Darling-Hammond et al., 2009; DiPaola & Hoy, 2008; NSDC, 2012b). The types and structures of the professional development provided may vary, but research points to several key components of effective professional development. This literature review focuses upon what defines effective professional development and various professional development options and how those options might impact teacher knowledge and instructional practice.

Effective Professional Development

Professional development is meant to improve and enhance teacher practice. Ideally these changes and improvements will be sustained over time in order to impact student achievement (Darling-Hammond & McLaughlin, 1995; DiPaola & Hoy, 2008; Lawless & Pellegrino, 2007; NSDC, 2012a; Polly & Hannafin, 2010; Reeves, 2010; Yoon et al., 2007). A crucial component for this sustainability is to make sure that the professional development provided is in accordance with state, district and school initiatives (ASCD, 2002; NSDC, 2012a) and also addresses current teacher practice and instructional goals (ASCD, 2002; Darling-Hammond & McLaughlin, 1995; DiPaola & Hoy, 2008; Gusky, 2003; NSDC, 2012a). If the professional development experience and expectations align with what teachers are required and expected to do in their daily work, then implementing and sustaining what is learned during the professional development are more likely to occur (Desimone, Porter, Garet, Yoon & Birman, 2002; Hughes, 2005; Klein, 2009; Polly & Hannafin, 2010; Quick et al., 2009; Yoon et al., 2007).

Content-focused professional development activities are important to ensure coherence between what is learned and what is expected of teachers in practice (Babette, Brown & Benken, 2009; Birman et al., 2000; Polly & Hannafin, 2010). This requires the alignment of professional development activities and content to the structures and strategies present in teachers' classrooms, what the teachers are doing in their classrooms, using curriculum-focused activities and content that the teachers are expected to teach, and utilizing instructional strategies that fit the classroom expectations and structure. Whether it's introducing new or improved instructional strategies or technologies, professional development should focus on using these approaches or tools within the participants' teaching context (Babette et al., 2009; Reeves, 2010). If teachers are expected to appropriate what they experience in professional development and apply this learning to their classroom practice, then the professional development should focus on helping teachers to make connections and see the relevance of what they are learning and how that connects to student achievement (Darling-Hammond & McLaughlin, 1995; Polly & Hannafin, 2010; Reeves, 2010; Silverman, 2012). Being able to create meaning in this way from what they are learning allows teachers to transfer their learning back into their classroom practice (Coffman, 2004; Desimone et al., 2002; Ingvarson et al., 2005; Silverman, 2010). If teachers experience professional development embedded within the curriculum content they are expected to teach, they are much more likely to continue to use the strategies, tools and skills from the professional development experience in their practice, and sustain that use over time (Frey, 2009; Garet et al., 2001; Hughes, 2005).

It is not enough for effective professional development to be content-focused; it should also involve active learning (Garet et al., 2001; NSDC, 2012b), where teachers are engaged in collaboration with others, working actively with content and skills, and reflecting on the process of what they are learning as well as how to use what they are learning in practice (ASCD, 2002; Darling-Hammond & McLaughlin, 1995; Dash et al., 2012; Ingvarson et al., 2005; NSDC, 2012b; Reeves, 2008; Polly & Hannafin, 2010).

DiPaola and Hoy (2008) emphasize the importance of identifying teachers' current knowledge of strategies and content and providing activities that will build upon those skills, allowing time for action, implementation, and reflection. Teachers who work on relevant instructional strategies, then collaborate and reflect critically with other teachers, have a better chance of learning and incorporating new knowledge and skills (Darling-Hammond & McLaughlin, 1995; Dash et al., 2012; Guskey, 2003; Polly & Hannafin, 2010).

The collaborative aspects of effective professional development are most successful when addressed within a school and as part of school-based initiatives (ASCD, 2002; Birman et al., 2000; DiPaola & Hoy, 2008; NSDC, 2012a). According to Birman et al. (2000), collaboration among peers within a school environment leads to more opportunities for active learning that is more likely to support school-wide learning initiatives and goals. The shared professional culture that is created through collaboration and reflection within professional development activities provides teachers with a support system that helps them with integrating concepts and strategies from professional development (Quick et al., 2009; Reeves, 2010). Collaborating with other teachers after practicing encourages deeper discussions and applications of professional learning, which impacts student learning and supports change in teaching practice (Garet et al., 2001; Ingvarson et al., 2005; Quick et al., 2009; Reeves, 2010).

In order to ensure inclusion of the components of effective professional development mentioned, time and support are crucial (Birman et al., 2000; Guskey, 2003; NSDC, 2012a). Learning content and strategies requires time to implement, practice, and reflect on in order to effectively integrate professional learning into instruction that can promote student achievement (Guskey, 2003; Penuel, Fishman, Yamaguchi & Gallagher, 2007; Reeves, 2010). Longer-duration professional development that is continuous and supported by both administration and colleagues is more likely to have a sustained impact on instructional practice (ASCD, 2002; DiPaula & Hoy, 2008; NSDC, 2012a; NSDC, 2012b; Penuel, et al., 2007; Quick, et al., 2009). Teachers should participate in at least an average of 49 hours per year of professional development in order to boost student achievement (Darling-Hammond et al., 2009; Yoon et al., 2007). The longer the duration and the more support in funding, resources and time that is provided, the more likely the professional learning will be implemented and sustained in the classroom (Pegg & Panizzon, 2007; Penuel et al., 2007; Polly, 2011; Quick, et al., 2009).

Education Technology Professional Development (ETPD)

Educational technology integration and the expectation for teachers to promote and demonstrate effective use in their instructional practice (ISTE, 2008) are important foci for professional development. ETPD can focus on any digital tool or resource designated for use in the educational setting, such as software, hardware, and Internet resources. Longer duration ETPD experiences, that provide more opportunities to learn over time, help to increase teacher knowledge, confidence and use of technology (Brinkerhoff, 2006; Swan, Jennings & Rubenfeld, 2002). According to the *Learn Now, Lecture Later 2012* report by CDW-G (2012), over the last two years, teachers are using more and a greater variety of technology tools to support teaching, administrative functions and communication. Because of this wide range of use, ETPD needs to be diverse in order to support teachers and technology integration. Eighty-eight percent of the 304 teachers surveyed by CDW-G (2012) reported that technology integration is hampered by many factors, including limited funding of and access to technology and a lack of technical support and professional development. 76% of the 301instructional technology staff surveyed reported requests for professional development had increased over the last two years, with training on specific technologies, instructional software and integrating that technology into teaching being the most requested. The CDW-Government (2012) report recommends professional development and support for teachers to help them support and enhance learning and become comfortable teaching with technology.

In their survey of 3,159 full-time K-12 teachers in the fifty United States and the District of Columbia on the availability and use of educational technology, Gray, Thomas, & Lewis (2010) attribute the contribution of professional development to increased technology integration in instructional practice. They found 40% of the teachers used technology in instruction practice. Of those teachers using technology in instruction, 61% attributing professional development to their being prepared to effectively use educational technology for instruction (p. 3-4). Even though 88% of the teachers reported that the professional development they received supported state and district goals and 81% felt it met their personal needs and goals (Gray et. al, 2010, p. 4), none of the teachers received the recommended 49 hours of training (Darling-Hammond et al., 2009). In fact, only seven percent reported receiving more than 33 hours of professional development in the past 12 months, with fifty-three percent receiving between 1-8 hours (p. 4). To be integrated effectively and sustained long-term in instructional practice, educational technology professional development should be structured according to the research-based guidelines mentioned previously, including longer duration programs, time for practice, active involvement, hands-on learning, content-focused activities, coherence with school curricula, collaboration with peers and reflection (Blocher, Armfield, Sujo-Montes, Tucker & Willis, 2011; Franklin & Sessoms, 2005; Harris, 2008a; Lightbody & Jones, 1998; Sugar & Wilson, 2005).

The type of educational technology professional development and support that is offered varies, and should be aligned to the teachers' particular *stages of concern* (Sandholtz, Dwyer & Ringstaff, 1996) in order to positively impact technology integration strategies. At each stage, different types of support are needed, which should guide the nature of the ETPD provided (Sandholtz et al., 1996). At the *entry* stage, teachers are uncertain about the technology and how it will impact their instruction. For teachers at this stage, ETPD should provide more emotional support and focus on building confidence and planning of how the technology might be used in instruction (Sandholtz et al., 1996). A first step in ETPD is instilling a belief that technology use may increase student learning, which provides a reason to commit to the goal of using that technology (Bowe & Pierson, 2008). ETPD models that are short in length and utilize demonstration and awareness work well at the entry stage as they provide an overview of the technology and how it can be used as a tool for instruction (Harris, 2008b). In these early stages of ETPD, it is important to focus on what Hurt (2007) calls the pretraining, which entails determining the experiences the learners bring with them, including previous experiences with the technology, and then structuring the learning experiences in a way that will help motivate and instill in the learner the desire to learn more. It is important at this stage to address specific technology needs of the teachers, including skills and content related to their classroom practice (Sugar & Wilson, 2005).

The next stage in Sandholtz et al's. (1996) model is the *adoption stage*. In this stage, teachers focus primarily on skills and strategies for using the technology in the classroom. This requires ETPD focused more on technological and pedagogical skills. Action-based, hands-on ETPD models with instructor-organized activities (Harris, 2008b) are appropriate at the adoption stage due to their systematic approach (Hurt, 2007). In these approaches, the instructor typically presents the material in a step-by-step way in order to help the teachers develop an overview of the tools and strategies for using the technology and get hands-on experience with the functionality of the technology, particularly in the case of software or hardware (Harris, 2008b). According to Sugar & Wilson (2005), teachers prefer technology workshops that use a hands-on approach in conjunction with collaboration and the ability to talk with an instructor who is often an expert on the technology.

In the *adaptation stage* (Sandholtz et al., 1997), teachers are trying to use the technology in their instruction. This involves integrating technology skills with content, where the focus is not on teaching the technology, but on teaching content *with* technology. ETPD models to address this phase require more collaboration and instructional sharing (Sandholtz et al., 1997), so examples of these technology training experiences are often structured as large and small group interaction and problem solving sessions (Harris, 2008b). Harris (2008b) describes these types of educational professional development sessions as being instructor-facilitated, more constructivist in nature, and involving more of a focus on teacher interests, problem-solving, and collaboration among participants. ETPD sessions to address the adaptation phase include collaborative learning, reflection and sharing of instructional experiences, and support for teachers as they are learning to integrate the technology in their classroom (Brinkerhoff, 2006; Harris, 2008b; Sandholtz et al., 1996).

The final stages in Sandholtz et al.'s (1996) five stages are *appropriation* and *invention*. Appropriation is when a teacher uses technology with their students regularly, can address technical difficulties, there is collaboration and deliberate planning of technology use. At the invention stage, teachers are creating their own lessons and goals for integrating technology into instructional practice. When teachers have reached the appropriation and invention stages, they use technology consistently and effectively as instructional tools (Sandholtz et al., 1997). The kind of PD that works at these stages involves opportunities for teachers to create new learning environments, where collaboration, team-teaching, project-based and individual pacing of learning are emphasized (Dwyer, Ringstaff & Sandholtz, 1991). At these stages, teachers are focusing on ways to question and use their knowledge and expertise to alter the ways in which their students learn.

Glazer and Page's (2006) Collaborative Apprenticeship approach to ETPD provides an example of similar phases in practice to the stages of Sandholtz et al.'s (1996) model. Glazer and Page's ETPD model is designed to help teachers build the capacity to integrate technology over a period of time, working through three phases of development, where the term *phase* is similar to Sandholtz et al.'s term *stage*. Each phase in Glazer and Page's PD model spans 9-weeks, with the first three phases listed as *introduction, developmental, and proficient*. First, teachers are introduced to the technology in a mentor-led, lab-based classroom. Teachers experience modeling by experts, hands-on learning, and collaboration. This is followed by a shift into the development state, with opportunities for the participants to apply the activities into classroom practice, with co-teaching, peer-observation and supportive feedback. In this developmental stage, teachers design lessons that integrate technology, in collaboration with mentors and colleagues. Technology coordinators may also provide advice and feedback to enhance the lesson. Teachers implement the lesson and reflect on the experience, and continue the process of designing technology-rich lessons with less and less reliance on mentors as they gain more confidence and experience integrating technology into instructional practice. Once teachers reach the proficient phase, they are developing lessons that integrate technology more independently, though still collaborating with and getting support from mentors. Teachers who are able to design and implement a lesson that fits into their curriculum and enhances students learning have reached proficiency. The fourth and final phase in Glazer and Page's (2006) model is mastery, where teachers are able to integrate technology into instruction effectively, without support, and then become mentors for other colleagues.

The final two stages from Sandholtz et al. (1996), *appropriation* and *invention,* and the final phase in Glazer and Page's (2006) model, *mastery,* demonstrate sustained integration of technology in instructional practice. To reach this sustained level of technology integration, teachers must first develop the necessary technology skills and instructional strategies outlined in Sandholtz et al.'s (1996) earlier stages of entry, adoption, and adaptation or similarly, Glaser & Page's (2006) earlier phases of introduction, development and proficient. Both Sandholtz et al.'s (1996) and Glaser & Page's (2006) ETPD models indicate the need to include long-term, hands-on, collaborative opportunities where teachers can collaborate, experiment, and reflect as they are learning both the technology skills and instructional strategies for incorporating educational technologies into their students' learning (Bowe & Pierson, 2008; Franklin & Sessoms, 2005; Harp & Taylor, 1998; Hurt, 2007; Sugar & Wilson, 2005).

According to Darling-Hammond et al. (2009), this type of well-designed professional development is rare, with the majority of professional development, including ETPD, not providing the research-based components needed to have a noticeable impact on instruction. Typical professional development for teachers, in general, consists of one to two days of workshops focused on specific content or resources (Darling-Hammond et al., 2009). Due to its limited duration and focus, this type of professional development is not effective for sustained teacher change (Birman, Desimone, Porter, & Garet, 2000; Garet et al., 2001; Quick, Holtzman, & Chaney, 2009). Financial considerations and constraints also limit the quality and quantity of professional development provided (DiPaola & Hoy, 2008; Garet et al., 2001). Research-based professional development that includes extended duration, content-focused activities, collaboration and reflection (Birman, et al., 2000; Corcoran, 1995; Garet, et al., 2001) adds to the cost and is less likely to be provided. Finding effective professional development options that can address the cost and time challenges is important so that teachers get the training and support needed to improve classroom practice. (Corcoran, 1995; Darling-Hammond & McLaughlin, 1995; Garet, et al., 2001). According to Dede et al. (2005), online professional development is an option that provides access and ongoing support that are often unavailable with other PD experiences.

Online Professional Development (OPD)

Online professional development is becoming a viable alternative for offering effective options for professional development, including ETPD, for teachers (Dede, 2006). Opportunities afforded to provide the long-term, collaborative, hands-on learning and reflection that is recommended for effective professional development (Darling-Hammond & MacLaughlin, 1995; Lawless & Pellegrino, 2007; Polly & Hannafin, 2010; Yoon et al., 2007) make OPD an attractive option. Dede (2006) defines OPD programs as diverse models of professional development delivered online that are structured according to a broad array of purposes, learner objectives, content areas, pedagogies, delivery methods, and assessment methods. These OPD experiences can be provided in a flexible time frame, enable just-in-time support, and provide resources and a variety of opportunities to help address content, pedagogy, and instructional practices and provide insight into student thinking and learning. As with any effective professional development, it is important that OPD focuses on knowledge, skills and instructional practice, and also promotes active learning and collaboration (Vrasidas & Glass, 2004; Silverman, 2012).

Models of OPD. There are various models of OPD that can provide a wide variety of options for the learner on participation and learning outcomes for the providers (Dede, 2006).

Online conferences are a model of OPD that makes it possible for teachers to attend virtual meetings or conferences, which under normal circumstances they would be unable to attend due to cost or geographical constraints (Anderson & Christiansen, 2004). Participation in online conferences can be done asynchronously (viewing archived lectures, for example), synchronously (attending a live webinar or lecture) or using a combination of approaches. Online conferences can provide themed presentations and activities relevant to the needs of participants, and can include discourse between participants. An example of this would be the recent Global STEMx Education Conference hosted by The International Society for Technology in Education and HP. This conference was a free, 3-day, completely online conference for science, math, technology, and engineering educators where presentations were delivered through an online collaboration webinar platform where participants could listen, watch and chat in a live, real-time format.

Online seminars or courses offer a longer-term OPD option often focused on content and designed to provide teachers with additional support, ideas, resources and discussion to help them improve their practice (Leach, Harrison, McCormick & Moon, 2004; Wiske, Perkins & Spicer, 2006). These courses are often asynchronous, providing various interactive tools such as resources, videos, threaded discussion forums, links to files and websites (Wiske et al., 2006) and a curriculum-focused agenda that encourages participation and exchange of ideas (Leach et al., 2004). These may be facilitated, such as the WIDE World model (Wiske at al., 2006), with support from an online coach who facilitates online teamwork, or self-paced, such as the Learning Schools Program (Leach et al., 2004), where teachers receive a certificate of completion after finishing the program.

There are more structured forms of online courses, such as those offered by PBS TeacherLine and the Concord Consortium (Ramsdell, Rose & Kadera, 2006) programs that take place within a more specified timeframe (typically 6-8 weeks) and are facilitated by an instructor. Participants are immersed in activities that are connected to classroom practice, helping to ensure that all activities (e.g., videos of classrooms, course materials for adaptation to the classroom, analysis of student work) help teachers to link what they are learning to their own teaching environments (Ramsdell et al., 2006). A fairly new trend in online courses are Massive Online Open Courses (MOOCs), that are free and open to anyone with Internet access (Kop, Fournier & Mac, 2011). Many MOOCs offer an open, social and constructivist way of learning where learners create, learn, interact and reflect on a topic of interest that follows a schedule and agenda and are facilitated by experts in the field of study (Kop et al., 2011). MOOCs rely on the formation of learning networks to support participants in their learning and studies (Kop et al., 2011). Online courses such as PBS TeacherLine and MOOCs can focus on providing resources and experiences relevant to teacher practice, and offer opportunities for teachers to participate in an online community for collaboration, sharing of ideas and strategies, and reflecting on practice (Kop et al., 2011; Leach et al., 2005; Ramsdell et al., 2006; Wiske et al., 2006).

Online learning communities are another model of OPD which, though not as structured as online courses, provide a place for professionals with similar interests to come together to share ideas and knowledge (Coffman, 2004). An example of this is the Ning platform, which provides a social website for groups to get together around a common interest, such as edtech in the K-12 education field (Frady, 2012). Classroom 2.0 is an example of a Ning community, where educators from all levels, grades and content areas discuss Web-based tools and social media issues (Fucoloro, 2012). Twitter and Facebook are informal social media networks that provide opportunities for personal learning and connections to others with similar interests and concerns (Richardson & Mancabelli, 2011). These virtual meeting places offer members ways to share resources and participate in discussions on various topics of interest (Coffman, 2004; Duncan-Howell, 2010; Frady, 2012; Fucoloro, 2012; Richardson & Mancabelli, 2011). The learning that occurs here is often informal, gained through sharing stories and discussions of problems (Gray, 2004). These can be online communities that teachers join of their own accord (Duncan-Howell, 2010) or as part of a plan for supporting learning and teaching (Gray, 2004).

Hybrid or blended forms of OPD combine both face-to-face and online components, where the face-to-face meetings can serve as introductions to the content and topics that will be explored more fully online (Owston, Sinclair & Wideman, 2008). The face-to-face meetings provide an opportunity for teachers to build community, collaborate, engage in hands-on learning, share experiences and provide feedback on classroom and online experiences (Ge & McAdoo, 2004; Owston et al., 2008). Online components provide teachers the opportunity to work in their own time and on their own individual learning goals, as well as utilize online resources to extend and support their learning (Ge & McAdoo, 2004). Ge & McAdoo (2004) also suggest that hybrid forms of OPD provide time for teachers to try things in their classrooms and share these experiences online, allowing for feedback and ideas from others through the use of discussion forums, chat rooms, email, file sharing. Blended models of OPD work well for school or district-based cohorts, such as coaching and mentoring programs, by providing a flexible model that supports a long-term goal of for sustained technology integration (Ramsdell et al., 2006). Advanced Broadband Enabled Learning (ABEL) is an example of a blended professional learning model, with online components in the school year and face-to-face components in the summer, designed to expose teachers to digital tools and collaboratively develop projects (Owston, Wideman, Murphy & Lupshenyuk, 2008).

A key component of many OPD models is the online community that develops through Web-based communication tools such as chat or discussion forums (Boling, 2002; Chambers, 2004; Coffman, 2004). According to Vrasidas & Glass (2004), these communities of practice provide a place for mutual learning and sharing of activities that creates a group of individuals "bound together by what they do and by what they have learned" (p. 6). Online communities can inform participants of recent and relevant topics and strategies (Coffman, 2004), provide insight, meaning and skill development (Glowacki-Dudka, 2007; Kop et al., 2011), and provide emotional support, especially when incorporating new teaching methods or content (Cole, 2006; Duncan-Howell, 2010). The online community can help teachers apply their learning from a professional development experience into classroom practice by providing a place to share implementation successes and practices and get support and assistance with modifications and suggestions from colleagues and peers in similar situations (Kop et al., 2011; Smith & Sivo, 2011).

The flexibility, accessibility and variety of options that OPD can provide suggests OPD might be a viable option for providing effective professional development (Boling, 2002; Carey et al., 2008). But, as with any professional development model, if the purpose is to impact teacher practice (Darling-Hammond & McLaughlin, 1995) and for participants' learning to be sustained over time and improve student outcomes (Darling-Hammond et al., 2009; Polly & Hannafin, 2010; Yoon et al., 2007), then it is important to examine the impact of that professional development on teacher practice and student achievement (Dede et al, 2005).

Impact of Professional Development

When looking specifically at educational technology professional development, including online educational technology professional development, many studies suggest that while teachers report their skills and confidence with using the technology have increased as a result of participating in the professional development, their use of the technology in classroom practice remains at a basic, skill-based or resource-only based level (Beatty, 2003; Blocher et al., 2011; Brinkerhoff, 2006; Mouza, 2009; Polly, 2011). There is evidence from several professional development studies that even after experiencing components of effective professional development, the impact on teacher practice is often minimal, with learning experiences only supporting existing practices rather than improving or substantially changing instructional practice (Beatty, 2003; Klein & Riordan, 2009; Mouza, 2009; Polly, 2011). The different types of professional development can have various impacts on teachers' instructional practices and it is important to look at each type to determine what those impacts may be.

Face-to-face technology professional development. Kanaya, Light and Culp (2005) studied how PD intensity impacted participants' technology integration. Their findings showed teachers' beliefs in the direct relevance of content and pedagogical strategies modeled and emphasized in the PD to their students were a predictor of teachers' use of new technology tools and implementation of technology-rich lessons in the classroom. The study looked at end-of-training survey results from a random sample of 237 K-12 teachers who had participated in a technology training PD program between

2002 and 2003. The 237 participants were narrowed down from the 4,000 total survey respondents by eliminating those who did not provide identifying information, who had participated in summer vs. school-year training, and who trained before 2002. Study participants had completed 40 hours of technology PD focused on integrating specific software applications and technology skills into project-based instruction. The PD program was the Intel Teach to the Future train-the-trainer model which breaks PD into ten, 4-hour modules that are delivered either in five intensive 8-hour days or spread out over eight weeks in 4-hour weekly training sessions.

With a focus on the Intel Teach to the Future PD program, Kanaya et al. were examining two questions: 1) were teachers using any of the three software applications or technology skills emphasized in the PD with their students after the training and 2) were teachers implementing other technologies lessons or activities in their classroom? There were only 228 of the 237 study participants that responded to the first question. According to the results from the 228 responses, 151 reported using the software and technologies with their students. On the question regarding the use of other technologies, only 235 of the 237 study participants responded. Of those, 184 reported they were using other technologies with their students. Kanaya et al. concluded that intensity of PD experiences influenced the PD outcomes, with teachers more likely to implement technology-rich lessons when the 40-hour training occurred in three months or less, and program content are important factors in PD when trying to impact teacher change in practice related to integration of technology-rich lessons.

A study by Brinkerhoff (2006) on the effects of a two-year educational technology professional development initiative and its impact on technology skills, computer self-efficacy and technology integration showed that while teachers' skills with technology improved, there was no change in their integration practices. There were 25 teachers in the study, which included a majority of elementary teachers along with two middle school teachers, though the number of each is not given. Brinkerhoff's study included training in the summer and subsequent training during the school year over a two-year period. In the first year, the professional development focused on technical skill development, questioning skills to engage students' higher-order thinking, and lesson development that focused on technology lessons aligned to instructional objectives and assessments. The second year focused on technology integration skills using real-world, hands-on projects, developing instructional web sites, introduction of Internet-based projects, and working with digital video and editing. The primary goal in year two was to help teachers integrate technology in the classroom. Participants were surveyed at three separate times during the professional development on their technology background, beliefs, skills and integration efforts. Six of the participants were interviewed after the professional development about their self-reported change in computer self-efficacy, technology skills and their technology integration. The six participants represented a purposeful sample, chosen because they represented several different teaching grade levels and came into the PD program with different levels of technology skills and ability. Brinkerhoff argues that participants' instructional decisions to integrate technology were often focused on "letting students experience the technology rather than having any clear standards-based instructional objectives" (p. 39). He recommends that technology-based projects should have clear student learning benefits for them to truly impact a teachers' integration practice.

In a study by Polly (2011), two teachers participated in a year-long educational technology professional development project called *Technology Integration in Mathematics (TIM)*. The two teachers were purposefully chosen from a larger group of math teachers who participated in the PD, based on their reported intent to enact pedagogies modeled in the workshop in their classroom practice. The teachers participated in a total of 48 hours of workshops that focused on technology-enhanced, standards-based pedagogies to teach mathematics. This included rich mathematical tasks and questioning skills that addressed technological, pedagogical, and content knowledge (TPACK). Polly conducted classroom observations, which included video and audio recording. The classroom observations provided evidence of technology use after the professional development concluded, but the pedagogical strategies the teachers used did not align to what was modeled in the professional development. Polly found that teacher integration of technology was at a basic or skill-based level, focused more on using the tools rather than using the technology to enhance the instruction and understanding of mathematics content.

Mouza (2009) examined teachers who had been involved in two educational technology professional development programs over a one-year period of time. The professional development began in the fall with weekly two-hour workshops focused on technology integration and exploration of technology tools to increase the participants' comfort level with the tools and pedagogical strategies for integrating those tools into their teaching. Two-hour weekly follow-up workshops in the spring focused on collaboration and teamwork to support teachers' implementation of technology-rich classroom activities. The goals of the professional development were to help the participants understand that educational technology can help them improve their pedagogical approaches and change classroom structures. Mouza purposefully chose 7 teachers from the same elementary school who represented illuminating cases (Merriam, 1998), had different teaching experiences based on years teaching, and had a similar number of computers in their classrooms. The data collected included interviews, classroom observations, surveys, artifacts and e-mail exchanges, with individual teacher interviews used as the primary data source. Mouza found all teachers were implementing technology for professional purposes (e.g. grading, attendance, writing lesson plans), but integration into classroom instruction was varied and often at a minimal and basic skill level. Teacher beliefs about their students' characteristics and abilities impacted their instructional decisions and how they chose to integrate technology in the classroom, with low expectations of students leading to low-level use of technology.

Bryan (2008) studied a purposeful sampling of fifty secondary teachers from 6 different schools who had participated in a team-based, long-term technology professional development experience. The PD included five days in the summer with two follow-up sessions in the fall and spring. The professional development focused on helping participants acquire technology skills and pedagogical practices for student-centered learning and create plans for incorporating those skills into practice. Bryan used questionnaires and focus group interviews with the teams of teachers at the end of the school year to examine how teachers had changed their teaching practices and integrated instructional technology as a result of participation in the professional development. The PD did influence teachers' instructional decisions and use of strategies learned, such as designing technology-rich lessons around essential questions. Teachers indicated willingness to implement strategies learned in the professional development, but often, other factors, such as lack of hardware, software and Internet access hindered their implementation. Bryan concluded that integration of technology required three key components: teachers needed strong curriculum background and knowledge of student curriculum goals; teachers and students needed a common set of technology skills and understanding of how the technology would be used; and teachers needed to believe the new strategies learned in the professional development would be successful (p. 1).

Duran, Brunvand, Ellsworth and Sendag (2012), in their study on a 1-year, research- based PD program on teachers' learning and practice with integration of wikis into classroom use, found that participants increased their technical skills with wikis and that the PD experience impacted their preparedness to use wikis with their students. The study included 218 teachers and administrators from a large school district who volunteered to participate, with 11 of those volunteers trained to be the facilitators of the PD. The study involved pre/post surveys, wiki page content analysis, and a follow-up questionnaire. The 11 trainers, after intensive training on the PD model, were assigned 2 cohorts from the remaining 207 teachers. Each cohort received a 2-hour initial PD training to learn the initial skills of working with wikis, learn how wikis could be used in the classroom, create their own wikis, and brainstorm ideas on how to use wikis in their classrooms. Follow-up PD occurred a few months later where participants shared and more fully developed ideas for integrating wikis into their classroom. Ongoing face-to-face and online support was provided by the facilitators, with many cohorts made up of participants in the same school, providing a collaborative peer support network. Participants completed a pre/post survey on their knowledge and skills related to wikis.

The researchers also analyzed participants' wiki pages in the fall following the PD experience to determine if they continued to use their wikis after the PD had ended. Additionally, approximately six months after the conclusion of the PD experience, the research team conducted a follow-up online questionnaire with 32 purposefully selected participants in the study, choosing one participant from each cohort who updated their wiki and one who did not, and selecting teachers with variation in teaching grade level. Their findings indicate that participants showed an increase in both knowledge and skills about wikis. The PD also helped teachers feel more prepared to use wikis in their teaching and learning. Two-thirds of the participants continued to use their wiki sites after the PD ended, indicating the PD had an influence in supporting sustained change in practice. Duran et al.(2012) concluded that the PD experience contributed to continued use of wikis due to the ongoing support from the district leaders, access to the wiki tools, and the relative ease of learning and using the tool. Those participants who did not continue implementation sited the need for additional time and more ongoing training, with more mentoring and training needed on integrating wikis into classroom practice. Overall, the researchers concluded that research-based PD that is sustained, focused on student-centered learning, involves active participation, and is supported by leaders and resources can impact teacher learning and practice on specific technologies.

Similarly, a study by Blocher et al. (2011) explored a 3-year technology professional development program designed to enhance teachers' technology skills and technology integration, moving them from beginning level technology skills to advanced levels where they could lead others in technology use and integration. The researchers found that as a result of participation in the professional development, teachers gained confidence in their technology use in the classroom, increasing both their technology competencies and by the end of the three years, increasing the use of technology with students in the classroom. The study included a core group of 20 teachers who were recruited from a consortium of seven rural school districts. Participants were asked to participate in the professional development for three years, agree to become technology leaders, and were compensated for their time. The program consisted of four 8-hour Saturdays and a four8-hours day, week-long intensive training during each of the three years. Trainings incorporated individual and collaborative activities, focused on learning technology skills through content-embedded lessons that could be used in the teachers' classrooms. By year 3, participants were designing their own lessons. The study drew on data from surveys conducted at the end of year two and three, where teachers completed questionnaires related to their level of competency with specific technologies, their present use of technology, and open-ended questions encouraging participants to reflect on the changes they experienced as a result of the professional development. The results of the study show that in the first two years of the PD, teachers reported an increase in their competency with technologies. There was an increase in both confidence and comfort in using technology. Between years two and three, teachers reported an increase in their use of technology in the classroom with their students, where teachers stated they were integrating technology on a regular basis. Blocher et al. (2011) suggest that the long-term nature of the professional development, as well as the emphasis on collaboration and support from the school district leaders are possible reasons for this self-reported change in beliefs, attitudes and use of technology by study participants.

Adherence to the learning goals of long-term, research-based professional development on technology-integration does have an impact on teacher knowledge and student outcomes, as shown in a study by Martin, Strother, Beglau, Bates, Reitz, and Culp (2010). This large-scale study was comprised of a multi-phased evaluation of a two-year technology integration professional development program with two different formats. Format one involved 250 hours of professional development and support as well as 10-12 classroom visits from the researchers each year of the program. The second format was less intensive, with 90 hours of professional development and support and 8-9 classroom visits from the researchers each year. Both formats focused on research-based PD components, such as active learning and connections to teacher practice, with the goal of helping teachers develop their technology skills and knowledge of how the technology supported their educational goals and teaching practice. Facilitators of the PD provided ongoing, on-site support and feedback for teaching and using the technologies in their lesson plans and classrooms. Martin et al.'s (2010) evaluation looked at three-phases of the two PD formats to determine their respective impact on teacher participants' lesson plans and their students' achievement. The study collected data from 31 different instructional specialists that provided the PD over two years, and 296 teachers involved in the PD. Teachers in the study came from 71 schools in 10 school districts. The data included 272 classroom observations, observations of instructional specialists during four-hour face-to-face PD sessions to ensure they implemented the PD program faithfully, as defined by the program developers, and lesson plans from 180 teachers. There were 287 elementary or middle school teachers in the study and 9 high school teachers. Three years of standardized test scores for students was also collected to determine if there was a relationship with teacher observations, PD participation, and lesson plans to student achievement.

The first phase of the evaluation in Martin et al.'s (2010) study explored how faithfully the PD was implemented across all sites by the instructional specialists. Using a core-component evaluation tool, six observers recorded behaviors or activities every fifteen minutes during the four-hour PD sessions and compared these behaviors and activities to the expected behaviors and activities designated by the PD program developers. The second phase explored how variations in the PD fidelity impacted teacher understanding of the PD content. Phase two involved 26 instructional specialists recording the training and support they provided during their classroom visits over the two-year program. These specialists recorded 2,195 classroom visits with 272 teachers, identifying how much time was spent on modeling, lesson planning, technology assistance, reflective practice and problem solving. Phase three involved evaluating how variations in PD fidelity and teacher understanding were associated with student outcomes. Results from Martin et al.'s study show that high quality technology lesson plans were most closely associated with PD factors that involved modeling instruction, technology utilization, connection to practice and focus on inquiry-based learning, with modeling instruction the strongest predictor of quality lesson plans. Evaluation of classroom visits showed that more time spent on lesson planning was associated with higher-quality technology lessons, whereas more time spent on technical assistance and problem-solving resulted in lower-quality lesson plans. Higher-PD fidelity was associated with improved teacher knowledge and higher-quality lesson plans. Unfortunately, Martin et al.'s study was limited in that it only shows how well teachers understood the concepts presented in the PD, based on the lesson plans provided, but does not show if the process actually impacted classroom teaching. Without actual classroom observations, it was impossible to determine what specific strategies from the PD teachers integrated into their instruction. It would be important to observe classrooms after some time as passed to determine if teachers are continuing to implement the concepts and strategies learned in PD.

Studies of longer-duration, face-to-face technology professional development experiences seem to suggest that these learning experiences influence teacher-reported changes in attitudes towards the use of technology and positive beliefs that the use of technology in instruction can enhance student learning (Beatty, 2003; Bennison, 2010; Blocher et al., 2011; Owston et al., 2008) as well as changes in lesson planning and intent to integrate technology (Martin et al., 2010). There are indications that teachers integrate technology with their students after participating in face-to-face educational technology professional development (Duran et al., 2012; Kanaya et al., 2005; Martin et al., 201), however integration is often focused on learning the basic skills of the technology or using the technology to practice academic skills, (Beatty, 2003; Mouza, 2009). Teachers attempt to implement many of the strategies learned in the technology professional development, but integration is not truly consistent with what was learned for various reasons (Bryan, 2008; Mouza, 2009). Since studies of face-to-face PD indicate various impact on teacher instructional practices around technology integration, it would be important to also look at the impact on teacher technology integration after online PD (OPD), as compared to face-to-face options, due to the increase in OPD as a viable option or alternative to face-to-face PD (Carey, Kleiman, Russell, Venable & Louie, 2008; Coffman, 2004).

Online technology professional development. OPD allows for longer-duration professional development that can be focused on specific content and skills (Boling, 2002; Macleod, 2010), including technology integration. Results from OPD focused on technology integration are varied, but indicate that the time and support afforded by the OPD platform contributes to sustained implementation of the skills and strategies learned from the OPD experience (Bryant, 2008; Crockett, 2010; Dove, 2011; Furges, 2011).

Overbaugh and Ruiling (2012) studied a grant-funded professional development program that was comprised of 75 six-week online technology integration courses or six one-week face-to-face technology integration summer courses available to 18 school districts. The courses focused on helping participants to use technology to enhance student higher-order thinking and learning as well as enhancing project-based learning environments with technology. The online courses were asynchronous and utilized group interactions with learners and facilitators, threaded discussion on course content and strategies, and session assignments and projects. Using a pre-course and two post-course surveys, one deployed several months after courses had ended, Overbaugh and Lu surveyed 377 PK-12 teachers to determine the effectiveness and impact of the online professional courses on teacher competence and confidence in technology integration. The teachers volunteered to participate, with the only requirement that they had taken one or more of the OPD offerings. Semi-structured interviews were also conducted by randomly selecting potential interviewees from the study participants, resulting in 51 participant interviews approximately six months following the courses. The interviews were used to triangulate the data and help understand the effectiveness of the PD program's impact on teacher confidence in technology and technology integration. The findings suggest that the OPD courses helped participants gain competence and confidence in integrating technology into instruction. Participants indicated that their technology skills increased and that the courses helped increase their willingness and confidence to use technology with their students. The follow-up survey indicated continued use over time, suggesting that the OPD experience effected change in self-reported teaching practice around technology integration.

In their study on the impact of one-year professional development programs for middle-school mathematics and science/technology teachers, Owston et al. (2008) provide an example of a study on the impact of long-term online professional development. The OPD focused on improving teacher attitudes, knowledge and classroom practice in regards to mathematics and science/technology education, with an ultimate goal of improving student attitudes and engagement in the learning of mathematics and science/technology. Sixty-eight mathematics and 65 science/technology teachers in the middle grades from several urban school districts participated in the study, as well as 477 students from the mathematics teachers' classes and 551 from the science/technology teachers' classes. The researchers generated surveys, classroom observations and interviews as data sources. Owston et al. concluded that participation in the blended, long-term online professional development experience contributed to positive impact on teachers' attitudes and confidence to try new technology skills and instructional strategies, but implementation in the classroom was modified or different than intended by the professional development providers. A study by Beatty (2003) of 59 elementary teachers, all who had participated in a district-wide OPD focused on using computers in teaching, suggests similar findings to Owston et al. (2008). Beatty (2003) concluded that teachers demonstrate an increase in skills and confidence as a result of the professional development experience, but that their implementation of those skills did not necessarily transfer to use in the classroom at more than a basic level. These findings are echoed by several other studies which suggest that the ways in which teachers make use of what they learn in professional development varies, and is often related to the teachers' perception of how the content of the professional development directly relates to their students, classroom practice and their own content knowledge (Babette et al., 2009; Franke, Carpenter, Levi, & Fennema, 2001;Hughes, 2005; Klein, 2009).

Vavasseur and MacGregor (2008) studied the effects of a blended OPD experience on middle school teachers' technology competence and efficacy in a mixed-methods case study. Participants were a homogenous, purposeful sample from two schools in the same school district, chosen because of their ongoing commitment to participate in ongoing professional development throughout the school year. Participants from each school included the principal and teachers of the core subjects in all grades, as well as resource teachers, with approximately 23 participants from School A and 15 participants from School B. The study explored a blended OPD module that focused on integrating new state-mandated standards with technology resources. The blended OPD experience included face-to-face sessions conducted twice a week during teacher planning and participation in online communities of practice designed to facilitate teacher collaboration and principal support. A teacher self-efficacy survey was administered at the beginning and end of the OPD experience as well as an assessment of a technology-enhanced unit plan teachers developed at the end of the OPD. The quality of the unit plan was assessed on six criteria using a rubric created by the state technology center, with each criteria rated on a scale of zero to three. Qualitative data consisted of focus group interviews with all teachers conducted at the end of the OPD experience and analysis of the online threaded discussion forums. Results from the study show teachers were developing new skills and knowledge related to technology and technology integration and also implementing new instructional approaches in their classrooms. Teachers from both schools demonstrated a more positive perception of the value of computers in teaching after the OPD experience. Vavasseur and MacGregor (2008) conclude that online communities of practice, as part of face-to-face technology PD, increase communication and collaboration among teachers. This online community allows for the extension of communication and learning beyond the weekly face-to-face meetings, providing ongoing support and reflection on content and pedagogy. Additionally, the presence of the principal in the online community provided opportunities for them to support and motivate teachers, demonstrated a presence as a leader in professional development, and allowed teachers to feel their needs and concerns were being addressed. The integration of an online community with face-to-face professional development allowed for engagement in reflective practice, collaboration, and ongoing support for adopting technology that ultimately impacted teachers' attitudes towards computers in the classroom and their confidence and ability to integrate technology with their students.

Bryant (2008) studied teacher technology integration with students at the end of a 2-year blended OPD experience focused on using interactive whiteboards and student-response systems in classroom instruction. Similar to Vavasseur and MacGregor (2008), the OPD included both face-to-face and reflective weekly online participant Web logs, with the addition of online courses and creation and implementation of technology projects and lessons teachers were expected to implement in their classroom. Eighty-one participants from 8 elementary schools participated in an online survey. Sixteen participant volunteers also agreed to be interviewed and granted permission for their online course logs to be used as data sources. Based on self-reported survey responses, analysis of teacher Web logs and interviews with selected participants and the project director, Bryant concluded that participants learned the necessary technology skills and were motivated to integrate technology in their teaching. Participants moved toward more student-centered pedagogy as the participants' technology skills increased, and the professional development experience had a positive impact on job interest and performance. Bryant indicated several reasons for teachers' integration of technology after the professional development, including: teacher choice in which courses to take, based on student needs; focus on content that addressed student needs; access to the technology in the classroom setting; time for practice and creation of lessons; support from a wide variety of sources; and collaboration with colleagues.

Crockett (2010) studied the impact of various online professional development opportunities on the instructional practices of math teachers through the use of an online survey and participant interviews. The sixty-five K-12 mathematics teachers in the study were selected from a convenience sample of teachers from a single public school district who had participated in a minimum of any five OPD technology experiences over a 2-year time frame. Crockett's findings suggest that teachers perceived the OPD as beneficial to their professional growth and success and enhanced their technology skills. Teachers indicated they were integrating technology to teach and reinforce math concepts and lessons. The participants also suggested that they transferred the content knowledge from the OPD to the classroom, resulting in increased student achievement. Crockett reported that participants' ability to share and engage with ideas and collaborate with colleagues in an OPD experience were strong indicators that the content and skills from the OPD would be integrated into practice.

In a case study done by Furges (2011), teachers who participated in three online technology courses completed surveys and interviews about their perceptions on integrating technology as a result of this participation. The goal of the self-paced online courses was to help teachers develop lesson plans that integrated technology to support student learning. Furges found that the OPD experience provided teachers with flexibility in accessing and learning the course content and provided appropriate experiences that allowed them to increase their technology skills. All participants indicated confidence in using what they learned in the OPD with their students and felt competent at the end of the experience to integrate the technology in their classrooms. Furges suggests that the time afforded by the OPD to help the teachers gain a comfort level and then practice the new skills was an advantage of the OPD. In addition, the online discussion space used by participants to communicate and collaborate with each other was a strength of the OPD experience, providing participants with ideas and support for integrating technology.

Another case study by Dove (2011) indicated similar findings to Furges (2011), in that time and support provided by the ongoing OPD experience helped teachers gain confidence, skills, and refine what they were learning. Dove's study examined the technology integration practices of math teachers who participated in a blended professional development experience to learn and integrate the mathematics software, *Sketchpad* into math instruction. Dove focused on data from four teachers who participated in a 2-year professional development experience focused on teaching Geometry with *Sketchpad*. The professional development included face-to-face summer institutes followed by six monthly online modules, all focused on how to integrate content, pedagogy and technology into Geometry instruction using the software. Through an examination of a series of four interviews and observations, emails, and online course artifacts, Dove (2011) found the ongoing professional development supported the teachers' development of new skills and strategies for integrating technology into classroom practice. The OPD provided continued support and increased participants' confidence and skills, in large part because of the ability to collaborate with colleagues to create, share and refine technology activities. Dove concluded that the professional development experiences, including the content and the collaboration with colleagues, provided opportunities that often initiated changes in teachers' technology integration and their continued use of technology.

OPD, both fully online and blended, appears to promote change in teachers' pedagogical beliefs and improve their pedagogical and content knowledge (Carey et al., 2008; Coffman, 2004; Owston et al., 2008). Teachers show positive attitude changes and increases in skills as a result of participating in OPD (Beatty, 2003; Coffman, 2004; Duncan-Howell, 2010; Frey, 2009; Morrow, 2002; Mouza, 2009; Norris, 2008; Overbaugh et al. 2008; Owston et al., 2008; Vavasseur & MacGregor, 2008). The support and collaboration with colleagues as well as the time to practice and implement new skills and practices are components of OPD that support teachers' implementation of content learned in the experience (Crockett, 2010; Dove, 2011; Furges, 2011; Vavasseur & MacGregor, 2008). While these studies indicate that implementation of learning from professional development has some impact on teachers, there may be other factors that influence implementation.

Factors Influencing Impact of Professional Development.

As Darling-Hammond & McLaughlin (1995) argue, effective professional development requires a commitment of resources that allows teachers to reflect on their teaching and develop new knowledge and beliefs that will inform and improve their instructional practice in order to impact student achievement. Even with these recommended components in place, there is evidence that professional development content and strategies are not implemented effectively or sustained over time by some participants (Klein & Riordan, 2009; Mouza, 2009; Owston et al., 2008; Polly, 2011). Several factors have a significant impact on the sustainability of strategies and skills learned during professional development. Those factors include limited access to resources, teacher beliefs, coherence, support, and collaboration.

Limited access to resources. Several studies cite limited access to resources as a potential barrier to participants' implementation of PD strategies and tools in classroom practice (Beatty, 2003; Hew & Brush, 2007; Zhao, Pugh, Sheldon, & Byers, 2002). In a study designed to determine the effect of an online staff development course on elementary teachers, Beatty (2003) found that integration of technology after the professional development was limited due to access to both hardware and software as well as technology support after the professional development. Zhao et al., (2002) also found that teachers trying to implement technologies were often hindered by the technological infrastructures, such as access to computers and the Internet. Bryan (2008) argues that teachers who had planned to integrate technology and implement what was learned in a professional development experience were hindered by lack of hardware, software, or Internet access. Bryant (2008) reports similar findings, indicating that shared technology resources often impacted teachers' ability to integrate technology.

Teacher beliefs. Teacher beliefs about their students and about their own learning both before and after professional development can also influence the continued integration of skills and strategies after professional development (Franke et al., 2001; Hew & Brush, 2007; Mouza, 2009; Klein, 2009; Pegg & Pannizon, 2007; Turner et al., 2010). Turner et al. (2010) found teachers weak in their own content knowledge had difficulty implementing strategies from professional development. They also found low expectations of students' abilities and attitudes influenced what and how professional development content and strategies were implemented. Specifically, lower expectations of students' ability and attitudes resulted in teachers being less likely to implement strategies and resources learned in professional development. Similarly, Franke et al. (2001) found implementation strategies of teachers who had participated in a three-year mathematics professional development program were constrained by their perceptions of their students' ability to learn and their beliefs in their own ability to learn.

Mouza (2009) suggests that teachers' beliefs about their students were critical variables influencing their decisions related to technology integration. Specifically, teachers who perceived students' behaviors and abilities as something they could not control (such as low academic abilities and English proficiency deficits) often chose not to utilize technology, whereas teachers who viewed student abilities' within their control integrated technology as a means of motivating and meeting student needs.

Coherence. Klein (2009) found that teachers consciously rejected skills and practices from professional development experiences if they could not connect their own teaching and classroom context to the content of the PD, or if they felt their situations were unique and not conducive to the strategies or skills learned in the PD. Teachers' beliefs about their own content knowledge and students' abilities and the relevance of the professional development to their situation directly impacted their engagement in the professional development experience and ultimately how they adopted or adapted the skills and strategies learned (Klein, 2009; Hew & Brush, 2007). Roschelle et al., (2010), in their study on a technology integration in middle school mathematics classrooms, found it was important that the content and technology integration strategies focused on in professional development be directly related to the curriculum teachers are required to teach, as this directly impacted what and how technology was integrated into classroom instruction.

Bryan (2008) confirmed that teachers found it much easier to implement the skills learned in technology professional development when the learning involved creation of content-specific activities they could use with their students. Participants in Bryant's (2008) study reported that previous professional development content and programs were not relevant to their classrooms, making it less feasible to implement. Consequently, ther were more likely to implement activities that were practical and transferable to their teaching.

Support. Sustained implementation of learning from PD is influenced by support from both school/district leaders as well as teacher colleagues (Babette et al., 2009; Franke et al., 2001; Owstein et al., 2008; Polly, 2011; Smith & Sivo, 2011; Turner et al., 2010; Vavasseur & MacGregor, 2008; Zhao et al., 2002). Lack of support from school and district leaders in providing a time and place for professional development meetings and access to resources were cited by Babette et al. (2009) as factors that hindered participants' ability to focus on what they were learning in the professional development experience. According to the findings of Turner et al. (2010), the lack of support from school staff and the principal for the changes that math teachers were trying to implement after participating in a nine-month collaborative professional development initiative made sustaining those changes difficult.

Bryant (2008) and Owston et al. (2008) reported that access to technology support personnel and the instructors of the professional development enabled participants to receive immediate support as well as individualized follow-up, which in turn contributed to continued technology integration after the professional development. Hardware, software and access to support personnel were crucial to successful integration. Additionally, teachers who perceived a lack of administrative support, which included time for learning, practice and access to resources, were less successful in their efforts to integrate technology (Bryant, 2008; Owston et al., 2008).

Collaboration. A final factor that significantly impacts sustained implementation of professional development learning is collaboration from colleagues, according to Franke et al. (2001). In particular, the ability of teachers from the same school to develop a collaborative environment to support each other over time as they continue their implementation of what they learned in PD is important for sustained implementation (Franke et al., 2001; Vavasseur & MacGregor, 2008). Hughes (2005) reported that teachers who participated in collaborative content and grade level support groups were able to support each other and guide integration of technology over time. Polly (2011) noted that the support is not only important from colleagues, but from the professional development providers as well, who can provide feedback as the participants continue to learn, modify and use technology strategies learned in professional development. Polly also noted that teachers who were able to co-plan with the professional development providers showed higher-levels of technology integration in their lessons.

Owston et al. (2008) concluded that the most notable change in school practice after the math and science teachers had participated in the long-term blended learning professional development was the amount and nature of teacher collaboration. As a result of participation in the professional development, reflective practices, sharing of ideas among colleagues, and incidents of teachers presenting for peers at district and staff meetings increased. Bryan (2008) reported that the continued collaborative efforts after the professional development was essential for sustaining the learning because it encouraged teachers to support each other's continued learning and implementation of skills. Similarly, Dove (2011) found that the continued support from other participants and the professional development providers helped teachers deal with challenges of teaching with technology, allowing participants to share, refine and collaborate on lessons on a regular basis. This was considered a positive outcome and influence on continued integration of technology.

Sustainability of the skills and strategies learned in professional development are impacted by many factors, including engagement in the professional development, teachers' beliefs about their own learning and their students learning, and how the professional development can impact student achievement (Klein, 2009). Teachers' content knowledge, their belief that changing practices will enhance student learning, and the degree to which the content and strategies align to their current teaching situation, impacts how and what teachers eventually implement in their instructional practice (Babette et al., 2009; Franke et al., 2001; Hew & Brush, 2007; Hughes, 2005; Klein, 2009; Mouza, 2009; Owston et al., 2008;Turner et al., 2010). Continued support for teachers from colleagues and administration also seems to impact sustainability (Bryan, 2008; Bryant, 2008; Dove, 2011; Franke et al., 2001; Hughes, 2005; Owston et al., 2008; Vavasseur & MacGregor). There are several components from research-based professional development that seem to influence sustained implementation and change in teacher practice. Identifying these influences is important for both the design of PD and implementation of PD. Studying the instructional decisions teachers make after participating in effective professional development as well as looking at other contextual factors that may influence those instructional decisions can provide a better understanding of how PD can support teachers' sustained implementation and changing practices.

Need for Research after Professional Development

How teachers decide to implement content and strategies from professional development experiences often differs from what was modeled for them (Klein, 2009; Mouza, 2009; Owston et al., 2008; Polly, 2011), even when the PD is structured according to recommended research-based components for effective professional development. Follow-up research on the impact of professional development on teacher practice often relies on teacher self-reports, which makes it difficult to determine if true change in teacher practice has occurred (Lawless & Pellegrino, 2007; Dede et al., 2005), since self-reports from teachers can often be skewed or unreliable (Pierson & Borthwick, 2010).

The transference of learning acquired during PD into practice and how the PD experiences influence classroom instruction should be a focus for determining the impact of PD (DiPaola & Hoy, 2008; Lawless & Pellegrino, 2007). According to DiPaola & Hoy, this type of evaluation on the impact of a particular professional development effort is rarely done because of the resources and time required. However, providing professional development that results in more effective teachers is crucial to improved instructional practice and student achievement (Darling-Hammond & McLaughlin, 1995; Dede et al., 2005; DiPaola & Hoy, 2008). It is necessary to go beyond evaluating participants' satisfaction with professional development and self-report data on the influence and usefulness of the professional development in their own practice (Dede et al., 2005; Lawless & Pellegrino, 2007). Instead, research designs should attempt to uncover what actually occurs in the classroom following PD and determine what, if any, changes might be attributed to a professional development experience. Lawless & Pellegrino (2007) emphasize the need to create evaluation of professional development that articulates the intended outcomes of the professional development and aligns strategies appropriate for assessing those outcomes. Research on whether professional development has had an influence on changing teacher practice should focus on determining which components of the professional development are influencing the instructional choices of teachers (Lawless & Pellegrino, 2007).

According to Lawless & Pellegrino (2007) and Pierson & Borthwick (2010), relying only on self-report data does not necessarily depict what is actually occurring in the classroom or ascertain long-term implementation in teachers' practice. A more systematic approach to evaluating the influence of educational technology professional development and the factors that contribute to sustained implementation of the intended skills and strategies is needed (Dede et al., 2005; Lawless & Pellegrino, 2007; Pierson & Borthwick, 2010). This means obtaining multiple sources of evidence of how teachers are incorporating technology into their instruction practice over longer time frames and what, if any, components of the technology professional development influence those changes. This will provide evidence for identifying and supporting structures that might be necessary in maintaining long-term change in teacher practice and ultimately tying technology professional development approaches to student achievement.

Several studies cited above provide models for how triangulated research design done over time is a better assessment of the effects of technology professional development on long-term change in teacher practice, as recommended by Lawless & Pellegrino (2007). Hughes' (2005) study used teacher interviews, classroom observations focused on the use of technology in relation to instruction and student learning, paired with analysis of student materials. This study found that content-focused learning yielded content-focused integration of technology and the teachers' interpretation of the technology's value for instruction and learning influenced their integration of the technology. Dove (2011) used classroom observations, teacher interviews and online course artifacts over a four-month period to conclude that teachers were incorporating learning from the professional development. The OPD had both a direct and indirect influence on lesson planning and teachers showed growth and integration skills over time. From Dove's findings, the OPD seemed to influence both teaching strategies and content, with the content focused lessons and activities providing participants with relevant activities to utilize in their classrooms. In both Hughes (2005) and Dove's (2011) studies, the integration of the technology was more prevalent when a connection to specific content, curricular goals or specific school or district goals was found, which supports Pierson & Borthwick's (2010) suggestion that evaluation of professional development should be conducted within the context of the organizational expectations as a whole.

Based on classroom observations, surveys and interviews over a period of nine months following one year after teachers had participated in technology professional development, Mouza (2009) found that teachers had improved their skills with the technology and increased their understanding of how to use that technology in the classroom. Mouza also found that teachers were not using the technology consistently or as modeled in the professional development, which was influenced by their beliefs about their students, the availability of the technology resources and both administrative and colleague support A major obstacle to long-term integration of technology was access to the resources and technical support as well as administrative support, which decreased over time. Colleague support, including collaborative technology planning was a factor in continual integration of technology, aiding in continued learning and improvement.

Owston et al. (2008) used a combination of data generation that included questionnaires for teachers and students, interviews with principals, classroom observations, analysis of online discussion forums and reflective journal entries, and small teacher group interviews. Findings indicated a change in teacher attitudes and beliefs as well as evidence of change in practice. Administrative support was a key component in the continued implementation of the professional development learning while a detriment to continued use of strategies was teachers' prior content knowledge, which contributed to their inability to apply the professional development learning into practice.

Polly (2011) used both classroom observations, which included video recording the classrooms, field notes on student actions during the classroom observations and observations of the professional development experience. Polly found that teachers showed evidence of integrating technology after the professional development, but that it did not encompass all of the components modeled in the professional development. While teachers all developed a willingness to use technology integrated activities, those that were planned in collaboration with colleagues were more likely to include the higher-level technology-rich activities similar to those modeled in the professional development.

These studies illuminate additional factors besides the professional development focus and structure which influence the long-term integration of skills and strategies, or as Pierson & Borthwick (2010) define it, the context within which professional development must be assessed. These other factors, such as access to resources, support from colleagues and administration, coherence to school and district expectations, and teachers' perceptions of their students' abilities, all contribute to the overall effectiveness and sustainability of professional development (Hughes, 2005; Mouza, 2009; Owston et al., 2008; Pierson & Borthwick, 2010; Polly, 2011). Relying on self-reported data from teacher surveys or teacher interviews on the influences of professional development on change in practice and integration does not provide sufficient evidence to inform what changes are taking place in the classroom, why those changes are occurring and what impact the professional development may have played on those changes (Lawless & Pellegrino, 2007).

Pierson & Borthwick (2010) recommend that observing and documenting teacher behaviors in classroom practice as the most direct route to evaluating the influence of professional development on teacher practice. The methods for data collection on classroom practice can include observations, surveys of teacher self-reported behaviors, teacher interviews, lesson plans, student artifacts, and video analysis. The data should be generated over a period of time, not just immediately after training, so that changes in instructional practice can be attributed to the appropriate variables, which may not be the professional development experience itself (Lawless & Pellegrino, 2007).

Summary

Professional development for teachers is designed to improve their practice, not only by improving their content knowledge, but also providing them with new resources, skills, and pedagogical strategies that will prepare them to use these new skills and strategies to improve student achievement (Darling-Hammond et al., 2009; Guskey, 2003). There are many options for providing professional development, from face-to-face models, online models, and blended models, but it is important to carefully structure professional development for it to have the greatest influence for sustained teacher change that positively impacts student achievement (Darling-Hammond et al., 2009; DiPaola & Hoy, 2008). Key components of effective professional development include:

- Coherence to teacher practice, school and district-wide initiatives, content and instructional goals;
- Active-learning, content-focused activities, and activities that are relevant to what teachers are doing in their own classrooms;
- Collaboration, experimentation and time for reflection on practice;
- Long-term implementation, providing time for learning and practice in the classroom as well as time for reflection, support and collaboration (Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Guskey, 2003).

The ways in which teachers implement ideas and skills introduced in professional development in their classrooms often differs from what was modeled for them (Beatty, 2003; Bryan, 2008; Mouza, 2009). If professional development is designed to incorporate the effective research-based components described above, then it is important to determine what, if any, of those components are hindering or helping teachers effect change in their instructional practice (Dede et al., 2005; Lawless & Pelegrino, 2007; Thurlow, 1999). Current research tends to focus on teachers' self-reports of the impact of the professional development through questionnaires and surveys, as exemplified in studies done by Coffman (2004), Colbert et al. (2008), Crockett (2010), and Desimone et al. (2002). Due to the nature of self-report data, these findings do not necessarily reflect the true influence of professional development on long-term integration and teacher implementation in practice (Lawless & Pelegrino, 2007; Pierson & Borthwick, 2010).

Research on what actually happens in the classroom after participation in professional development using classroom observations can provide evidence of implementation, with teacher interviews providing more information on what components from effective professional development may be influencing teachers' instructional decisions (Pierson & Borthwick, 2010). Using a combination of data generation approaches, such as classroom observations, interviews, analysis of Web logs and discussion forums from OPD, provides a broader perspective on the influence of professional development on teacher implementation (Pierson & Borthwick, 2010). These triangulated studies suggest factors that contribute to teachers' lack of implementation of professional development, including: access to resources, teacher beliefs about their own knowledge and learning, teacher beliefs about students' abilities, and support from administration and colleagues (Beatty, 2003; Bryan, 2008: Bryant, 2008; Crockett, 2010; Dove, 2011; Franke et al., 2001; Furges, 2011; Klein, 2009; Mouza, 2009; Pegg & Pannizon, 2007; Turner et al., 2010; Zhao, Pugh, Sheldon, & Byers, 2002). Determining how contextual factors and professional development experiences contribute to teachers' instructional decisions is important to informing the types of resources, support and professional development provided so that teacher change is sustained long term (Lawless & Pellegrino, 2007).

According to Lawless & Pellegrino (2007), while there is evidence that technology integration occurs immediately after participation in professional development, there is little evidence that the practice persists. Looking at teacher integration of technology following participation in professional development after time has passed may provide valuable insight into what influence the professional development had on sustaining technology integration, and what other factors might be influencing instructional decisions. Classroom observations and teacher interviews, in addition to teacher surveys, may provide insight into what is actually occurring in the classroom, the instructional decisions around technology integration teachers are making, and whether those decisions are a result of the professional development influence or other factors.

This study examined the perceived influences on instructional decisions teachers made regarding planning and implementation of technology lessons after participating in a long-term, blended PD experience. I drew on classroom observations, one-on-one interviews and the teachers' lesson plans to generate data on teachers' instructional decisions planning for and implementing technology-integrated lessons, and how their experiences in OPD may or may not have influenced those instructional decisions. I explored why they make those decisions, and what other components may have influenced those decisions. Analysis of the observations, interviews and written lesson plans, using constant-comparative data analysis procedures, provided insight into how, if at all, the OPD experience influenced instructional decisions and what other influences impacted teachers' integration of technology. Focusing on what teachers actually did in their classroom and why they made the instructional decisions that led to this practice provided insight into what, if any, components of the professional development influenced their use of technology. The grounded theory developed from this study will inform the planning and structure of future professional development focused on technology integration.

Chapter 3

Methods

Purpose of the Study

Professional development is instrumental in improving and supporting teachers' skills and strategies in order to raise student achievement (NSDC, 2012a). Research defines several key components for effective professional development: curriculum content focus (Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Polly & Hannafin, 2010); hands-on active learning (Garet et al., 2001; Ingvarson, Meiers, & Beavis, 2005; Polly & Hannafin, 2010); and professional development that is sustained, intensive, and connected to teacher practice (Darling-Hammond et al., 2009; Polly and Hannafin, 2010). Online professional development, including hybrid models that combine both face-to-face and online components, can address the necessary components of research-based effective professional development (Boling, 2002; Carey et al., 2008; Dash et al., 2012; Dove, 2011; Furges, 2011; Russell et al., 2009). There is evidence that professional development, including online or hybrid approaches, when conducted using these research-based components, does contribute to the continued use of skills and strategies learned (Bryan, 2008; Bryant, 2008; Crockett, 2010; Dash et al., 2012; Dove, 2011; Furges, 2011; Mouza, 2009).

Lawless & Pellegrino (2007) suggested that reported change in teacher practice as a result of participation in technology-based professional development is often derived from teacher self-reports, which should not be relied on solely, as these self-reports are not necessarily an accurate depiction of what occurs in the classroom, nor do they demonstrate long-term impact on teachers' practice. Researchers must use additional data types besides teacher self-reports to determine the impact of professional development on teacher knowledge and practice (Dede et al., 2005; Pierson & Borthwick, 2010). Research should explore how invested in the professional development teachers were and whether it met their expectations and engaged them in the learning (Dede et al., 2005). Research should also analyze the instructional decisions teachers make after participating in professional development and determine if those decisions and changes in instructional practice were influenced by the professional development experience (Lawless & Pellegrino, 2007).

This study focused on the instructional decisions teachers made after participating in a seven-month long, research-based, hybrid technology professional development experience. The professional development centered on *Sketchpad* software and pedagogical strategies for integrating the software and The Common Core State Standards for Mathematics [CCSSM] (National Governors Association Center for Best Practices, Council of Chief State School Officers [NGACBP], 2010) into mathematics instruction. The study incorporated classroom observations, semi-structured interviews, and written lesson plans that documented teachers' instructional decisions and practices related to integrating *Sketchpad* software in their classrooms after OPD, how experiences in the OPD influenced those instructional decisions, and what other factors influenced those decisions. An extended time frame for data collection after professional development was recommended by Lawless & Pellegrino (2007). Data collection for this study took place over a three-month time span beginning approximately 10 months after the actual professional development in order to gauge continued use, if any, of the learning from the professional experience. This study provides evidence of instructional decisions teachers demonstrated around incorporating technology and skills into their instructional practice after participating in a hybrid OPD experience and what, if any, components of the professional development influenced their instructional decisions.

The analysis of the data identified categories and themes that led to the development of a grounded theory concerning teachers' practice of technology integration. By providing evidence of what teachers actually did in the classroom after participating in a research-based, long-term, hybrid technology professional development, the resulting grounded theory provides insight into the design of and planning for future technology professional development.

Research Questions

According to Lawless & Pellegrino (2007), there are several studies that show technology integration increases immediately following professional development, but there is little evidence that this change persists. Dede et al. (2005), in their synthesis of 40 empirical studies on online professional development, noted that few of the studies measured observable changes in teachers' knowledge or skill. They argued that long-term evidence, collected after significant time has elapsed after the professional development experience and collected over a longer period of time, is needed. This evidence should go beyond teacher self-reports so that new skills and practices can be correlated to change in instructional practice (Lawless &Pellegrino, 2007). This study focused on teachers' implementation of technology into mathematics instruction after participating in a hybrid OPD experience. The study included observation of teachers' actions and interviews about their instructional decisions and decision-making process around technology integration conducted over a three-month span of time in the academic year following participation in a seven-month hybrid technology professional development. The study provides what Lawless & Pellegrino suggested - "detailed evidence of how teachers incorporate technology in their pedagogies over time and some of the prior training and/or concurrent support factors that influence observed changes" (p. 607). A grounded theory research approach was used to explain teachers' perceived influences on instructional decisions they made around technology integration after participation in professional development focused on technology integration into mathematics instruction. To address the phenomenon of teachers' perceptions of the influences on their instructional decisions concerning technology integration and how these may or may not be influenced by participation in hybrid OPD, this study was guided by three research questions:

1) How, if at all, did experiences in a TPACK-based OPD influence participants' instructional decisions when planning for technology-integrated lessons using *Sketchpad*?

2) How, if at all, did the participants draw on their experiences from OPD about integrating *Sketchpad* software in mathematics classroom instruction after participating in a seven-month hybrid online professional development program?

3) What, if any, other factors influenced teachers' instructional decisions regarding their integration of *Sketchpad* that are not related to the OPD experience?

Research Design

According to Merriam (1998) qualitative research "helps us understand and explain the meaning of social phenomena with as little disruption of the natural setting as possible" (p. 5). Qualitative research is concerned with "understanding the phenomenon of interest from the participants' perspective" (p. 6). According to Lawless and Pellegrino (2007), research to inform technology professional development and its impact on sustained implementation should include "detailed evidence of how teachers incorporate technology in their pedagogies over time" (p. 607). Being in the field is necessary to build understanding according to Merriam (1998) "in order to observe behavior in its natural setting" (p. 7). This study sought to understand the influences on teachers' instructional decisions and practices around technology integration after PD. This was done by observing teachers in their classrooms, interviewing them about their instructional decisions, and looking at their planning processes. The study occurred approximately ten months after teachers had completed the professional development experience and took place over a three-month span of time.

Grounded theory is a form of qualitative research where, using constant-comparative methods of data analysis, the "data gradually evolve into a core of emerging theory" (Merriam, 1998, p.191). According to Birks & Mills (2011), grounded theory "seeks to explain the phenomenon being studied" (p. 16), and generates theory that "explicates a phenomenon from the perspective and in the context of those who experience it" (p. 16). Grounded theory involves generating concurrent data, where "some data is generated with an initial purpose and coded before more data is generated" (p. 10). This includes writing memos and using constant comparative methods for data analysis in order to generate a theory grounded in the data themselves. Researcher memos in grounded theory are "records of thoughts, feelings, insights, and ideas in relation to the research" (p. 40). The constant comparative method for data analysis compares interpretations, conclusions and developing initial codes from all generated data and constantly refines those codes until emerging categories and themes develop. Grounded theory is appropriate when there is little known about a particular topic (Birks & Mills). The participants in this study, along with the researcher, generated multiple concurrent data sources that sought to explain the phenomenon of knowledge teachers developed during OPD and how this knowledge influenced their instructional decisions related to technology integration after professional development.

This study used a grounded theory approach in which triangulated data from multiple sources were used to uncover and confirm emerging themes and patterns. Data were generated from the following sources: classroom observations, personal interviews, and written lesson plans. Participants in the study comprised a deliberate convenience sample from two cohorts of mathematics teachers who were part of a long-term, hybrid, technology OPD experience in a large, urban school district. Using multiple qualitative data types and sources provided an opportunity to look for and discover patterns within and across study participants. Constant-comparative methods of data analysis were used to develop categories and themes. Using constant-comparative methods, each source of data were compared with other sources of data on a continuous basis to determine similarities and differences (Merriam, 1998). Using suggested data analysis coding techniques from Birks & Mills (2011), a grounded theory explaining the influences on teachers' instructional decisions and practices when integrating *Sketchpad* into mathematics instruction emerged.

The participants in this study came from what Smith calls a *bounded system* (as cited in Merriam, 1998, p. 19); in this case, two specific groups of mathematics teachers from a large urban public school district who participated in a focused technology professional development experience. The seven participants for this study comprised a deliberate convenience sample from this bounded system. They represented a subset of the two cohorts who participated in the professional development who were willing to participate in the study and who represented different levels, in grades they taught, teaching experience, and in how they implemented technology in their classrooms. Classroom observations, personal interviews, and analysis of written lesson plans provided detailed description of the phenomenon under study. A constant comparison of memos and coding helped to identify emerging patterns, categories, and themes related to the study's three research questions. These categories and themes were linked together to create results that explain the data's meaning (Merriam, 1998). The results provided by this study contribute to understanding the influences on instructional decisions and practices of teachers related to technology integration. Specifically, the results help illuminate how, if at all, teachers perceived the influence of research-designed, long-term, hybrid OPD on their instructional decisions and practices around technology integration.

Professional Development Framework

While this study was not an evaluation of the OPD experience, it is important to understand the context and design of the OPD, as it provides the TPACK framework for data analysis during the study. Participants in this study completed a professional development experience focused on learning and integrating *Sketchpad* (KCP Technologies, 2011) and The Common Core State Standards for Mathematics [CCSSM] (National Governors Association Center for Best Practices, Council of Chief State School Officers [NGACBP], 2010) with specific focus on The Common Core Standards for

Mathematical Practice [CCSMP], into mathematics instruction. The CCSMP were developed as part of the CCSSM to "describe varieties of expertise that mathematics educators at all levels should seek to develop in their students" (p. 6). The eight CCSMP are based on the National Council for Teachers of Mathematics process standards of problem solving, reasoning and proof, communication, representation and connections (NGACBP). They also incorporate mathematical proficiency as specified by the National Research Council, Mathematics Learning Study Committee (2001), which includes adaptive reasoning, strategic competence, conceptual understanding, procedural fluency, and productive disposition. Because the school district had adopted the CCSSM (NGACBP, 2010), the professional development described here focused on specific mathematics standards, in particular, incorporating the CCSMP as a guiding framework for integrating technology into mathematics instruction. Teachers spent approximately 1-2 hours per week reading, connecting, and applying the CCSMP to activities, Common Core math content standards, lesson plans, and lesson implementation strategies. The CCSMP formed the framework around which teachers' integrated technology into mathematical instructional practice in order to help their students become mathematically proficient. Table 1 identifies the eight mathematical practices and student characteristics associated with each practice.

Table 1: Common Core Standards of Mathematical Practice (NGACBP, 2010)

Practice	General Characteristics
1. Make sense of problems and persevere in solving them	• Able to explain meaning of problem and look for entry points • Analyze givens, constraints, relationships and goals • Make conjectures and plan a solution pathway • Monitor and evaluate progress and change course if necessary • Can explain correspondence between various features • Check their answers with different methods • Understand various approaches to solving
2. Reason abstractly and quantitatively	• Make sense of quantities and their relationships in problem situations • Can decontextualize and contextualize when solving problems with

	quantitative relationships • Can create coherent representation of the problem at hand, including considering units involved, the meaning of the quantities and how to flexibly use different properties of operations and objects
3. Construct viable arguments and critique the reasoning of others	• Understand and use stated assumptions, definitions, and previously established results in constructing arguments • Make conjectures and build a logical progression of statements to explore the truth of their conjectures • Able to analyze situations by breaking them down and exploring counterexamples • Justify their conclusions, communicate them to others, and respond to the arguments of others. • Reason inductively, make plausible arguments
4. Model with mathematics	• Can apply the mathematics they know to solve problems arising in everyday life, society and the workplace • Are comfortable making assumptions and approximations to simplify a complicated situation • Able to identify important quantities in a practical situation and map their relationships using various tools • Can analyze relationships mathematically to draw conclusions • Interpret mathematical results in the context of the situation, reflect on whether the results make sense, and possibly improve the model if it does not serve the purpose
5. Use appropriate tools strategically	• Consider available tools when solving a mathematical problem • Familiar with appropriate tools and able to make sound decisions about when each of these tools might be helpful • When making mathematical models, know that technology can enable visualization of results of varying assumptions, explore consequences, and compare predictions with data • Able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems • Able to use technological tools to explore and deepen their understanding of concepts
6. Attend to precision	• Try to communicate precisely to others • Try to use clear definitions in discussions with others and in their own reasoning • State the meaning of the symbols chosen • Specify units of measure and label axes to clarify the correspondence with quantities in a problem • Calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context • Examine claims and make explicit use of definitions
7. Look for and make use of structure	• Look closely to discern a pattern or structure • Can step back for an overview and shift perspective • Can see complicated things as single objects or as being composed of several objects
8. Look for and express regularity in repeated reasoning	• Notice if calculations are repeated, and look both for general methods and for shortcuts • Maintain oversight of the process as they work to solve a problem while attending to the details • Continually evaluate the reasonableness of their intermediate results

The CCSMP (NGACBP, 2010) focus on eight mathematical practices teachers are encouraged to incorporate into their classroom teaching as a means of helping students develop mathematical proficiency. These eight practices provided a guiding framework for analyzing the data collected from the classroom observations, personal interviews, and lesson plans. Teachers in this study participated in experiences focused on helping them incorporate the CCSMP in the instructional decisions and activities they use in the classroom as they integrate *Sketchpad* in mathematics instruction, providing opportunities for students to develop proficiencies for each of the eight practices.

During the professional development experience, participants were expected to implement mathematics lessons that integrated *Sketchpad* and the CCSMP two to three times per month. Following the professional development and continuing into future academic school years, teachers were expected, on a daily basis, to create instructional lesson plans, and exhibit instructional decisions and actions that incorporate the CCSMP in their classrooms, including when integrating *Sketchpad* in their teaching. The effective integration of the CCSSM, the CCSMP and *Sketchpad* in the classroom required teachers to develop their knowledge of technology integration. The focus of the OPD was on assisting teachers in integrating the CCSSM, CCSMP, and *Sketchpad* into their teaching practice. The use of the TPACK construct during this professional development helped the participants develop a sense of how math content knowledge, their technological knowledge of *Sketchpad* software, and their pedagogical knowledge worked together in their instructional practice.

TPACK represents a teacher's knowledge that enables her to draw upon her technology, pedagogy and content knowledge to provide the most appropriate instruction, teaching strategies and representations in their instructional practice (Mishra and Koehler, 2006). As defined by Mishra and Koehler, TPACK is "the basis of good teaching with technology" (p. 1029). Mishra and Koehler's (2006) TPACK construct represents the "connections, interactions, affordances, and constraints between and among content, pedagogy, and technology" (p. 1025). Teaching is a "highly complex activity that draws on many kinds of knowledge" (p. 1020). In the TPACK construct, technological, pedagogical and content knowledge are central to developing good teaching. TPACK emphasizes the interconnected nature of these three domains of knowledge, due to the "complex interplay" (p. 1025) between them. As an example, a teacher wanting to differentiate instruction and provide visual examples of math content, may choose a *Sketchpad* activity to visually model the math concept of slope, and then using questioning strategies and *Sketchpad,* connect the visual representation of slope to the symbolic equation of slope. The TPACK construct represents the relationship among all three forms of knowledge. Being able to interweave these three forms of knowledge seamlessly is the goal for good teaching, so understanding each type of knowledge as well as the connections between combinations of these three is important to effective instruction.

Content knowledge (CK) is the actual subject matter to be learned or taught, and is often selected and interpreted through the curriculum standards in K-12 schools, of which the CCSSM (NGACBP, 2010) are an example. Mishra & Koehler (2006) describe technology knowledge (TK) as knowledge of the skills required to operate a particular technology, exemplified in this study as understanding the skills needed to use *Sketchpad.* Pedagogical knowledge (PK) is knowledge about the practices and methods of teaching and learning. PK includes classroom management, instructional strategies, lesson planning, and student evaluation strategies. The CCSMP (NGACBP, 2010) would be an example of pedagogical practices specific to math instruction. Pedagogical content knowledge (PCK) is the intersection of pedagogy and content, and means knowing what teaching approaches best fit the content that is being taught and having the ability to recognize and use the most appropriate teaching strategies to address particular conceptual understandings. A teacher who understands that using paper-folding and tracing to help students understand properties of reflection is demonstrating PCK. Technology content knowledge (TCK) is similar, in that it is knowledge about which technology can support and represent the teaching of content. TCK represents an understanding of how to select and connect the use of a particular technology to the content focus. A teacher who knows that *Sketchpad* may help students understand the triangle sum theorem because it can provide far more examples compared with the traditional paper-pencil method is an example of TCK. Technological pedagogical knowledge (TPK) is knowledge about technology and its capabilities and how the use of a particular technology will support, extend, enhance or even change the teaching strategies that are used. TPK can also include an understanding of how to most effectively teach with a particular digital tool or resource. An example of this would be a teacher who understands the need to first model and demonstrate an activity using *Sketchpad* and then have students work in pairs at the computer to practice the skill. Technological pedagogical and content knowledge (TPACK) is the convergence of all three types of knowledge working together to create cohesive technology-facilitated, content-based teaching and learning.

The ability of a teacher to draw on her interconnected knowledge of technology, pedagogy and content is central to the TPACK construct (Mishra & Koehler, 2006). Effective teaching and learning with technology requires the ability to choose appropriate technologies and pedagogical strategies to teach particular curriculum content. Understanding how to use these three components together demonstrates good teaching and well-developed TPACK. Developing teachers' TPACK was central to the OPD experience in which study participants engaged during the year prior to the study. The design of that professional development was based on helping teachers build their technological knowledge of *Sketchpad,* their pedagogical knowledge of the CCSMP (NGACBP, 2010), and their content knowledge of the CCSM, but more importantly on how to integrate all three in classroom instruction. This study sought to understand how teachers planned for and used *Sketchpad* in practice after participation in a TPACK-focused OPD experience in relation to the use of *Sketchpad* in. Using TPACK as a lens to help in my data analysis of classroom observations, teacher interviews and lesson plans, the findings of the study illuminate how teachers integrated technology into mathematics instruction

Participants

Participant selection. Teachers invited to participate in this study represented a deliberate convenience sample subset of participants from two cohorts of teachers who completed the OPD experience. Of the 17 total teachers from the two cohorts, seven volunteers were chosen to participate in this study based on their different grade levels, teaching experiences, and technology integration practices, as determined from their prior OPD experience. They agreed to allow me to conduct classroom observations, one-on-

one interviews and to collect written lesson plans demonstrating their plans for integration of *Sketchpad* in their classroom teaching. All participants signed a consent form demonstrating their willingness to participate in the study. This form can be found in Appendix A. The district leaders of the school division agreed to allow the classroom observations and interviews to take place over a period of three months, and asked that the lesson plans provided by the participants become part of a district databank of lessons for use by all district math teachers. The participants in this study had varying backgrounds and teaching experience and taught in both middle and high school settings across the district, providing a diverse sample of teachers.

Participants' prior professional development experience. Participants came from two cohorts of mathematics teachers who participated in a seven-month, hybrid technology professional development during the 2011-2012 academic school year. The school division is located in an urban area with approximately 80,000 students. Teachers from each cohort were full-time middle or high school teachers in the division. The professional development was designed as part of a grant procured by district math leaders in partnership with a local university and a major employer in the region. The district math leaders advertised the professional development and all participants voluntarily applied to participate in one of the cohorts. As part of the grant, all participants were paid for their face-to-face and online time, and earned professional development hours towards recertification. All cohort participants signed an agreement with the school division to attend all the face-to-face workshops and complete all the monthly online course and in-classroom components. I had no part in the procurement of the grant, application process or selection of participants.

There were two cohorts involved in the OPD experience: a middle school cohort of 9 middle school mathematics teachers and a high school cohort of 8 high school mathematics teachers. Both cohorts focused on learning the *Sketchpad* software, the CCSSM and CCSMP (NGACBP, 2010), which included specific content standards and the related mathematical practices, and pedagogical strategies for incorporating technology into mathematics instruction. Particular focus was put on the CCSMP. Each cohort experienced the same six face-to-face workshops and similar online course components, with the major difference being the specific math content focus, discussed in detail below. *Sketchpad* activities were chosen from a searchable database of CCSSM-aligned activities based on the content focus. Teachers worked through the activities themselves, using the sketches, teacher notes and student worksheets during the online courses.

Based on a directive from the district math leaders, the middle school cohort focused on proportional reasoning content from the CCSSM and the high school cohort focused on algebra and function content from the CCSSM (NGACBP, 2010). Teachers had access to the *Sketchpad* software, *Sketchpad LessonLink* ™ (Key Curriculum Press, 2008), which is a searchable online database of complete *Sketchpad* lessons aligned to content and standards, and the Internet to utilize both *Sketchpad LessonLink* and the online course. Each cohort participated in six face-to-face workshops that occurred in December, 2011, and January, February, March, April, and June of 2012, for a total of 18 face-to-face hours. Each cohort participated in six online asynchronous course modules, which varied from four to six weeks in length, in December 2011/January 2012, January/February 2012, March 2012, April 2012, May 2012, and June 2012, for a total of approximately 36 online and classroom implementation hours. The face-to-face and online components combined provided participants from both cohorts approximately 54 hours of professional development, which exceeds the average of 49 hours of professional development hours recommended for teachers to improve their teaching skills and practices (Darling-Hammond et al., 2009; Yoon et al., 2007).

I worked with district math leaders to develop both the face-to-face and online components of the technology professional development, using the TPACK construct and recommended strategies for quality professional development as guides. I have specific expertise and background in developing both face-to-face and online technology professional development for mathematics teachers. My expertise comes from my 17 years of middle and high school mathematics teaching experience, my previous district math specialist responsibilities, and my position managing and directing the professional development for an educational company, where development and implementation of technology professional development were regular foci of my job. I have over 15 years of experience integrating *Sketchpad* into mathematical instruction, both in my own math classrooms and as a professional development provider at local, state and national levels.

The face-to-face workshops all occurred at a centrally located high school in the district used for district-provided professional development. Each cohort met separately as a group for 6 three-hour, face-to-face, hands-on workshops, where they had access to computers, *Sketchpad,* and the Internet. The online modules were mediated via a *Moodle* platform for course delivery and were modeled on Key Curriculum's current *Teaching Algebra with Sketchpad* (Key Curriculum Press, 2007) and *Teaching Middle School Math with Sketchpad* (Key Curriculum Press, 2010) online courses, though content and structure were modified to address the district's specific content requirements, CCSSM and CCSMP (NGACBP, 2010) focus and to provide activities designed to help teachers integrate technology, pedagogy and math content.

Participants from each cohort had their own *Moodle* access for their specific course and could access the online course content at any time via the Internet. The middle school cohort focused on Proportional Reasoning Standards from the CCSSM and the high school cohort focused on Algebra and Functions Standards from the CCSSM. Mathematical content was embedded in the *Sketchpad* activities modeled during the face-to-face sessions and in the online course activities and discussion forums. Different *Sketchpad* skills were learned and practiced each month and the CCSMP from the CCSSM were embedded into all face-to-face and online components as a guiding pedagogical structure.

At each face-face session, I focused on specific affordances of the software that would be utilized in the follow-up online component. I led the participants through content-related lessons that incorporated both new tools and features of the software, specific mathematical concepts, and pedagogical strategies structured around the CCSMP in the CCSSM (NGACBP, 2010). Participants actively engaged as students in the lessons at computers, working both individually and collaboratively. After each lesson was completed, the participants participated in collaborative discussion and a thorough debrief. In all but the first face-to-face workshop, participants shared their own experiences with implementing *Sketchpad* into their classroom instruction, instructional strategies they used, obstacles they encountered and their methods for integrating technology in their individual classrooms through collaboration with me and the rest of the cohort. At the last face-to-face workshop, all participants shared a lesson they had implemented, reflecting on what worked and where they had difficulties. The other participants and I then provided feedback and suggestions.

I created the online components using activities and course content from Key Curriculum's online database of *Sketchpad* activities, *Sketchpad LessonLink*, and Key Curriculum's online courses. The online components of the professional development were 4-6 weeks in length and included:

- Specific learning videos that focused on teaching with *Sketchpad* and modeling *Sketchpad* skills.
- Learning and connecting specific CCSSM (NGACBP, 2010) content standards to the *Sketchpad* activities.
- Learning, practicing, and reflecting on pedagogical strategies for implementing *Sketchpad* into classroom instruction, with specific focus on the CCSMP.
- Learning, practicing, and implementing, in their individual classrooms, specific math content-related *Sketchpad* activities that also reinforced *Sketchpad* skills, focused on appropriate pedagogical strategies and fit specific content needs.

Participants' responsibilities for the online components included completing the assigned weekly activities focused on learning software skills, learning specific mathematical content, and learning pedagogical strategies for implementing the content into classroom instruction using the CCSMP (NGACBP, 2010) as a guiding structure. Activities included *Sketchpad* lessons, how-to videos, classroom teacher videos, lesson planning, and lesson implementation. Participants had assigned weekly discussion prompts, which required reflection on their learning of the software, pedagogical strategies, standards and practices, applications, and lesson implementation feedback and analysis. The online components were designed to allow participants time to continue to learn the software and practice using it in the classroom with their students. The online platform provided participants with the opportunity to reflect on their learning and their experiences implementing technology with their students and get feedback and support from colleagues and me.

The overall structure of the OPD was designed to improve participants' TPACK (Mishra & Koehler, 2006). Content and learning activities focused on using *Sketchpad* to teach the algebra and function standards and/or proportional reasoning standards, with emphasis on pedagogical strategies that incorporated the CCSMP (NGACBP, 2010). Learning was scaffolded over the seven-month period, with teachers learning both the software and the standards, practicing on their own and implementing lessons slowly into their classrooms. The end goal was for participating teachers to reach what Sandholz et al. (1996) describe as the *appropriation* and *invention stages,* where they create and design lessons aligned to content standards that integrate the software in their classrooms on a regular basis.

Researcher as Instrument

I was directly involved in all aspects of the hybrid OPD experience participants in this study engaged in prior to the study. I worked for Key Curriculum Press, the developers of *Sketchpad,* which the district leaders purchased. As part of my job, I was in charge of designing and implementing PD experiences for customers. At the time of the

OPD, I had 17 years of math teaching experience in middle and high school. I had been a math district administrator for 2 years prior to working for the company, and had been the director of math and technology professional development for the company for over 4 years. I also had been presenting PD workshops for over 15 years, focused on instructional practices and integrating technology into math practice. I had specifically taught and provided PD on the use of *Sketchpad* in mathematics instruction for over 15 years, even prior to my working for the company.

This background as both a math teacher and developer and provider of PD, specifically with the use of *Sketchpad*, provided me with expertise for designing the OPD experience participants were engaged in prior to this study. As described previously, I worked directly with district leaders to design the OPD. I personally facilitated all online and face-to-face components of the OPD, and over the seven months the OPD occurred, developed personal relationships with all seven participants in this study. These relationships were comfortable, with participants seeking my advice or suggestions on using *Sketchpad* during the OPD but also afterwards, usually via email. Participants in the study volunteered to participate in part because of their relationship with me and desire to support my study, as expressed in emails to me.

These personal relationships I had with the participants along with my belief in the power of *Sketchpad* as an instructional tool for mathematics had the potential to influence the findings in this study. The study did not presume to evaluate the effectiveness of the OPD, though there is the tacit assumption that the OPD itself was effective. It is possible that my bias towards using *Sketchpad* and my own belief that the OPD experience was effective could have impacted my assumptions and interpretations of this study's findings. Additionally, my personal relationship with participants might have made me overlook actions and decisions that may have been unfavorable to them. Realizing my assumptions and interpretations could be biased, I made every effort to be transparent in my data generation and analysis and use appropriate methods to ensure internal and external validity for this study. These methods are explained later in this chapter.

Data Generation Methods

Multiple sources of data for this study included classroom observations, face-to-face personal interviews, and written lesson plans. Data generation occurred over a three-month span of time in the spring semester of 2013. Patton (as cited in Merriam, 1998, p. 137) states that using a combination of observations, interviewing and document analysis provides opportunities to validate and cross-check findings. Triangulation is the use of multiple investigators, sources of data or methods to confirm studies emerging findings (Merriam, 1998), which in this study was operationalized through the use of multiple participants and data sources.

Observations. I observed each participant in the study twice over a three-month period during the 2013 spring school semester. Due to the requirements of the school district, observations had to be arranged in advance on a mutually agreeable date and time. Observations were set up ahead of time, based on the participants' schedules and my travel schedule. Participants were given a two-week window for each potential observation to occur, with the first observation window at the end of April and beginning of May and the second observation window at the end of May and beginning of June. Participants chose the dates and class times for the observations, with the understanding that I was coming to observe their use of *Sketchpad*, CCSSM and CCSMP. I sat in a location in each classroom that caused the least amount of disruption to the classroom environment, as chosen by each participant. For each observation, I kept field notes, using the Observation Protocol (Appendix B) as a guide. Using this protocol, I described the classroom activities, conversations and other pertinent information that provided insight into the teachers' instructional practices and technology integration during each observed classroom session. The observations lasted for the duration of each class, approximately 50 minutes for all participants with the exception of one participant, whose observations were approximately 15-20 minutes in length, as that was the amount of time relegated to him for his part in a co-teaching environment.

Due to the length of observations, all observations were video recorded to ensure I would not miss any teacher action or dialogue. The camera focused solely on the teachers and their instructional screen at the front of the class, as directed by the school district. Students were not filmed specifically, though some classroom desk arrangements made it impossible to avoid having the backs or sides of students in the video. During observations, I used the Observation Protocol (Appendix B) to note specific teacher actions as well as other classroom structures. The recording and detailed notes taken during the classroom observation helped provide me with a rich depiction of what occurred and what was said during the lesson. The field notes documented details of the physical environment, interactions and behaviors within it, and my own responses to the events observed (Birks & Mills, 2011). I later viewed, transcribed and coded videos of each, looking for themes and patterns. Coding is defined by Merriam (1998) as the assigning of short-hand designations to the data in order to identify themes and patterns of incidents so they can be retrieved later and interpreted. Only the teachers' actions and dialogue were transcribed and coded, as the focus of this study was on teachers' instructional decisions and actions, though student responses and actions were noted when relevant. I also coded the Observation Protocol data and compared those codes with the observation video transcription coding to confirm emerging themes and patterns. Each participant's coded transcriptions were compared to each other to ensure a complete list of codes and confirm emerging patterns. Appendix E shows a sample portion from a coded observation transcript. Appendix F shows a sample of a coded Observation Protocol. Additional thoughts, questions and observations were recorded in my memo journal throughout the whole process.

Interviews. Post-observation interviews were conducted face-to-face with each participant in the study. These interviews occurred on the same day and immediately following the observation whenever possible. Participants were interviewed two times for a total of fourteen interviews. Each interview lasted anywhere from fifteen to twenty minutes, depending on the time each teacher had available before their next class. A semi-structured interview protocol (Appendix C) was used to ensure interviews focused on the research questions and to provide consistency across observations with each participant and participants as a whole. This allowed for comparison of each participant over time, and a cross-comparison of participants as a whole. Participants were provided with the interview protocol prior to the first interview so they would be aware of the guiding questions. The same interview protocol was used for all interviews. Interview responses were recorded by me during the interview and then, as soon as possible, all responses were typed and saved as a Word document. The main purpose of a research interview is to find out "what is in and on someone else's mind" (Patton, as cited in Merriam, 1998, p. 71). The semi-structured interview "allows the researcher to respond to the situation at hand, to the emerging worldview of the respondent, and to new ideas on the topic" (Merriam, 1998, p. 74). Follow-up questions, not part of the questions included in Appendix C, were asked, based upon participant interview answers, in order to clarify a response. For the purposes of this study, the interviews sought to uncover the instructional decisions that led to the actions observed, and why teachers made those decisions.

Personal interviews occurred directly following each classroom observation. Participants were interviewed two times for a total of fourteen interviews. Interview responses were recorded by me during the interview and then, as soon as possible, all responses were typed and saved as a Word document. Each interview was then analyzed and coded and then compared to other participant interviews to ensure a complete list of codes and themes and confirm emerging patterns. Memos of emerging patterns and observations were recorded in my journal during this whole process. Appendix G shows a sample from a coded interview.

To ensure that my interpretations of participants' interview responses were representative, a follow-up interview summary was sent to each participant after all observations and interviews were completed and analyzed, as a means of doing member-checking. Member-checking is when the researcher returns their analysis to participants for them to check and comment on in order to validate interpretations and conclusions (Merriam, 1998). Member-checking occurred throughout this study and is detailed later in this chapter. In some cases, it may be necessary to modify interviews and/or conduct additional interviews with certain participants in order to clarify or confirm apparent categories that seem to be developing (Birks & Mills, 2011). For this study, no interviews were modified and there were no additional interviews conducted.

Lesson plans. Teacher-created lesson plans were the third type of participant-generated data. Each participant contributed one to two written lesson plans during the study. These lesson plans described a technology-integrated lesson that incorporated *Sketchpad,* CCSSM and the CCSMP (NGACBP, 2010), and were lessons different than those documented during the classroom observations. Combined with the observation and interview data, the lesson plans provided a more complete picture of what, if anything, teachers implemented that was informed by the content and experiences from the OPD in which they participated.

Teachers in the school district followed a common lesson plan format that included four component parts: launch, explore, summarize and apply. The protocol promoted the use of inquiry and hands-on learning. This lesson plan template can be found in Appendix D. Participants were encouraged, but not required, to use this lesson plan template for the lessons they contributed to the study. The district's math leaders informed participants that these lesson plans would become part of the district-wide resource bank of approved lesson plans for integrating *Sketchpad* and CCSSM, so participants had an incentive to create these lessons to support district initiatives. These lesson plans are considered elicited texts by Birks & Mills (2011) since "they are produced by the participants at the request of the researcher" (p. 82).

Each participant was encouraged to contribute two lesson plans that demonstrated their planning for integration of *Sketchpad*, the CCSSM, and CSMP, in their classroom instruction. There were a total of thirteen lesson plans submitted, two from six of the participants and one from the seventh participant. All lesson plans were coded and compared to identify themes and emerging patterns, looking for evidence that participants were planning for Sketchpad integration that supported the CCSSM and planning for appropriate CCSMP. The lesson plans were then compared to the coded interviews and observations to note consistency among individual participants in their instructional decisions and practices and confirm emerging patterns across participants as a whole. Memos were recorded in my journal throughout this whole process. Appendix H shows a sample of a coded lesson plan.

Member checking. Taking the data and interpretations of the findings back to the participants and asking if conclusions were plausible is an important part of enhancing internal validity of a qualitative study (Merriam, 2008). All transcripts of observations and interviews were sent to participants for checking to ensure that my interpretations of their actions and words were accurate. At the conclusion of my analysis, I created a summary of each participant's instructional decisions and practices. This summary provided a written explanation of my findings using the semi-structured questions from Appendix C as the guiding format and incorporated my interpretations of their instructional decisions, practices and influences from all generated data. I sent the typed summary to each participant in the study via email, asking for them to read and email me comments or changes, in order to check the accuracy of my interpretations (Birks & Mills, 2011). Participants emailed me back confirming my summations and editing as they felt necessary. Any additions or changes were incorporated into the final summary for each participant. Only two participants added feedback to my summations. Appendix

K shows an excerpt from each of those participant's summaries and their member check response.

Data Analysis

Merriam (1998) argued that data collection and analysis is a simultaneous activity in qualitative research (p. 151). A constant comparative method of data analysis was used throughout this study, using a recursive process of generating and testing codes and categories, which is essential in grounded theory (Birks & Mills, 2011). Constant comparative methods are where analysis of observations, interviews, lesson plans, field notes, and memos are compared to previous ones, both within and across participants, constantly comparing interpretations, conclusions and developing initial codes and constantly refining those codes into patterns and themes. Memos were used throughout to document emerging categories. Intermediate coding was used to "make connections between and within categories" (p. 97). This involved analyzing the initial codes, comparing them, finding consistencies and connections, and grouping these initial codes into more cohesive and descriptive categories. The intermediate categories were further refined and grouped according to connections and similarities. The final grouping of categories led to identification of "explanatory, conceptual patterns" (p. 98), which were the four categories developed in this study that seek to explain the influences on teachers' instructional decisions around planning and practice around *Sketchpad* integration.

Data memos. Birks & Mills (2011) define memos as "records of thoughts, feelings, insights and ideas in relation to a research project" (p. 40). Memos allowed for the exploration and questioning of the interpretations I derived from the data. Memoing is a process that occurs throughout the study and leads to the refinement of categories, themes and ultimately the final overarching theory (Birks & Mills). I kept a journal of memos throughout my data generation, transcription and coding procedures, which provided a means of recording my thoughts related to the developing patterns and themes. Appendix I contains a sample memo early in the process of observations. I had observed several classrooms and noticed very minimalistic use of *Sketchpad*, which caused me to question what factors contributed to this limited implementation. Appendix J shows sample memos later in the process, after I had also analyzed some lesson plans. It shows my awareness of classroom structures and access to computers as possible influences on the teachers' instructional decisions and practices. Revisiting my memos enabled me to identify commonalities among participants and pose questions that guided me as I continued to compare and code. These memos served as a catalyst for determining if additional observations and interviews were needed to clarify or refine categories and themes. Memos also "served as a reference throughout" (Birks & Mills, 2011, p. 116) and by using memos to sort and compare categories, they aided in creating a "logical scheme that reflects the studied experience" (p. 116).

Coding and categorization. Following the suggested grounded theory methods outlined by Birks & Mills (2011), initial coding and categorization of generated texts occurred with the first observations and interviews (p. 9). The memos served as a record of my thinking as the research progressed, identifying categories, themes and clarifying thinking. Theoretical sampling—the process of strategically deciding what or who will provide the most information-rich source of data to address specific analysis needs (Birks & Mills, 2011, p. 11)—was used to determine which participants might need additional observations or interviews as the study progressed. An example for this decision might be based on the need to confirm a particular category that a participant has not exhibited compared to the others. Coding occurred throughout data analysis, beginning with initial coding and progressing to intermediate coding, suggested by Birks & Mills as a way to fully develop individual categories and to connect those categories together (p. 12). A core category – the central theme that connects all other categories – was defined once the coding seemed to link all the categories together with a cohesive overarching theme. This process focused additional data generation and analysis until theoretical saturation was reached (p. 115), meaning further data generation and analysis did not add additional themes or categories (Birks & Mills).

Initial Coding. Initial coding is the first step in grounded theory analysis (Birks & Mills, 2011). Using a constant comparative method of analyzing all the data, initial coding occurred by analyzing the observation transcripts, observation protocols, interviews and lesson plans. Coding was done by looking at teacher actions, words, and lesson plan content and assigning a code that seemed to identify what was happening. Glaser's three questions (as cited in Birks & Mills, 2011, p. 96) guided this initial coding: 1) what is the data a study of; 2) what category does this incident indicate; and 3) what is actually happening in the data? Transcriptions of classroom observations, written records of interviews, and the written lesson plans were examined line by line or paragraph by paragraph, as appropriate, to identify codes. Data were constantly compared both among individual participant documents and between participants and examined several times to identify codes. Memoing occurred during this process of constantly comparing the data so I could keep track of any emerging patterns and commonalities. Initial coding continued until the coding categories seemed repetitive and exhaustive. In the end, I identified thirty-seven codes organized around three main categories: 1) instructional decisions; 2) technology strategies; and 3) other influences (Appendix L).

When I first started coding the data after my first few observations and interviews, I used short-hand coding and related it back to TPACK and the CCSMP. I used codes such as TCK to represent technology content knowledge, or PK to represent pedagogical knowledge or SMP to represent pedagogical practices aligned to the CCSMP. I realized this approach was too limiting in my coding, so I went back again to my data and became more descriptive in my coding and in what I was observing or noting in regards to my impression of each participant's actions and words. Figure 1 is an excerpt from an observation protocol coding where you can see my initial coding and then my more descriptive coding.

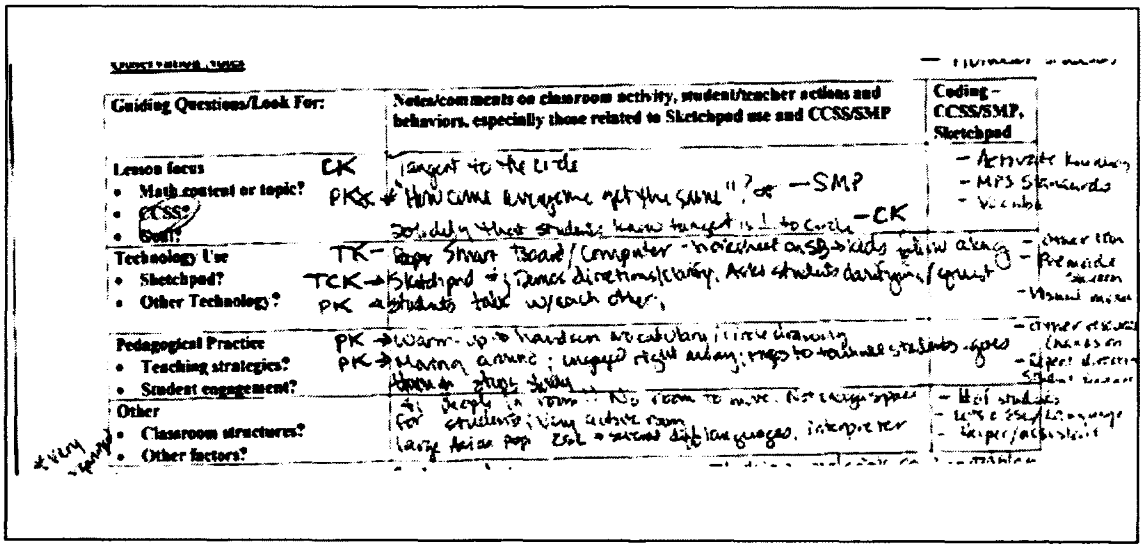
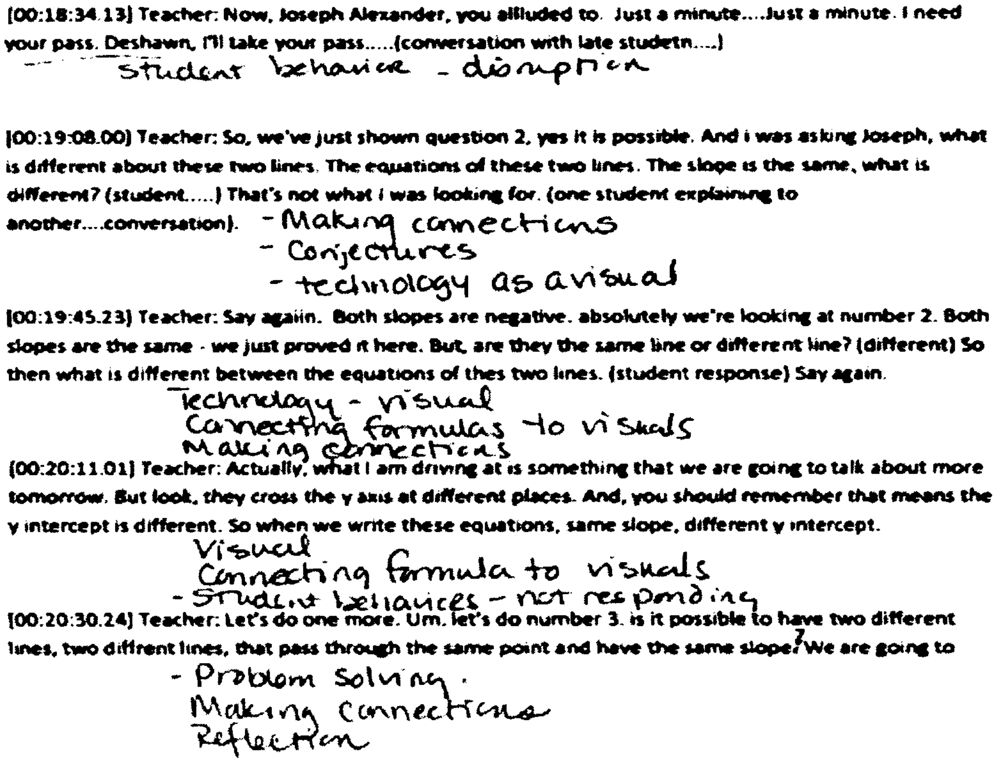


Figure 1. Sample from observation protocol coding.

I realized I was using different wording in my coding to represent the same idea (for example, making conjectures vs. students conjecturing), so I made a conscious effort to keep my coding consistent. As I gathered more data, the consistent coding made it easier for me to identify the common themes. Figure 2 shows a sample from an observation transcript where you can see the consistency in the coding emerging.



(00:18:34.13) Teacher: Now, Joseph Alezander, you allluded to. Just a minute....Just a minute. I need your pass. Deshawn, I'll take your pass.....(conversation with late studetn....)

Student behavior - disruption

(00:19:08.00) Teacher: So, we've just shown question 2, yes it is possible. And i was asking Joseph, what is different about these two lines. The equations of these two lines. The slope is the same, what is different? (student.....) That's not what I was looking for. (one student explaining to another....conversation).

- Making connections
- Conjectures
- technology as a visual

(00:19:45.23) Teacher: Say agaiin. Both slopes are negative. absolutely we're looking at number 2. Both slopes are the same - we just proved it here. But, are they the same line or different line? (different) So then what is different between the equations of thes two lines. (student response) Say again.

Technology - visual
Connecting formulas to visuals
Making connections

(00:20:11.01) Teacher: Actually, what I am driving at is something that we are going to talk about more tomorrow. But look, they cross the y axis at different places. And, you should remember that means the y intercept is different. So when we write these equations, same slope, different y intercept.

Visual
Connecting formula to visuals
- Student behaviors - not responding

(00:20:30.24) Teacher: Let's do one more. Um, let's do number 3. is it possible to have two different lines, two diffrent lines, that pass through the same point and have the same slope? We are going to

- Problem solving.
Making connections
Reflection

Figure 2. Sample observation transcript initial coding.

The initial coding entailed looking at all the data sources several times to clarify the coding and ensure consistency of coding. I then listed all of the codes in an Excel spreadsheet and alphabetized them, combining those that still seemed repetitive or redundant, which resulted in thirty-seven codes. Next to each of the thirty-seven codes in my list, I marked what type of decision each represented, and came up with my initial three groupings: instructional decisions, technology decisions, and other influences. Codes grouped under instructional decisions impacted both how content was chosen and disseminated to students. Those grouped under technology strategies were directly related to how *Sketchpad* seemed to be utilized. The codes put under other influences were those that either seemed to be an outside influence or other technology besides *Sketchpad*. Appendix M shows the Excel spreadsheet categorizing my initial thirty-seven codes.

Intermediate Coding. The next phases in the coding process were to link together and integrate the categories by grouping the initial codes (Birks & Mills, 2011). I had already grouped them initially into three basic categories, but realized there were other possible connections between the thirty-seven codes. To help me identify connections between my categories and lead to the formation of a core category, I placed the thirty-seven codes on individual post-it notes. I then placed the post-it notes on my floor where I could easily move them to create a visual mapping of codes and groupings. I grouped the post-it notes according to similar purposes or patterns and placed the grouped post-its on individual sheets of paper that identified the unifying theme. Appendix N is a picture of the visual mapping on my floor.

Focusing on one of the unifying themes from this visual map will help illustrate my thinking related to the grouping of the codes. Appendix O shows one of these groupings of codes. The codes placed on this sheet all focused on decisions or actions related to student questioning, communication, and thinking. It made sense to group these codes together since they reflected the ways in which the participants were encouraging students to demonstrate understanding or work to learn the content. When trying to determine what the common theme was, I struggled a bit, at first calling it student questioning. Looking at these as a whole, there were more than just questioning strategies, so it made more sense to think of these as instructional strategies. All the codes in this grouping related to the teachers' PCK and the instructional strategies they utilized to support student learning and understanding. Continuing this process with all thirty-seven codes and groupings resulted in six sub-categories: 1) planning goals and activities; 2) instructional strategies; 3) reasons for using *Sketchpad;* 4) classroom management with technology; 5) other resources and technology; and 6) barriers to *Sketchpad* use (Appendix P).

The final steps in the intermediate coding process were to identify a core category that is connected by a set of related concepts (Birks & Mills, 2011). According to Birks & Mills, a core category is selected when "a researcher can trace connections between a frequently occurring variable and all other categories, sub-categories and their properties and dimensions" (p.100). Continuing the constant comparative method, keeping in mind the three questions that guided this study, the six sub-categories were refined into four connected categories that represented influences on teachers' instructional decisions (Appendix Q). When looking at the two sub-categories of instructional strategies and classroom management with technology, it made sense to combine these into a unifying category called teaching practices. All the codes from the two categories of instructional strategies and classroom management with technology reflected either participants' PCK or TPACK. A single category called teaching practices encompassed all the strategies participants used, with and without technology, to help students learn and understand the content. While it could be argued that some of the teaching strategies may have been a result of participation in the OPD, it could have also been from participants' own previous understanding of teaching strategies, so I didn't feel I could put any of these in the professional development category. Similarly, the sub-categories of other resources and technology and barriers to using *Sketchpad* were combined into one category, internal and external factors. All the codes within this category were factors that prevented participants from using *Sketchpad,* so it made sense to consolidate them into one unified category.

Theoretical Coding. The initial coding and intermediate coding resulted in the identification of the core category: influences on teachers' instructional decisions around planning and practice for *Sketchpad* integration. According to Birks & Mills (2011), the "core category is the hub of the developing theory" (p. 115). In revisiting the data on a regular basis, constantly comparing and clarifying coding and category development, I reached a point of theoretical saturation with the data. Theoretical saturation is when no new properties or codes can be added to the established categories (Birks & Mills, 2011). The four categories that emerged from my analysis provide the basis for a grounded theory to explain the influences on teachers' instructional decisions around planning and practice for the integration of *Sketchpad* in classroom instruction. I used the suggestion from Birks & Mills (2011) to diagram my findings as a means of conceptually mapping my analysis. My diagram and an explanation of my findings and detailed description of how the four categories connect and explain the core category are detailed in Chapter 4.

Establishing Credibility and Reliability

In order for research studies to contribute to understanding of practice or theory, they must be credible so that others have confidence in the results. The conclusions and insights from a study must "ring true to readers, educators, and other researchers" (Merriam, 1998, p. 199). Credibility is addressed through "careful attention to a study's conceptualization and the way in which the data were collected, analyzed, and interpreted, and the way in which the findings are presented" (p. 200). In the case of qualitative research, the credibility of the results is often challenged due to a smaller sample size, researcher presence and bias in both collecting and analyzing the data, and perceived lack of generalizability (Merriam, 1998). According to Merriam (1995), qualitative research is based on different assumptions regarding reality and therefore validity and reliability should be conceptualized in the paradigm in which the research is conducted. There are strategies that qualitative researchers can use to ensure validity and reliability, with the strategies used for this study outlined below.

This qualitative study used a grounded theory approach to explain influences on teachers instructional decisions related to technology integration after OPD. The data sources were the participants in this study, with data generation that included classroom observations, interviews and lesson plans. This study used Merriam's (1995) data analysis techniques to ensure credibility and reliability. These techniques are listed in Table 2 below and described in more detail in the subsequent text.

Table 2 – Methods to Ensure Credibility

Internal Validity – the extent to which the research findings match reality (Merriam, 1998)	**Consistency** - whether the results of a study are consistent with the data collected (Merriam, 1998)	**External Validity** – the extent to which the research findings can apply to other situations (Merriam, 1998)
• Triangulation	• Triangulation	• Thick description
• Member Checks	• Researcher's Position	• Multi-site designs
• Researcher's position	• Audit Trail	
• Engagement in the research situation		

Internal validity. Internal validity is concerned with how closely research findings capture reality (Merriam, 1998). Merriam (1995) defined reality in qualitative research as constantly changing, multi-dimensional and constructed by the circumstances and participants involved, resulting in many interpretations of reality. The interpretations of reality for this study came from what actually occurred in the teachers' classroom and their instructional decisions around technology integration. The instructional decisions were constructed and influenced by a variety of factors, which may or may not have included the prior professional development experience. In order to strengthen the internal validity of qualitative research, Merriam (1995) made several recommendations that I used in this study. These include: triangulation, member checks, researcher's position, and engagement in the research situation.

Triangulation. Denzin described triangulation as the use of multiple investigators, sources of data or methods to support the emerging findings (as cited in Merriam, 1998, p. 204). In this study, there were multiple participants, or sources of data, that generated multiple data types, which included classroom observations, interviews and lesson plans. In relation to this study, classroom observations were compared to interview responses and lesson plans, both individually and across participants, in order to identify similar patterns and emerging themes. Using triangulated data and constantly comparing this data helped to confirm that my interpretations of what was seen, heard, and read captured teachers' instructional decisions and behaviors and provided a rich depiction of what occurred in the classroom, supporting this study's internal validity.

Member checks. Throughout the study, after analysis from observations, interviews and lesson plans, I sent summaries of my interpretations and analysis to participants for them to check the plausibility of my interpretations (Merriam, 1998). Participants were invited to check, correct, and comment on my depictions of their actions, thoughts, and feelings to ensure my interpretations were consistent with their perspectives. This helped rule out misinterpretations of the meanings of what they said or did in the classroom to ensure a depiction of each participant's instructional decisions and practices that matched their own perceptions.

Researcher's position. Clearly describing my experiences, both in the previous professional development and during the study is an important component of internal validity. At the beginning of this chapter, I describe my involvement in the prior OPD as well as my role during the study, providing my assumptions, biases, and background. This background also provides an understanding of how my teaching experience, knowledge of *Sketchpad*, and understanding of TPACK impacted how I analyzed and interpreted the data (Merriam, 1998).

Engagement in the research situation. According to Merriam (1995), generating data over a long enough time frame will support an in-depth understanding of the phenomenon under study. This study took place over a three-month period of time with one or more observations, interviews and lesson plans analyzed for each participant in the study. There were approximately 14 hours spent observing participants in their classrooms and 5 hours spent interviewing participants during the course of the study. I was in participants' classrooms at several different points in time over the three months, at varying times during the day, and in many different types of classrooms, which supports an in-depth look at instructional decisions and practice related to technology integration.

Consistency. In other types of research, researchers strive for consistency – whether findings would be the same if the research were replicated with the same subjects or in a similar context (Krefting, 1991). In quantitative studies, reality is constructed and linked to the perspective of those in it, with the idea that there is one reality and studying it repeatedly will yield the same results (Merriam, 1998). Qualitative studies seek to understand the reality under study from the perspective of those in it (Merriam, 1995), and because of this subjective nature of reality, replicating a qualitative study will not yield the same results, but instead a different perspective and interpretation of the reality under study (Merriam). So, in qualitative research, the focus for consistency is not about replication, but rather that the results are consistent with the data. What is of importance in qualitative research is consistency of results; whether the results make sense, based on the data, and whether the findings are consistent and dependable. Lincoln & Guba define dependable findings as those where the methods used are identified, explained and supported throughout the study (as sited in Galafshani, 2003). In this study, the use of triangulation, researcher position and maintaining an audit trail were strategies used to ensure that results are consistent and dependable (Merriam, 1998).

Triangulation. Triangulation means comparing different kinds of data and using different kinds of data types, such as observations and interviews, to corroborate each other (Merriam, 1998). Using multiple data types of observations, interviews and lesson plans in this study helped to strengthen consistency of my interpretations and dependability of my findings (Merriam, 1995). Having multiple participants allowed me to compare across data types, using the same coding and memo process. I compared emerging themes and patterns from one participant's generated data to another to identify similarities and differences. I compared within each participant's generated data, looking at their observations, interviews and lesson plans, to confirm that my interpretations of each participant's decisions and practices were consistent across the data. This constant-comparative method across multiple data types provided consistency and grounded my findings in the data.

Researcher's position: Being open and descriptive about my assumptions, position and relationship to the participants and how the study was conducted is an important contribution to the study's consistency because it provides background on the context in which the study was done and helps to explain how and why I may have reached my interpretations. Earlier in this chapter, I outlined my background, role in both the previous OPD and the study, and relationship to participants in this study. This background on my position in relation to the study and participants demonstrates my best efforts in providing consistent and dependable findings that support the data (Merriam, 1995).

Audit trail. An audit trail is a detailed description of how data were generated, how categories were derived, and how decisions were made throughout the study (Merriam, 1998). The purpose of an audit trail is to provide a means for others to authenticate the findings of the study (Merriam). I described each step in the study, kept detailed field notes during observations and interviews, videotaped and transcribed observations and interviews, recorded all thoughts and ideas through memoing and journaling, and provided a detailed trail of what was done and what decisions were made throughout the study. By keeping track of my emerging ideas, the process by which I developed, organized, and synthesized my codes and emerging theory demonstrate ways I tried to ensure dependability. I do not plan to have an external audit performed on my study's results, as this is an unfunded dissertation research study and will not be used to determine large-scale changes in practice or policy.

External validity. The ability to apply findings and suggestions from one study to other contexts and settings is important because this is how study results can inform future actions. Qualitative studies' results are more challenging than quantitative studies to apply, since random selection of participants is rarely used, making generalization to a larger population difficult (Merriam, 1995). Because the goal of qualitative research is to understand a phenomenon in depth, what is learned in a particular situation can inform similar situations (Merriam, 1998). If someone is able to look at the findings of a qualitative study and take those findings and apply it to their own situation, then those results have been useful, or as Merriam (1995) described, have user generalizability. I attempted to increase the external validity of this study by using thick description and a multi-site design.

Thick description. According to Merriam (1995), thick description involves providing detailed and rich information and description about the phenomenon explored in order for readers to compare their own situations and determine if there is enough of a match so that the findings would be relevant. This means providing details about the participants and their backgrounds, physical settings and resources available during the study, and descriptive examples from the data to support my interpretations and findings. Readers can use these descriptions and details to determine if their own situations are similar, and if so, possibly use findings from this study to apply to their own situations. In this study, I have provided information and description on all the previous professional development participants experienced, and in Chapter 4, details on participants' backgrounds and teaching experiences, classroom settings and multiple examples from the data to support my findings. This thick description is grounded in field notes, transcripts of observations and interviews, journals and memos of my thoughts, and coding of data, decisions and interpretations of findings.

Multi-site designs. This study included seven different participants, teaching seven different grade levels and subject areas at six different school locations within the school district. These multi-site locations and multiple participants with differing backgrounds, experiences and classroom situations provided diverse examples of *Sketchpad* integration. The use of several sites allows for diversity of the phenomenon under study and thus provides the ability for the results to apply to a wider range of people or situations (Merriam, 1998). This was a deliberate convenience sample of participants that provided a variety of approaches and influences related to technology integration after a common professional development experience. A deliberate sample assumes that the participants chosen will provide the most insight and understanding to the study's purpose. In this study on *Sketchpad* integration in classrooms after OPD, participants were chosen because of their stated commitment to continued use of *Sketchpad,* different grade levels and teaching experiences, and willingness to allow me to come into their classrooms and observer their teaching.

Ethical Issues and Potential Risks

According to Merriam (1998), ethical dilemmas in qualitative research are likely to occur in both data collection and data analysis, due in large part to the researcher-participant relationship. I had a relationship with each of the participants in this study because I was the provider of the OPD experience, so there was the potential risk that my personal bias and feelings would impact the data generation and analysis. The use of triangulated data generation and analysis at different points, over a longer period of time, helped address this potential risk by providing multiple types and sources of data. The analysis of these multiple data sources helped generate the patterns and themes that supported the theory that developed.

Ethical issues around the observations and the interviews were few, as participants in the study knew when they were being observed ahead of time and had given informed consent with their signatures (Appendix A). The interviews followed the protocol (Appendix C), which was provided to them in advance, so participants were aware of the semi-structured questions. Member checking was used with participants to ensure that my interpretations of their instructional decisions and classroom practices were plausible and reflective of the participants' perceptions of what occurred.

Summary

This study used a grounded theory approach to explore the perceived influences on teachers' instructional decisions and classroom practice related to technology integration. The study focused on teachers' instructional decisions and practices around integration of *Sketchpad* in math classrooms in order to determine what influences, including the OPD experience they shared, impacted their actions and decisions. Data generation began approximately ten months after the OPD participation and occurred over a 3-month span of time. Seven teachers participated in this study. Data generation methods included classroom observations, personal interviews, lesson plans, field notes and memos. Constant-comparative methods of data analysis were used to identify categories and themes within varied data types from multiple data sources. Through initial coding, intermediate coding and theoretical coding, four categories emerged: teaching practices; professional development; and internal and external factors. These four categories support a grounded theory on the perceived influences on teachers' instructional decisions around planning and practice for technology integration in classroom instruction. Several strategies were used to ensure consistency, internal validity and external validity of this study. Strategies included multiple participants, triangulation, member checking, researcher position, and thick description. Chapter 4 details the findings of this study.

Chapter 4

Results

The purpose of this study was to better understand the perceived influences on the instructional decisions teachers make related to technology integration after participation in long-term technology professional development. The findings generated from the research design described in Chapter 3 are detailed in this chapter. The research followed a grounded theory approach using classroom observations, written lesson plans and personal interviews to develop a grounded understanding of how teachers integrate a specific technology after experiencing a seven-month, hybrid-format professional development experience. A deliberate convenience sample of seven teachers were observed and interviewed over a three-month span of time. The findings of this study have implications for researchers studying professional development and technology integration, as well as educational leaders planning for technology professional development.

Context

Hybrid Online Professional Development Experience. Participants in this study took part in one of two 7-month hybrid online technology professional development experiences in the 2011 – 2012 school year. Participation in the OPD experiences was voluntary and designed to support teachers' integration of *Sketchpad* and the CCSSM and CCSMP (NGACBP, 2010) into their mathematics instructional practice. The OPD experiences differed only in the specific content focus, with the high school cohort focusing on algebra content standards and the middle school cohort focusing on ratio and proportion content standards. All other aspects of the two OPD experiences were the same. The OPD consisted of monthly online modules to help participants learn *Sketchpad* software skills, specific math content standards from the CCSSM and the eight CCSMP, and pedagogical strategies focused on integrating *Sketchpad* and standards into mathematics instruction. Participants learned how to use the software to address specific math content standards and were provided with video tutorials, pre-made *Sketchpad* activities and teacher notes to learn and implement in their classrooms, and a reflection forum in which to share their learning and collaborate with peers. There were required forum postings each month wherein participants reflected on what they had learned and shared their personal classroom experiences when trying to implement *Sketchpad* activities. Each month participants were to practice and implement the skills and instructional strategies they learned in the online course in their respective classrooms. Participants were encouraged to use the pre-made content-focused *Sketchpad* activities and questioning and learning strategies emphasized in the CCSMP. A follow-up face-to-face session with me occurred each month. In the face-to-face workshops participants shared their implementation experiences, collaborated with others on lesson planning and strategies, learned additional software skills and focused on specific pedagogical strategies included in the CCSMP.

The OPD experience was designed according to research-recommended components: content-focused learning centered on what teachers were teaching in their classroom, hands-on learning, extended duration, collaboration, reflection, and sustained support over time. The goal of the OPD experience was for teachers to understand and be able to integrate *Sketchpad* into their math instruction appropriately to support the learning of math content leveraging the CCSMP. The Technology, Pedagogy and Content Knowledge (TPACK) construct was a guiding framework for the design of the OPD activities. The district leaders hoped that participants in this OPD would become leaders and mentors in the use of *Sketchpad* in the math classroom. There was the expectation that these teachers would share their *Sketchpad* lessons and instructional experiences using *Sketchpad* with other math teachers at their schools and in the district. This study did not attempt to evaluate the effectiveness of this OPD, but rather determine what influence, if any, the OPD had on teachers' technology integration.

Study Participants. There were a total of seven participants in this study. Participants came from a deliberate convenience sample from the two cohorts who participated in the OPD experience. There was one female and two males from the middle school cohort and one male and three females from the high school cohort. They represented different levels, in the grades that they taught, in their teaching experience and in how they implemented technology in their classrooms. All participants volunteered to be in the study and agreed to be observed, interviewed and to submit lesson plans to me as part of their participation. All participants worked in the same urban school district, with the middle school teachers working at three different middle schools and the high school teachers working at three different high schools within the district. Two of the high school participants worked in the same high school. Pseudonyms have been used to ensure participant confidentiality. Table 3 below provides an overview of the participants at the time of the study as a means of comparison, with more detailed descriptions of each participant provided afterwards.

Table 3 – Participant Comparison

Name	Gender	Grade Level Taught	Subjects Taught	Years Teaching at time of study
Adam	Male	Middle School – 6, 7	6th & 7th grade math	17
Brenda	Female	High School – 8, 9, 10	Algebra, Geometry Algebra 2	5
Connie	Female	High School – 9, 10	Algebra, Geometry, Algebra 2	23
Dave	Male	High School – 9-12	Special Education – co-teaches in Algebra	7
Eileen	Female	Middle School - 6	All subjects excluding science	14
Fia	Female	High School – 9 -12	Algebra & Transition College Math	6
Gordon	Male	Middle School – 5 - 8	Math, English and Special Education	7

Adam. Adam was in his 16th year of teaching during the OPD and finishing his 17th year of teaching at the time of this study. He was engaged in the OPD and made every effort to try the modeled activities with his students, though his online participation in the discussion forums was inconsistent. Adam attended all of the face-to-face PD workshops and contributed to the collaboration and sharing of experiences during these sessions. He had access to computers on a daily basis since his classes met in a computer lab, though about half of the computers were not working, so he often relied on students pairing or teaming at the computers. He did not have access to a SMART Board – an interactive white board projection screen - so relied on a computer and LCD projector for whole classroom instruction. Adam's class size averaged 25-28 students. Adam's classes were approximately 50 minutes in length.

Adam had established consistent classroom routines and his students were comfortable working in small groups and with various technologies in the room, as evidenced by their immediate use of calculators and computers as they walked in the room, without needing direction or support, and the collaboration and talking about mathematics in groups of 2-3 as soon as class began. There appeared to be a routine to the beginning of the class, with students working on start-up problems, often in collaboration with each other and using calculators or computers, while Adam took attendance, walked around and collected homework, and prepared students for the lesson. There was a great deal of differentiation in the classroom, with some students sent to computers to work on various technology programs based on their needs, while others were focused on the *Sketchpad* lessons I was observing. Adam employed whole-class demonstration and explanation activities, but used small groups at computers to actually work on the lessons. It seemed apparent that Adam's students had used *Sketchpad* frequently and were comfortable collaborating with each other and working together to solve problems due to their observed ease in opening the program at their individual computers and immediately following directions, sharing and talking about what they were seeing and learning while working with the *Sketchpad* activity. I often observed students standing up and explaining their answers and problem-solving processes to the rest of the class, using *Sketchpad* to justify their responses. Adam demonstrated pedagogical strategies that kept students on task and focused on the lesson by walking around the room, asking probing questions that helping students' think and test conjectures with *Sketchpad* without giving them the answers. It was evident that his students were used to this collaborative and technology-centered class structure by their willingness to share their ideas out loud with the class, ask questions of other students and the teacher, and get up in front of the class to demonstrate and support their answers.

Brenda. Brenda was a fourth year teacher at the time of the OPD and in her fifth year of teaching during the time of the study. She was engaged in the OPD experience, though not always consistent with her posting and participation in the online discussion forums. She did try to implement activities with her students during the course of the OPD, but, as a newer teacher, struggled with time and classroom management, which she noted in the online discussion forums. Brenda was present at all face-to-face PD sessions and actively engaged in the activities and discussions. Brenda often asked for support and suggestions from me and her colleagues during the face-to-face sessions to help with her time and management difficulties. Brenda's classes averaged from 25-30 students, with students at a variety of grade levels in one classroom. Brenda did not have access to computers for student use and relied on a presentation computer at the front of the room that was attached to the SMART Board, graphing calculators and the TI-Navigator System (an interactive classroom management system connected to the graphing calculators) for classroom instruction. Brenda taught classes that were approximately 50 minutes in length.

Brenda's classroom was arranged with students in rows. Due to the large number of students in Brenda's classroom, this seating arrangement appeared to be designed to fit all the students in the room more comfortably and to help control classroom behaviors. Students could not move about the room easily once they were seated and were evenly spaced about the room with their own graphing calculators already at their desks. During classroom observations, there was very little content-related collaboration or talking among students, though there was frequent non-content- related talking. Brenda used the TI-Navigator and graphing calculator system to help manage classroom behaviors. Students all had their own calculators, and she could get them to respond to a question using the TI-Navigator system quickly, and immediately post responses (in graphical form) on the SMART Board. The TI-Navigator system allowed Brenda to quickly use her presentation computer to visually see those students who had or had not responded and access an image of each student's calculator to observe their work. Brenda used the ability to use the TI-Navigator to monitor student engagement to refocus students on the lesson when they appeared to be distracted or when talking and disruptive behaviors occurred.

Brenda's students were not familiar with *Sketchpad*, as evidenced in the first observation where Brenda introduced the program to them, explaining what the program could do and that she would be trying to incorporate it into classroom instruction more. Brenda appeared unsure and uncomfortable using *Sketchpad*, especially in conjunction with the SMART Board. When students seemed to be losing attention, she reverted back to the TI-Navigator and calculators to have students respond to a question.

Connie. Connie was a math teacher with 22 years of experience at the time of the OPD and was in her 23rd year of teaching at the time of the study. Connie was present at all face-to-face PD workshops and actively engaged in learning of new skills, collaboration and discussions. Connie was less present in the online components of the OPD. Her participation in the online learning activities and discussion forums was sporadic, though when she did contribute her contributions to the discussions and activities were complete and provided supporting detail. She did not fully engage in the

OPD implementation requirements because her students did not have access to computers, but she did try several lessons with her students during the course of the OPD using her presentation computer and SMART Board. Connie's classes were very large, averaging from 36-42 students in one class. The make-up of Connie's student population included a majority of second-language learners speaking multiple different languages. Connie was from another country herself and spoke a different language, so students from other countries were assigned to her class because she could communicate more effectively with them than other teachers in the school. This was evident in classroom observations when Connie spoke to students in a non-English language to help them understand directions or concepts. Connie did not have computers for her students and relied on her computer, SMART Board and graphing calculators for classroom instruction. Connie taught classes that were approximately 50 minutes in length.

Due to the large number of students who spoke many different languages, Connie spent a large proportion of class time trying to make sure students understood simple directions, often circulating around the room to ensure individual students understood by speaking to them in non-English language. The large number of students in the small classroom made movement very difficult and restricted. Things went slowly due to the language difficulties and Connie's attempt to keep everyone participating in the lesson. The students did work together, mainly because there were so many students huddled around each table. They had to share even simple resources, such as rulers and protractors, due to the limited number of resources in the classroom. It was clear Connie did not use *Sketchpad* with her students regularly, as she had to explain what it was during the first observation. Additionally, during both observations, Connie was unsure how to do basic steps using *Sketchpad* and expressed surprise at what happened on the screen when she moved something in the *Sketchpad* sketch. Connie demonstrated her preference for using the SMART Board over *Sketchpad* by frequently reverting back to SMART Board tools in the midst of using a *Sketchpad* activity, even when the *Sketchpad* activity was more applicable to the math content being taught. When students became disengaged in the lesson and Connie had to repeat directions, she used the SMART Board over *Sketchpad* to demonstrate and regain control.

Dave. As a special education teacher, Dave taught students in grades 9-12. He was in a co-teaching situation where he supported the algebra teacher in the regular classroom with special education students. Dave also taught self-contained special education classes, but did not use *Sketchpad* in those situations. For the purposes of this study, only Dave's co-teaching classes were observed. During the OPD, Dave was in his 6th year of teaching, and during the study was completing his 7th year of teaching. Dave was an active participant during the OPD, contributing to all the components of the online course and attending all of the face-to-face sessions. Dave had more difficulty implementing the *Sketchpad* activities in the classroom due to his co-teaching situation, but tried to do so as much as possible during the OPD so that he could share his experiences in the online discussion forums. Dave did not have access to computers for his students and relied on a presentation computer, SMART Board, graphing calculators, and an interactive student response clicker system for classroom instruction. Due to the structure of his co-teaching classroom, Dave's instructional time was relegated to the first 15-20 minutes of each class. During that time he led the class warm-up and review.

Dave's algebra classes averaged 25-30 students and were approximately 50 minutes in length.

Dave's classes had a definite routine in place for the beginning of class, which was the part that he facilitated. Students came in and chose a calculator and clicker, logged in to the clicker system, and began to work on the first question that was displayed on the SMART Board. There was a significant amount of talking, questioning and lag time due to the large class size and students not getting on task quickly, despite the known routine. There was also a student assistant in the room, along with Dave's co-teacher, and it took all three to get everyone on task. The students were very familiar with using the graphing calculators and the clicker system, both of which were used throughout the lesson to encourage students to remain focused on the questions Dave was displaying. The clicker system allowed Dave to monitor who was in the class and who had answered questions. The ability to monitor student progress with the clicker system helped Dave with the pacing of the questions, management of classroom behavior to some extent, and allowed him to address specific students who were not fully engaged. Dave's use of *Sketchpad* was intermittent and minimal throughout his warm-up questions, with just screen shots of math content visuals used to ask questions of the students. He did not utilize any of the dynamic features of *Sketchpad.* The calculators and student clicker systems seemed to be the technology of choice because they were accessible to students and helped to manage behaviors and engagement.

Eileen. Eileen was a middle school teacher of 6th grade students and had been teaching 13 years at the time of the OPD and was completing her 14th year of teaching during the time of the study. Eileen taught in a self-contained classroom of approximately

30 sixth grade students, where she taught all subjects except science. Eileen was one of the most active participants in the OPD course, regularly exceeding the posting requirements and course expectations. She was present at every face-to-face session and made a concerted effort to implement the course components in her classroom on a regular basis. Eileen had access to laptops for her students on a daily basis, as well as a presentation computer attached to the SMART Board, graphing calculators and a TI Navigator System. Eileen's math instructional time varied, often going longer than the participants' average of 50 minutes. As a self-contained teacher with the same students all day, Eileen was able to structure her daily instructional schedule and extend the learning time devoted to particular subjects in order to complete the lesson.

In Eileen's classroom students were exposed to a number of different types of technology and hands-on learning tools such as 3-dimensional shapes and building cubes. Eileen had a very crowded classroom. Her students were accustomed to working together and collaborating on problem solving, as evidenced by their immediately focusing on solving a problem in pairs as soon as Eileen gave the directive. Eileen was able to integrate all her different technologies into the observed lessons, going from a hands-on activity, to having students look at *Sketchpad* examples on the SMART Board, to then using the TI-Navigator and graphing calculators to elicit feedback on student understanding. Eileen's students worked with *Sketchpad* regularly on their own personal laptops, as evidenced by their ability to quickly open activities and follow the steps in the directions and test their conjectures. Students could use whatever resources and tools best helped them reach a solution and explain their answers, moving from the calculators to the hands-on resources to computers very quickly. They were able to explain their problem solving to others in the classroom and appeared confident about justifying their solutions and collaborating with each other. As students worked in pairs or in small groups, Eileen walked around, asking questions or supporting students.

Fia. Fia was a career switcher; she entered teaching following a career outside of education. She was teaching while also taking education classes to earn her teaching certification. Fia had previously worked in the business profession for 18 years and came to the district through a Teaching Fellows program. At the time of the OPD, Fia was in her 4th year of teaching and was teaching algebra and college math to low performing students in a large high school in the district. She was completing her 5th year of teaching the same subjects during the time of the study. Fia was engaged in most of the online components of the OPD, particularly the discussion forums and learning of the CCSMP. She was present at all the face-to-face sessions and actively engaged in collaboration and group discussion related to standards and pedagogy. She struggled with the implementation aspect of the OPD because she did not have access to student computers in her classroom and because of student behaviors, as stated in discussion forums, but did make the effort to practice and learn on her own during the OPD. Fia's class sizes were large, averaging 25-30 students. She did not have access to a computer lab and relied on a presentation computer at the front of the room connected to a SMART Board, and graphing calculators for each student. Fia's classes were approximately 50 minutes in length.

Fia's classes were large and loud, with frequent student outbursts and discipline issues, such as students speaking out, walking in and out of the classroom, and disrupting the instruction. Fia had some management techniques she used and was consistent with, but students appeared to be deliberately disruptive throughout the observed classes with repeated loud noises, loud talking and refusal to follow Fia's directives. Fia was comfortable with the SMART Board and the graphing calculators as her main technology resources, rather than with using *Sketchpad,* as evidenced by her switching back to those tools when students were misbehaving. Each student had a calculator, so Fia often used calculator activities to engage students. Because each student had their own calculator they could directly access and stay involved in the lesson.

Students were not familiar with *Sketchpad,* which was evident when Fia explained what the program was in the first observation. Students asked her what the sketch was on the SMART Board, and Fia explained the program and that it would help them see the math more clearly, stating that this was something she hoped to start using with them. As she herself was not comfortable using *Sketchpad* with her students, which she stated in her interview responses, she would revert back to using the SMART Board tools in the midst of a *Sketchpad* activity, especially when students seemed to get disruptive or seemed to disconnect from the lesson. At one point in an observation, when Fia allowed a few students to come up to the front of the room and move components of a *Sketchpad* sketch on the SMART Board, the class as a whole became much more engaged in the lesson. But, after a few minutes, when other students in the class became disruptive, Fia sent students at the SMART Board back to their desks, had all students pick up their calculators, and switched out of *Sketchpad* and back to the SMART Board tools. Fia's students had access to graphing calculators, providing a quick, hands-on way, along with SMART Board calculator tools, for Fia to reengage everyone, address disruptive behaviors and focus students back on the lesson.

Gordon. After spending 20 years in the Army, Gordon returned to school to become an educator. Teaching since 2006, Gordon was a middle school teacher with a Special Education endorsement. At the time of the OPD, Gordon was in his 5th year of teaching and during the study he was completing his 6^{th} year of teaching. He worked with 5^{th} through 8^{th} grade students who have special needs in academics as well as behavioral issues. Gordon actively engaged in all aspects of the OPD experience, including both the online components and the face-to-face sessions. He was very active in the online discussion forums and put a lot of effort into using *Sketchpad* with his students on a regular basis during the seven-month OPD experience, as evidenced in his forum postings and lesson reflections. Gordon had access to a computer lab, which allowed his students hands-on access to computers two to three times per week. He did not have access to a SMART Board, but utilized a presentation computer at the front of the classroom attached to a LCD Projector system for classroom instruction. Due to the nature of Gordon's students and their academic and social needs, his class size was small, averaging 10-12 students. Gordon's classes were approximately 50 minutes in length.

Gordon's students were very familiar with *Sketchpad,* as they were able to quickly work with the activities and manipulate and add components to the sketches. Gordon's class was small but very active and loud. He had low-performing students with often very severe discipline and behavior issues, so there was a considerable amount of talking and disruption, though more often than not, the disruption was due to being excited about something they had just done or discovered in the *Sketchpad* lesson. Gordon spent considerable time walking around the computer lab redirecting students, going over directions and helping keep students focused on the task at hand. He would often use his LCD projector to bring the students back together to emphasize a point and refocus them on the learning goals and questions. He spent a lot of time questioning students, expecting them to explain what they were doing and how they arrived at problem solutions. He used collaboration in his class, so students were used to working together, and it seemed that having them work together was part of behavioral learning as much as mathematical learning, as evidenced by Gordon's verbal emphasis on appropriate collaboration behaviors and praise when students demonstrated those behaviors. Gordon stated in his interviews that he used *Sketchpad* regularly with his students, which was apparent when students were able to quickly open *Sketchpad* on their computers and work with the sketches using several advanced features of the program.

This overview on participants' backgrounds and classroom atmosphere will help guide understanding of the findings of this study. In the next section of this chapter, I detail the findings from this study, using excerpts from observation transcripts, interviews and lesson plans to exemplify and support my interpretations and theory development.

Findings

The intention of this study was to explore the teachers' perceptions about the influences on their instructional decisions and practices for implementing *Sketchpad* into their classroom after participation in a long-term technology OPD. My study sought to provide insight into how the OPD experiences influenced, if at all, instructional decisions related to technology integration after OPD. This included exploring instructional decisions on both planning for and implementation of technology into classroom practice, why teachers made those decisions, and what other factors influenced those decisions. The guiding questions for this study were:

1) How, if at all, did experiences in a TPACK-based OPD influence participants' instructional decisions when planning for technology-integrated lessons using *Sketchpad*?

2) How, if at all, did the participants draw on their experiences from OPD about integrating *Sketchpad* software in mathematics classroom instruction after participating in a seven-month hybrid online professional development program?

3) What, if any, other factors influenced teachers' instructional decisions regarding their integration of *Sketchpad* that are not related to the OPD experience?

To explore the four major perceived influences on teachers' instructional decisions identified in this study, I have organized my findings into three main foci: the influences on teachers' instructional decisions when planning for technology-focused lessons using *Sketchpad*, the influences on teachers' instructional decisions when implementing technology-focused lessons using *Sketchpad*, and other influences impacting their instructional decisions around *Sketchpad* integration.

Planning for technology-focused lessons with *Sketchpad*. A significant part of the OPD experience focused on finding and planning for content-related *Sketchpad* activities that would support the learning of specific CCSSM. Analysis of the generated data revealed three influences on participants' planning for *Sketchpad* integration: curriculum and district expectations, professional development, and teaching practices. Teachers used their curriculum and district expectations to guide the lesson topic. This lesson topic then guided the choice of *Sketchpad* activity and the teaching practices that would then be used to teach the content. These three influences worked together to inform the resulting lesson plan.

Curriculum and district expectations. The participants understood that the district leaders expected them to adhere to the district curriculum as evidenced by the written curriculum guides all participants had on their desks and stated by participants in their interviews. CCSSM, district mandated standards and pacing guides were the driving force behind the instructional focus of all submitted lesson plans. The content for lessons was chosen based on where teachers were in the prescribed math curriculum and pacing guide. Participants demonstrated both CK and TCK through their choice of specific CCSSM and aligned *Sketchpad* activities found in the *Sketchpad LessonLink* (Key Curriculum Press, 2008) online resource bank of content-focused *Sketchpad* activities. In written lesson plans, pacing and standards were listed by CCSSM number at the beginning of each written plan and the specific, named *Sketchpad* activity(ies) were identified. Figure 3 is an example from one of Fia's lesson plans, showing the specific Chapter and lesson number from the district pacing guide (Lesson 4.1), the specific Common Core (F-IF.4) standard that supported the lesson focus and the lesson name, identifying the specific *Sketchpad* activity she planned to use.

LESSON PLAN

Course: **Algebra** Teacher(s): **Fia**

Chapter and Lesson **lesson 4.1** Lesson Name **How Slope is Measured** Date(s): ______

Common Core Math Standard (s): **Functions - Interpreting Functions (F-IF.4)**

4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship.

Materials to be used, including technology: **Geometer's Sketchpad Lesson: How Slope Is Measured**

Assessments: **exit ticket**

Figure 3. Lesson plan excerpt showing content and standard

Participants demonstrated knowledge of the content and understanding of the specific CCSSM and chose appropriate content-related *Sketchpad* activities in their lesson planning. An example of this can be seen in Figure 4, which shows Eileen's planning for specific content and CCSSM, including the materials and *Sketchpad* activity she chose.

LESSON PLAN

Course: Math 6th grade Teacher(s): _____

Chapter and Lesson CMP2 6th grade Lesson Name 2.5 Naming Fractions Greater Than 1

Date(s): _____

Common Core Math Standard (s):

6.NS The Number System: Apply and extend previous understandings of numbers to the system of rational numbers

6. Understand a rational number as a point on the number line. Extend number line diagrams and coordinate axes familiar from previous grades to represent points on the line and in the plane with negative number coordinates.

Materials to be used, including technology: **Textbook, graph notebook and rulers, SMART Board, Sketchpad, TI-84 Sketchpad Lesson Link Mystery Fractions, Part 1, and Mystery Fractions Part 2, three 60-minute class periods, one additional 60-minute period for Sketchpad play.**

Assessments: **Unit Exam: CMP2 and TI-84 Fractions Exam, Classroom notebooks: notes, graphs and operations.**

Common Core Standards of Mathematical Practices – explain how these are addressed, if applicable

1. Make sense of problems and persevere in solving them: This problem might be one of the most difficult of the whole CMP2 series. It certainly requires connecting to the problem, visualizing it, and understanding the complex relationships among the fractional numbers involved to find the solution to the four different scenarios.
2. Reason abstractly and quantitatively:
3. Construct viable arguments and critique the reasoning of others: **Students need to collaborate and conjecture to solve this problem, as it is one of the most challenging ones in the whole series.**
4. Model with mathematics:
5. Use appropriate tools strategically:
6. Attend to precision: **Students need to sketch precise number lines, subdivided and labeled in precise ways to find the solutions graphically. They also need to verify their answers by setting up the problems and solving them through multi-step addition and subtractions operations.**
7. Look for and make use of structure:
8. Look for and express regularity in repeated reasoning: **Students use a number line to represent each of the scenarios presented in the problem. Once they figure out and quantify their displacements along the number line, they find a structure that, applied methodically, will walk them through the solutions to all five scenarios.**

Figure 4: Lesson plan exerpt showing content and CCSMP

In this example, the section where she details the CCSMP demonstrates Eileen's CK and TCK. She addressed and planned for potential student difficulty in learning the math concept and discusses how the use of the number lines in the *Sketchpad* activity will support student understanding. Eileen emphasized how she always tried to find an appropriate *Sketchpad* activity to support the concept to be learned, stating, "I look at what the topics are and always have *Sketchpad* in mind if it can deepen or visualize the learning. I always plan with *Sketchpad* in mind."

Like Eileen, Adam demonstrated how the curriculum and district expectations guided his choice of content-related *Sketchpad* activity from this excerpt from one of his lesson plans.

> I will be using the *Cell Phone* sketch activity. I choose this lesson because we're working on unit rate right now and in the previous unit we were working on function equations with tables and graphs. We also had discussions about analyzing graphs when students were finding slope from the graph. This sketch will help the lesson and be a benefit to my students because they can tie in what was previously taught in the last unit and apply their knowledge to what they're learning now. This fits Common Core Standard 6.RP.3: Use ration and rate reasoning to solve real-world and mathematical problems, e.g. by reasoning about tables of equivalent ratios.

Adam explained in his plan how the content drove his choice of activity and how that activity would help students make connections, as required in the standard he lists in his lesson. He used his CK when he discussed the how the different math concepts work together, and demonstrated TCK by his choice of activity that will provide his students opportunities to connect the different math concepts and apply this understanding to a real-world application of cell phone plans. Both Adam and Eileen used the content and district expectations to plan their activities, and demonstrated both CK and TCK in their choice of activities and plans for helping students use those activities to support student learning.

The CK demonstrated in the written lesson plans cannot necessarily be attributed to participants' experiences in OPD. All participants were trained math educators and assumed to have math CK. But, as the two previous excerpts' demonstrate, the OPD did influence the participants TCK through their choice of *Sketchpad* activities that aligned to the lesson plan focus. In the next section, further detail about the influence of the professional development on planning for *Sketchpad* integration is provided.

Professional development. The TCK developed in the OPD experience influenced the planning of *Sketchpad* integrated lessons, as evidenced by the activities used in classroom sessions I observed and in their lesson plans. Participants used pre-made *Sketchpad* activities emphasized in the OPD experience in all lesson plans and classroom observations, with the exception of Dave. Dave used screen shots from these *Sketchpad* activities, rather than the entire activity due to his unique co-teaching classroom structure. The specific pre-made activities, which included pre-made sketches, student worksheets with questions, and teacher notes, were chosen because of their fit to the content and their ability to help students understand the content, as indicated in participant interviews. Adam said, for example, "The *Sketchpad* activities fit perfectly with this Factoring Trinomials content and let me demonstrate for the students." According to Brenda, "the *Sketchpad* activity turned out to be a really good fit and I think worked great to help reinforce what they had learned and prepare them for solving with substitution that is coming up." Similarly, Fia said "I know that *Sketchpad* is engaging so I tried to find something pre-made that would work with the content I had to teach." Teachers demonstrated knowledge of what specific *Sketchpad* activities would best fit the content to be taught and provide a more meaningful way to teach that content.

This prior experience with and knowledge about *Sketchpad* activities from the OPD influenced participants' choice of activities and helped them find activities to fit their curriculum and current content focus. The following excerpts from different participants' interviews exemplify the influence from OPD experiences on planning for content-related activities. Brenda, when asked how the OPD influenced her lesson, stated:

> It's really helpful having the pre-made lessons and, when I have specific content areas I am planning to teach, knowing specific Sketchpad activities that will fit is something that the PD helps me plan for.

Similarly, Connie said, "The pre-made lessons from the PD help me get ideas on how to use *Sketchpad* with the content." Gordon stated that "I could use the pre-mades and they would fit nicely with the content I was teaching and the PD was helpful because it gave me activity suggestions." Adam, describing how often he did not have resources to support the curriculum and district expectations, said, "Well, actually, the *Sketchpad* classes and activities we used are the greatest help because there are a lot of things in our book that are not aligned to the standards. I operate according to our pacing guide." Participants' choice of activities was influenced by the content they were expected to teach. Having had the experience with many *Sketchpad* activities in the OPD and the ability to find content-related activities in *Sketchpad LessonLink*, participants were able to make appropriate instructional decisions on activities to integrate into their instruction. From my own knowledge of math content and the specific *Sketchpad* activities, the activities chosen in all participants' written lesson plans were appropriate and supported the content focus of the lesson.

The one exception to the decision to use these pre-made *Sketchpad* activities was Dave. Due to his unique teaching situation as a Special Education teacher co-teaching in a regular math classroom, Dave's responsibilities in the class were relegated to the beginning class warm-up and review. His use of *Sketchpad* was limited to screen shots. While Dave did say his technology content knowledge around *Sketchpad* was part of his planning process, his focus was "on how you could take something, like a pre-made sketch or idea, and make it your own." He "really wanted to use *Sketchpad* to specifically be able to show visuals for the clicker part of the lesson warm-up and reviews." Some of his visuals were from pre-made sketches that he simply copied as a picture, but he did not use the pre-made activities in their entirety as the other participants did.

Even though Dave only used *Sketchpad* as screen shots to provide visuals of content, like the other participants in the study, *Sketchpad* was part of his instructional decisions when planning. In their planning process, all participants in the study demonstrated an understanding of how *Sketchpad* could be used to support the learning of the content and how to integrate it into their instruction appropriately to teach that content. This technological pedagogical content knowledge (TPACK) was a key component of the OPD participants experienced. Reasons for using *Sketchpad* varied, but all participants emphasized its ability to help students visualize the content and provide multiple approaches and representations of the content to help students deepen their understanding. Figure 5 shows an excerpt from a lesson plan demonstrating how the use of a pre-made *Sketchpad* activity will help students visualize the content, make connections and then apply what they have learned. The teacher used her TPACK to plan an appropriate technology-integrated lesson to teach the specific math content using several instructional strategies.

LESSON PLAN:
Launch Open Balancing.gsp and open page "Balance." Enlarge the document window so it fills most of the screen. Explain, ***Today you're going to use a Sketchpad balance to model solving equations. Have you ever seen a balance like this one? How does it work?*** Let students share their understanding of balances. **Explore:** show the students how the balance works by keeping the balanced "balanced" and moving the weights to do so. Use it to show an equation by moving the necessary parts on each side to keep it balanced. Go over a few that they create and have them come up to the board as well. As they are using the balance, be sure to introduce the notation as well for solving. Put up a few to have them solve using the notation. **Summarize:** Have students talk about the different methods of solving (undo table as well) to see the connections. Make sure all questions are asked. **Apply:** Give 5 problems similar to today's work to see how the students are doing on it. Continue work with it tomorrow (include exit ticket then)

Figure 5. Lesson plan exerpt showing pre-made and TPACK.

In the launch section of the plan, the teacher has identified the pre-made Sketchpad activity (Balancing.gsp) and included questioning and pedagogical strategies to illicit students' responses and assesses their understanding. Using the sketch, she has planned for ways to help students use the technology to visualize and make connections between actual balances and the math concept of balancing equations. She planned for different pedagogical methods to integrate the technology with the content, using whole-class demonstration, students working on their own examples at the presentation computer, and student collaboration as they reflect on their understanding. This lesson demonstrates how, by using the pre-made *Sketchpad* activities, the teacher planned to use her TPACK to create instructional experiences that used the technology to support learning of content. The teaching practices demonstrated in this example are influenced by the pre-made activities chosen and instructional decisions on how best to use the pre-made activity to support student learning of the content. These chosen *Sketchpad* activities influenced how they integrated *Sketchpad* into classroom practice, often using the teaching notes and modeling they had experienced in the OPD to guide their teaching practices.

Teaching practices. As mentioned in the previous section, the teaching practices that teachers planned for in their *Sketchpad* lessons were influenced by their content focus and their choice of activity. In the written lesson plans, there was evidence from all participants of planning for specific instructional strategies focused on questioning skills that would help students develop their own understandings of the content. In the OPD experience, pedagogical content strategies focused on the eight CCSMP were emphasized, particularly questioning students and having students make and test conjectures to develop their own understandings and connections rather than using direct teaching methods, which are methods where the teacher is directly defining or demonstrating the content and students are watching and listening. Modeling mathematics using *Sketchpad* was also a significant focus of the OPD experience, and was evident in lesson plans for all participants. Figure 6 is an excerpt from a lesson plan that exemplifies the planning for questioning and modeling, based on specific math content and a *Sketchpad* activity designed to support the learning of the chosen content.

EXPLORE (Making, Investigating, Finding . . .)	
Sketch and Investigate - student worksheet. **Discuss how students can measure the slope or steepness of a staircase.**	**1. What determines the steepness of the stair?** **2. What happens to rise over run is we switch A and B?** **3. Can you have a steep step on a staircase that isn't steep?** **4. Explain why the slope of a horizontal line is 0.** **5. Explain why the slope of a vertical line is undefined.**
SUMMARIZE (*Closing the Lesson,* Discussing, Writing)	
We have learned how to calculate slope based on the coordinates of 2 points. (show sketchpad) **We have learned the connection between slope and steepness of a line.**	
APPLY (Solving in a New Context)	
Geometer's Sketchpad: Slope Game - in pairs	**Next Day**

Figure 6. Lesson plan excerpt showing teaching practice.

Under the explore section of the lesson, the teacher planned to use the sketch and the student worksheet. She has planned some specific questions to help guide student thinking that incorporated making conjectures and justifying answers. In the summarize section, she planned to use whole-class demonstration and additional questioning to help students visualize what they were learning with *Sketchpad* and make connections to the math concept and visual representation. In her apply section, she planned to use another component of the *Sketchpad* sketch and pair students up to play a game. Using the sketch as a game, where students would demonstrate their understanding of slope and create visuals of different lines to challenge each other to find the different slopes, the teacher incorporated student collaboration and planned to assess student understanding of slope by walking around the room and monitoring student game results.

In the written lesson plans from participants, specific emphasis was given to having students reflect on the content they were learning in order to make connections on their own, use problem solving skills to make conjectures about the content, and justify and explain their answers. All participants specifically mentioned the CCSMP they would be focusing on in their written lesson plans as Figure 7 exemplifies.

Common Core Standards of Mathematical Practices – explain how these are addressed, if applicable

1. Make sense of problems and persevere in solving them:
2. Reason abstractly and quantitatively: **Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.**
3. Construct viable arguments and critique the reasoning of others:
4. Model with mathematics:
5. Use appropriate tools strategically:
6. Attend to precision:
7. Look for and make use of structure:
8. Look for and express regularity in repeated reasoning: **By paying attention to the calculation of slope as they repeatedly check whether points are on the line through (1, 2) with slope 3, students might abstract the equation $(y - 2)/(x - 1) = 3$. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.**

Figure 7. Lesson plan excerpt showing CCSMP.

In this example, the teacher has detailed the specific CCSMP she planned to address during the lesson, connecting the standard to the math content focus of her lesson. Participants may have included the CCSMP because the lesson plan template

(Appendix D) that most participants used to submit their lesson plans contained a section that specifically asked for CCSMP to be listed. However, in their interviews, many mentioned that they did plan specific questions that would address the CCSMP, in particular questions focused on conjecturing, justifying and making sense of problems.

The focus on questioning students and using the CCSMP throughout a lesson was also seen in other sections of the written lesson plans. Figure 8 shows an excerpt from one of Eileen's lesson plans, exemplifying this planning for teaching practices that incorporate CCSMP throughout the lesson, rather than just listing the practices in the specified section of the template.

LAUNCH (Introducing)	
Real-case scenario. Students are participated of a summer cleaning project of Jackson Park, located three miles south of our school. We talk about how we will divide the group in teams to cover the maximum surface of the park, in our field trips time frame. When students are all excited, you take them to 10-mile highway stretch that will be cleaned by Johnson School. Based on the differences between Greenfield and Johnson Schools cleaning projects, we decide that we will solve Johnson School's program with a number line. We also decide that we will carefully plan our summer field to allow some time to picnic and play :)	6 Attend to precision. Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning.
EXPLORE (Making. Investigating. Finding . . .)	
Students explore the application of the number line to solve math problems by solving problem one. Their findings and methods will be the clue to solve the remaining four, more challenging problems. Students really need to cooperate in their small groups to be able to find a general strategy that can be applied to the rest of the problems, by slightly modifying their fractional reference points: different wholes, different starting points, different sizes of the parts, etc.	They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other.

Figure 8. Lesson plan excerpt showing TPACK.

In the side margins next to both the launch and explore, Eileen has emphasized specific CCSMP teaching practices she will have her students engage in during the lesson. She mentioned precision, communication, justifying their answers and collaboration with others. Eileen has planned to use the practices to elicit specific responses from students, planning for what students will be doing in the left column and what the expected learning goal outcome is in the right column.

A similar excerpt from one of Fia's lesson plans shows her plan to incorporate both questioning and student collaboration and justification of their thinking using *Sketchpad.* Figure 9 is an excerpt from one of Fia's written lesson plans that indicates her plan to incorporate CCSMP questioning and justification strategies.

Launch
Students write in their journal explaining the sneaky squares method: draw a diagram and find the area of each inner rectangle.
Explore
How can you use algebra tiles to multiply $(x+2)^2$? Demonstrate how to move the tiles using sketchpad. Provide students with a set of algebra tiles to use as an area model for multiplying two binomials. Have students work in teams to investigate how to square a binomial and factor perfect-square expressions using rectangle area models. Have students write an equation showing the product of the two binomials and the equivalent polynomial in general form. Students demonstrate and explain their answers on the Smartboard using Sketchpad

Figure 9. Lesson plan excerpt showing CCSMP and PCK.

In the launch, Fia planned for students to explain their understanding of finding area using what they learned from the *Sketchpad* sketch, Sneaky Squares, explaining their understanding and justifying how the method works to reach their solution. In the Explore section, she planned for CCSMP teaching practices. This includes using models (algebra tiles), having students collaborate and communicate their problem solving methods, and make connections by writing equations to match the visual models. She then planned for students to justify their solutions, incorporating modeling with the SMART Board and *Sketchpad*.

As Fia's lesson demonstrated, she planned to use *Sketchpad* to demonstrate the content and model the activities at the front of the room. All participants planned for this type of direct teaching with *Sketchpad* in their written lesson plans, using a whole class modeling approach at the front of the room to help students visualize the math content. Eileen stated she liked to demonstrate with *Sketchpad*, "since *Sketchpad* gives the measures and they change and I wanted them to see the measures and compare to their hands-on measurements and see the connections." Even Dave, in his limited use of *Sketchpad*, used it to help students connect and understand math concepts, saying, "I tend to use *Sketchpad* as a visual to help with those beginning review and warm-up questions."

In addition to this planning to use *Sketchpad* for whole-class demonstration and modeling, Adam, Eileen and Gordon planned for the use of hands-on technology learning with students. These participants had regular access to computers for students to work with the *Sketchpad* program and showed TPACK in their teaching practices in how they planned to structure the learning of content with the technology. Figure 10 is an excerpt from one of Gordon's lesson plans demonstrating his plan for whole-class demonstration as well as his plan for students to collaborate and work hands-on at computers.

Lesson
Lesson Activities:

Before:

1. First part will be done as 'whole group'. Tell students today you're going to move the point to locations on the grid that fit certain rules. Your challenge will be to describe and make sense of the rules. We'll do one together; the rest you'll do in pairs.Open Sketchpad Coordinate Patterns. Introduce the model by pressing the + and – buttons. After each press, ask students to describe how the point has moved. Continue to work through the Activity Notes.

During:

2. Hand out work sheets and assign each group to a computer. Give students ample time to complete their worksheets.
3. Walk around observe and give assistance as needed.
4. Bring students back together and let each pair explain how they solved their problems.

Figure 10. Lesson plan excerpt showing whole-class and hands-on.

Gordon, in his before description, used one of the techniques used in the OPD experience, modeling the *Sketchpad* activity with students first to help them understand how it works before they work with it themselves individually. In the during section of the lesson, Gordon planned for students to be in groups at computers, guided by the activity worksheet. He planned to support them at the computers as he walks around. Gordon concluded by bringing students back together, expecting students to explain and justify their solutions. Figure 11 shows similar planning for both whole-class and hands on from one of Adam's lesson plans.

Day One:

I will start out with the students in groups. Two of the three groups will be led by students, one group will be led by me and the third group will be a independent work group. We will rotate every 5 minutes. Group one will work with the Sketchpad going through the student notes portion. Group Two will be going over homework related to ratios. Group three will be working on and discussing unit rate by going over warmup problems related to that. Group four will work on material from the group they just left.

Day Two:

Whole group will discuss the cell phone plan that they looked at on the Sketchpad. Students will be given a prompt of how did the answer of $.40 per minute come about? They will be given 3 minutes to try and come up with a strategy. Not the answer because they know this. Different answers will be discussed. They then will be given a prompt of what from the graph, can you determine if there is a flat rate, constant rate of change, slope, and y-intercept. Also, how can this information help analyze the graph.

Figure 11. Excerpt from lesson plan showing whole-class and hands-on.

In this example, Adam planned for students to work in groups at various stations, which included a hands-on computer station with *Sketchpad.* All four stations helped students learn about ratios, using real-world math situations, problem-solving, and *Sketchpad.* The plan had students collaborating on solutions, communicating, and making conjectures. Adam then planned for whole-class demonstration and discussion to help students connect what they did on their own, justify their solutions, and make real world connections. He plannedfor ways to integrate technology, pedagogy, and content into his teaching practices to help students learn and understand the math.

The influences of curriculum and district expectations, professional development and teaching practices worked together to impact participants' instructional decisions when planning *Sketchpad* integrated lessons. In practice, as observed in participants' classrooms, these three influences on participants' instructional decisions continued to be evident. Often times, for some participants, what was observed differed from what was planned, particularly the teaching practices that were enacted in the classroom. The next section further details how these three influences manifested in classroom observations.

Implementing *Sketchpad* into classroom instruction. Similar to planning for *Sketchpad* integration, the influences on observed implementation of *Sketchpad* were: curriculum and district expectations, professional development, and teaching practices. Participants' classroom practices incorporated activities and strategies for integrating Sketchpad that they experienced in the OPD. Classroom integration of *Sketchpad* was influenced by the content of the lesson, the *Sketchpad* activity chosen to support the learning, and the teaching practices used. How each of these influences impacted participants' *Sketchpad* integration and instructional decisions in their classroom practices is detailed in the following sections.

Curriculum and district expectations. Just as the written lesson plan showed the influence of the curriculum pacing and district focus on CCSSM and content in planning, classroom observations also illustrated the importance of these expectations for the teachers. All participants began their classes with explanations to the students of the lesson focus, standards and learning objectives. Standards and content focus were displayed in all observed classrooms in a prominent area of the white board, on the chalkboard or on a bulletin board. This excerpt from one of Gordon's classroom observations exemplifies this focus at the start of class on content standards, goals and activities. As Gordon spoke, he was pointing to where the goals were listed on the board.

> So, this is what we're working on today. Can everybody see? Okay, this is what we're going to do. We're going to estimate the measurement of an angle. So, we have our learning objective, our strategy. How are we going to reach our

> instructional goal? We are going to reach those by using our *Geometers Sketchpad*, our student worksheets, which I will hand to you, and our prior knowledge, about, listen, and our prior knowledge about acute angles, obtuse angles, right angles, 180 degree angles.

Like Gordon, other participants began their classes stating standards and learning goals. Additionally, in the interviews participants identified CCSSM content standards and district pacing as the reasons they chose the lesson goals and the specific content-related activities, including the use of *Sketchpad.* Fia stated, for example, "The topic is slope, which is where we are in the pacing guide and curriculum." According to Connie, "The topic was tangent theorems because it was in the district curriculum, so I was going with the pacing." Eric was "following the curriculum and pacing, which was focused on point slope/slope intercept." Brenda "chose this topic because it's in the pacing guide and curriculum and is where we are right now in the lesson."

This content focus and participants' experiences with specific content-related activities during the OPD that supported student learning helped participants choose appropriate activities for their lessons. In many of the observed lessons, the *Sketchpad* activities used were directly from the OPD. These were activities participants had spent time learning and practicing, providing them with experience of how the activity could support the learning of specific math content. Participants stated in interviews that having had the experience with the activities themselves, when they reached that specific topic in their pacing, it triggered their memory and influenced their decision to integrate *Sketchpad* into the lesson.

This decision to use specific *Sketchpad* activities because of the content focus was most often revealed in interviews with participants; however, the following excerpt from Brenda's first classroom observation shows how the content focus influenced her decision to use a specific activity to visually show the math concept to students.

> [00:23:12.02] Teacher: Alright so we're going deal with systems of equations. We're going to use what is called Geometry's *Sketchpad* and this sketch because it shows what we are learning today. Uh, we are going to use it more and more. It has some cool simulations on it where I can show you guys how it works by, just kinda by pushing buttons. I've learned some of it. I am still learning a lot about what it can do.
>
> [00:24:01.27] Teacher: Here we are going to be looking at the lines. We can turn them on and off when we want to. We can find out intersection points from here. So that's going to be really helpful. Uh, depending on what we are using we can do different things with it. So this one we are going to be using systems of equations. But they have all different kinds where you can do all different activities with them, so it's pretty nice.
>
> [00:24:21.04] Teacher: There's actually somewhere. So this one here I'm going to show you guys, I'm gonna have you. We're going to kinda go through it together and work out together. There's ones where you can actually get a sheet

Brenda starts off, at the first time stamp, stating how the lesson content is the reason she chose the sketch. She continued to emphasize how it can support the learning of the content when she mentions how she will be able to do simulations, turn the lines on and off, and find intersection points, all of which are part of the learning of systems of equations. At the end of this excerpt, Brenda explained how she was going to work through the activity together with the students, but hinted at how there are other activities with students' worksheets they will use. The use of the pre-made activities and their supporting resources from the OPD influenced what students' and teachers actually did in observed classrooms.

Professional development. As Brenda hinted at in the above observation excerpt, participants and students could use the supporting resources provided with the *Sketchpad* activities as part of the instructional activities. Often times the chosen *Sketchpad* activities and their accompanying resources guided participants' instructional decisions and focused students on the activity through the use of student worksheets and teacher notes. All seven participants sited the pre-made content-focused technology activities from the OPD as the biggest influence from the OPD on their integration of *Sketchpad* into classroom instruction. This is exemplified in the following excerpt from one of Eileen's interviews:

> Sure - the specific lessons that help students with areas, like the Fractions or the Zooming Decimals. I want to use technology as much as I can so seeing how to use these with the kids is great. I have a whole library now of activities from the PD that I know are good.

Eileen emphasized both the importance of having experienced the activities herself first and having a library of pre-made activities she can use to support the teaching of math content with her students.

Classroom observations, with the exception of Dave's, confirmed the use of these pre-made *Sketchpad* activities. Participants used the sketch and often times the accompanying student worksheets, even in the classrooms that did not have individual computers for students to work on the program. The use of the pre-made *Sketchpad* activities was for various reasons, such as providing real-world applications, visuals, simulations and helping students make connections to abstract formulas or between different math concepts. Figure 12 is an excerpt from a classroom observation transcript showing some of the coding that supports these various uses.

[00:01:58.29] Teacher: Yea, let's do that. Cause I think you... i think your confusing two things. I, i....Well first of all, they say you can have a narrower box, does anybody disagree with that? i agree that you can have a narrow box. But I am not too sure about the reasoning, ok. So, show us a narrower box. I agree you can have a narrower box. TCK → using tech to justify answer and model; providing visual

[00:02:30.01] Teacher: You want to click here and here...I do agree. You can have a narrow box. But...let me ask a question while you do that, to the group. When you say have a shorter number line, are you meaning you just have a shorter scale, so instead of going by 10's you're going by ones? is that a narrow box?

Questioning; Making conjectures; make connections; reflect; testing conjecture

Student: I'm talking about...the range is smaller. you have to have a smaller range.

Figure 12. Observation transcript with coded uses of *Sketchpad*

In this section of the lesson, a group of students explained, using a pre-made *Sketchpad* activity on box and whisker plots, how the range changes the width of the plot. The teacher had the students model what they are explaining with *Sketchpad*, using it as a visual. Students also used the sketch to test their conjectures and make connections to the mathematical formula they calculated.

This ability to use *Sketchpad* activities to model multiple representations of math content and quickly demonstrate new approaches to solutions or test student conjectures, as experienced in the OPD, was another influence on participants' decisions to integrate *Sketchpad*. According to Gordon, "*Sketchpad* is a way to reach the students visually and quickly. Technology is a way to get them engaged." Eileen, who said she always had her students do things with concrete, hands-on materials first, could then have students "connect it to the *Sketchpad* models and activities and see it because it helps them understand things better." Even Dave, who did not use complete *Sketchpad* activities, found content-related activities from the OPD or from searching *Sketchpad LessonLink* , "that had good visuals already made." Dave used what we learned in the OPD about altering pre-made sketches to fit specific needs. He altered them in a way that allowed him to capture them as a screen shot for his purposes. According to Dave "I did like the focus in the PD on how you could take something, like a pre-made sketch or idea and make it your own."

No matter the reason for choosing the pre-made *Sketchpad* activities, the activities themselves offered direct suggestions for teaching practices and questioning. Along with the teacher notes on how to use the activities in the classroom with students, participants also used their own personal learning experiences with the activities to guide the teaching practices they used in class with students.

Teaching practices. The prior experiences with the pre-made *Sketchpad* activities in the OPD and the focus on how to use the activities with students impacted how participants used these activities in the classroom. The OPD focused on questioning, using the CCSMP foci. The pre-made activities included teacher notes and student worksheets, which provided questioning and pedagogical guidance along with specific content-related, inquiry type questions. Teaching practices, such as classroom management strategies or critical thinking questioning strategies when working with *Sketchpad,* were modeled during the OPD experience and seen in classroom observations.

Questioning techniques, particularly those focused on the CCSMP, were evident in classroom observations. It was unclear in some observations if the PCK demonstrated was influenced by the OPD experience. In a memo dated May 28, 2013, I questioned what I was seeing, asking, "Is this just good teaching or is it a result of knowing the CCSMP?" I did note that often questions came directly from the pre-made *Sketchpad* activities, stating on May 28, 2013, "Pre-made activities helped with questioning and guiding inquiry." Teacher notes from the pre-made activities offered guiding questions to support teachers' questioning practices and provided inquiry questions on student worksheets focused on making conjectures and justifying discoveries. Eileen said in one of her interviews:

> I liked the focus on good questioning and trying to get the students to focus on deepening their understanding. Getting them to explain their thinking and use the right vocabulary. *Sketchpad* activities help because it forces them to use the correct terminology.

Similarly, Adam stated:

> Before I assign problems I check through the activities on the S*ketchpad LessonLink* because this is the revelations or the end of what I what to get to. It is the questions from those lessons that drive a lot of what activities I do in the class. There are great questions from the *Sketchpad* activities aside from the *Sketchpad* visual. I like looking at those questions and then designing activities around that.

PCK was more apparent in the classrooms where participants regularly used *Sketchpad* with their students. These participants incorporated more of the CCSMP type questioning than those participants who used *Sketchpad* infrequently.

Some participants who did not use *Sketchpad* regularly relied on the questioning support from the pre-made *Sketchpad* activities as a tool to their integration of *Sketchpad*. According to Fia, "Using the pre-made activity is great because it was all right there. I haven't used *Sketchpad* much so this was a good way to start off with something already done and questions there as well." Similarly, Connie said, "The pre-made sketches and worksheets are really helpful because it has the questions there to help them make connections." However, despite often using the pre-made activities to guide their questioning strategies, Brenda, Dave, Fia and Connie's observed instructional questioning strategies were usually basic recall type questions rather than CCSMP types of questioning. There were times when each demonstrated PCK and the use of CCSMP in ways that elicited students making conjectures, reflecting, and problem solving in order to make connections with the content, but more often, they asked questions that required simple response answers to factual questions, as evidenced in this example from Brenda's classroom:

> But right here I do have my base, one times 3 so that's the bottom. Right here...what's that base...how big is the base? One times 3? Just three right? We can count those. And then I have my height here, the two, so I multiply by that two. So how much, how many different...what is my volume in there? What's my volume in there then? 6, definitely six.

Brenda asked factual questions that required students to give a numerical answer and often gave the students the answer herself or provided them with the steps. Instead of asking a more thought provoking question, as emphasized in the CCSMP, that would require students to make a conjecture or explain how they obtained a solution, she asked simple questions that required very little conjecturing or explication.

Similarly, in practice, Dave asked very simple questions requiring one answer responses from students with little emphasis on conjecture or explanation by students. Dave's classroom observations occurred during the warm-up or review at the beginning of class. The format used for this portion of the class was a multiple-choice structure using a student response clicker system for students to respond to the questions. The use of the clickers forced Dave's questions to be more fact-based and quick response rather than incorporating CCSMP questioning strategies to deepen student understanding. This example from one of Dave's classroom observations exemplifies his fact-based questioning:

> Alright. Number two. Hero invests a hundred dollars in a savings account that earns 8 percent. A little bit better. It's compounded quarterly. How much will be in the account after five years, to the nearest cent? Ok, so, don't miss this. Quarterly means what? How many quarters are there in a dollar (*student response - four*). Four. So if you split up a year into quarterly, there is four quarters in a year, right? So, how many years do we have? (*student response...five*). Five years. So how many total segments should we have? If we have four in each of those years. (*student response...20*) Twenty. ok. So this is going to be to the 20th, right? So, starting value?
>
> Dave is focused on simple questions and students responded with the numerical response.

Students were not asked to explain how they reached their answers, which would have incorporated justifying and making sense of the problem, teaching practices emphasized in the CCSMP. He also did not ask questions that required students to make conjectures or communicate with each other, and in this example, demonstrated how he often led them to the answer or even gave them the answer.

Just as Dave often provided his students with the answer or a lead-in to the answer, Fia also indicated she tended to give students solutions and too much help. In one of her interviews, Fia said she tried to focus on the CCSMP in her lesson, but indicated it is not her usual practice, stating, "I tend to give them the answers a lot, so I really wanted to try to let them come up with the answers and explain things."

As these examples show, participants incorporated different questioning strategies into their observed teaching practices, with those participants who incorporated *Sketchpad* more regularly showing more evidence of using CCSSMP questioning strategies. The classrooms that had access to computers for students also demonstrated many of the teaching practices modeled and emphasized in the OPD. Adam, Eileen and Gordon had access to computers for their students and exhibited the following teaching practices when using the pre-made *Sketchpad* activities: modeling with students first; walking around supporting students at the computers; making connections; grouping students at computers in order to focus on student collaboration and communication; having students test conjectures and explain their solutions using *Sketchpad*. Gordon summed up the impact of the OPD teaching practices on how he integrated *Sketchpad* succinctly in the following interview excerpt.

I use the pre-made activities and the teacher notes/student worksheets all the time. It really helps with my questioning and getting the students to explain. I try to use *Sketchpad* as much as possible. It takes longer with these students but I do what we discuss in class – lead them through and model the sketch first to make sure they understand and then give them time to work on it on their own or with a partner. I try to find activities that we have worked on in class because it helps me understand and know how to use it. I do need more learning in the math stuff so the pre-mades and the ones we tried in class I am more comfortable with.

This was seen in other classroom observations, as this quote from one of Adam's observations shows:

So you're going to get in groups, identify the question, and look at ideas on answering that question. Within your group you're going to come up with, and make maybe, throw some numbers out, make a box and whisker and come up with some ideas whether your question can be answered, or how can it be answered and such, right? Once you come up with your idea to answer the question, after time is up, alright, you come up and demonstrate the answer to your question. If it can't be answered, you come up here and say it can't be answered, or if the answer is no, you come up here and demonstrate that as well.

Adam planned for his students to collaborate in groups, working together to answer specific questions about box and whisker plots. He expected them to discuss and communicate as they worked on solving the problem posed to them, developing an answer together, and then coming to the front of the class and using *Sketchpad* to help model and explain their solution. Adam incorporated CCSMP and integrated technology appropriately into the content focus of the lesson.

This integration of technology in those classrooms that did not use *Sketchpad* regularly was done as a whole-class approach, with the teacher at the front of the room showing the *Sketchpad* activity on the SMART Board. They were using *Sketchpad* to show visuals of the math content, to represent a real-world application of the content, to do simulations of the math content and to help connect visuals to math formulas. As noted in a memo dated May 10, 2013, "*Sketchpad* is used for modeling often, either as a visual to review or introduce math content." Participants were not walking around the room or grouping students for collaborative experiences, as these participants did not have access to computers for students. These participants, as previously shown, used more simple questioning skills as they worked with *Sketchpad*. In this sample from Brenda, students were looking at a graph that represented a real-world connection to pricing rates and using the visual from *Sketchpad* to help students make the connection from the formula to the graph to the real-world context:

> Alright, and we can see that definitely in the graph. It's definitely not as steep. And when we talked about that rate, what was that rate for that green one? How much is it increasing by? (*student response...40 cents*) 40 cents on that one. And what was the rate here? (*student response...2.75*) 2.75. And this one is definitely a lot steeper there. We can definitely see that...which one is increasing faster then? (*student response...Cercana*) Cercana? That Cercana was increasing a lot faster.

What Brenda demonstrated with *Sketchpad* was a visualization of two different real-world problems that dealt with different price rates. Students could visually see what the rates look like by comparing two different lines. They could connect the math equations and slope of those equations to the lines on the sketch, providing the ability to understand how the slope, or price rate, impacts the steepness of the line. Though Brenda asked very simple questions, the use of *Sketchpad* helped students visually make connections to the word problems and math equations.

Very much like Brenda, Fia used *Sketchpad* to help students visually see the math concept of slope, using a different activity then Brenda. Fia stated she would "go into *Sketchpad* where they could see the slopes as the line moved." This demonstrated her use of *Sketchpad* to help students visualize and simulate the math content they were learning, providing ways for students to connect math equations to the visualizations to deepen understanding. Though there was not as much emphasis on the CCSMP type of questioning, Fia and Brenda both demonstrated using *Sketchpad* appropriately to model mathematics for students.

While their observed teaching practices around using *Sketchpad* may not have always incorporated CCSMP, Brenda and Fia were using *Sketchpad* to support the learning of the math content in ways that fit their classroom needs. They did not have access to computers for student use, which influenced the ways they incorporated *Sketchpad* into practice. This lack of computer access is just one external factor influencing instructional decisions for *Sketchpad* integration. There are several internal and external influences on participants' instructional decisions, and while these factors were not always the same for each participant, all participants were impacted in some part by these factors.

Internal and external factors influencing *Sketchpad* integration. Participants' instructional decisions and practices related to integrating *Sketchpad* are influenced by more than just the content they are required to teach, the professional development they have had or the teaching practices they utilize. Oftentimes, there are other factors that can support or hinder the integration of technology. All participants in this study had factors that influenced their instructional decisions related to integrating *Sketchpad* into classroom instruction, with some participants having less influencing factors than others. Despite working in the same large urban school district, all participants had different classroom environments and available resources, which impacted their ability to integrate *Sketchpad*.

Internal factors. The integration of *Sketchpad* into classroom instruction was influenced by a few notable internal factors. How I define internal factors for this study are participants' perceptions and beliefs about their own abilities with technology. While all participants experienced the same OPD, not all of them continued to use *Sketchpad* on a regular basis. Brenda, Connie, and Fia specifically stated in interviews that they only used *Sketchpad* in the observed classes because they knew I was coming. According to Brenda, "I used *Sketchpad* because I knew Karen was coming, so it forced the issue and activity." There was a ten-month gap between the ending of the OPD and the first observations for this study, and these three participants had not been using *Sketchpad* during that time. This ten-month lapse in use was evident because during classroom observations they were not comfortable with *Sketchpad* and had forgotten many of the skills they had learned in the OPD. I first made note of this in my memo dated April 29, 2013, where I stated, "Some are uncomfortable with the tool despite training (is this lack of use?)." I made a similar memo notation later on, after the second set of observations, stating on June 3, 2013, "Some still uncomfortable with the program, it's obvious they have not used it much."

As a result of this lack of use, these participants had very basic skills with the technology itself, and therefore found it difficult to integrate it into their lessons, as observed and noted in interviews. Connie said, "I think I should have practiced more so I would have used *Sketchpad* better." Similarly, Fia stated, "Well, not being as comfortable with *Sketchpad*, I think I hurt the lesson a bit." Their internal discomfort with their knowledge of how to use *Sketchpad* impacted their decisions and ability to use *Sketchpad* in their instructional practice.

While noting their discomfort with using *Sketchpad*, these three participants did comment during interviews on their comfort and reliance on other technology resources available to them in their classrooms. This comfort level with other technology tools led to their instructional decision to use those tools instead of *Sketchpad*, even if *Sketchpad* would have been the more appropriate technology resource for the content focus. Fia sums this up when she stated:

> I would have liked to be able to use the SMART Board instead to do similar things. I know they wouldn't have seen all the great things but in my mind the SMART Board is easier. I know it is more powerful sometimes but it's easier to fall back on SMART Board.

SMART Board, an interactive whiteboard that has built in mathematical tools, was the predominant piece of technology in participants' classrooms except for Adam and Gordon. These two participants only had a projection screen and an LCD projector to display *Sketchpad*. During observations in Fia's class, she consistently reverted back to the SMART Board tools to construct visuals, even when using *Sketchpad* would have been quicker and more visual, due to its dynamic movement capabilities, which would have allowed students to see how the constructs changed and connected with differing measures. I noted this in both of Fia's classroom observations. On April 29, 2013, my memo says, "Fia resorted back to SMART Board every time instead of staying in *Sketchpad.*" Her second observation on May 20, 2013, has a similar memo stating, "She is back to using the SMART Board not *Sketchpad* to show visuals." When asked why she didn't stay in the *Sketchpad* environment, she said:

> I have a habit of using the SMART Board tools. I don't use *Sketchpad* often except maybe to plot points or show slope. The SMART Board is what I am familiar with and so I go with that most of the time.

Similarly, Brenda mentions falling back on the technology tools she is most comfortable with, which included her TI-Navigator, a student response system tied to the students' graphing calculators. "I tend to use the things from the book or that I already have on the TI-Navigator or SMART Board because it's easier" she said. Comfort with technology tools that are easily accessed and used on a daily basis impacted the instructional decisions these teachers were making. Their internal beliefs about their abilities and perceptions about the difficulty of using *Sketchpad* with the content focus influenced their integration of it. These internal factors worked with external factors to shape the instructional decisions on technology integration.

External factors. External factors include physical resources, classroom environments, and behaviors and situations that participants were unable to control or not adept at controlling. These external factors influenced participants' instructional decisions related to *Sketchpad* integration. Different external factors impacted each of the participants, but those participants that used *Sketchpad* the least with their students had similar external factors, such as lack of computer access, other technology resources, classroom structures, and student behaviors.

Lack of computer access. Lack of computer access for students to use was one of the main reasons stated in interviews by participants for not using *Sketchpad.* In Brenda, Connie, Fia and Dave's classrooms, there was no access to computers for students. This lack of access limited the use of *Sketchpad* to whole-class demonstration and modeling using the presentation computer and SMART Board. Fia stated, "If I had more resources like computers I might have been able to do the lesson different and go faster." Dave stated, "I would have loved for students to work with the sketches; however, a computer lab is unavailable." Student access to computers where students can work hands-on with *Sketchpad* is a recommended way to use the program. Adam, Eileen and Gordon had regular access to computers for student use, and each of them stated in interviews that they used *Sketchpad* consistently. This was evident in observed classes by the familiarity students had with the program, opening the program quickly and using the tools efficiently, and by the teachers' instructional practices surrounding the integration of *Sketchpad.* Brenda, Dave, Fia and Connie exhibited this comfort and familiarity with other technologies in their classrooms, which influenced their choice to use these technology tools instead of *Sketchpad.*

Other technology tools. Other technology tools were readily available in most participants' classrooms, though each participant did not have the same available tools.

These tools included the SMART Board, TI-84 graphing calculators, TI-Navigator student response system, and other student response system. These other technology resources were used on a daily basis by those participants without access to computers for students, as noted in interviews.

All the high school classrooms had a presentation computer, SMART Board and graphing calculators. Brenda had the additional TI-Navigator student response system. This system allowed her to get immediate student responses to questions, which could then be shown in graphical form on the SMART Board. Brenda used the TI-Navigator often to assess student understanding quickly. This tool was a contributing factor to why her questioning was more basic and factual. Since the response system questions were often limited to multiple choice or single number responses, questioning was very factual, requiring one number or word responses. Dave had a similar student response clicker system, which he used, along with the presentation computer and SMART Board, and calculators for his warm-up and review questioning. Fia used the presentation computer and SMART Board, with her students using graphing calculators consistently throughout observed classes. Connie had limited calculators, which her students had to share. Connie relied on the presentation computer, SMART Board and SMART Board tools for most of her instruction.

Like the high school teachers, the middle school teachers had access to other technology, though Eileen was the only one with access to a SMART Board and the TI-Navigator student response system. In each observation, Eileen used these other technology tools in conjunction with *Sketchpad.* Gordon and Adam only had a presentation computer attached to an LCD projector and shown on a pull-down projector screen. Middle school teachers used graphing calculators as well, and all three middle school teachers had regular access to computers for student use. Adam and Gordon taught in computer labs and Eileen's students had portable laptops to use each day. Instructional decisions about integrating *Sketchpad* were influenced by the technology resources that were accessible to participants and students.

This access to other technology and limited access to computers impacted all teachers' decisions to integrate *Sketchpad* and the instructional strategies they used. The middle school teachers demonstrated an ability to use all the technology in their room to support different aspects of the learning. As seen in all middle school classroom observations, participants used *Sketchpad* in conjunction with the other technology tools, integrating the different technologies appropriately and using each tool at various points in the lessons. Figure 13 is an excerpt from Eileen's class that exemplifies this ability to switch between technology tools to support student learning.

Excerpt from Eileen's class:

[00:11:06.02] Teacher: I will ask everybody. Everybody, everybody. Go to the radius.

Students moving w/TI navigator and their "points' showing up on Sketchpad.

00:11:38.21] Teacher: Alright. Are you already there? Right here...I see them all moving. Okay. got it? I will stop it in five, four, three, two, and one. Okay. Look at this. some of you still have a little bit of doubt. What is a radius? Tell me what a radius is?

Figure 13. Observation excerpt showing integrated technology use.

At this point in the observation, students all had graphing calculators, which were attached to Eileen's TI-Navigator system. Eileen had a *Sketchpad* activity on the SMART Board that showed a large circle with the different parts of the circle constructed. Students had graphing calculators attached to the TI-Navigator student response system. This allowed each student to appear on the SMART Board as a different colored dot.

Eileen was using the TI-Navigator system in conjunction with *Sketchpad,* so each student's dot appeared on the *Sketchpad* sketch, somewhere on the circle. As students pushed the arrow buttons on their calculators, their dots moved to different locations in the circle, which they could see in the sketch. Eileen would give directions for students to move to a specific location on the sketch, such as "go to the radius". Students moved their dots to the requested part of the circle, providing Eileen with immediate visual feedback on which students understood the concept, since those students who may not have known what a radius was would be at somewhere on the sketch besides the radius. If there were several students not on the specified area of the sketch, Eileen would review the concept, asking questions and having students explain what the specific part of the sketch was. This allowed her to use the sketch to reinforce the math concept.

Unlike the middle school teachers, the high school teachers did not demonstrate in classroom observations the ability to integrate their other technologies in their classroom in conjunction with *Sketchpad.* They relied much more on their other technology resources, using *Sketchpad* more as just a visual tool to demonstrate after students had done the work with the calculator. To exemplify the difference between middle school and high school participants' ability to integrate other technology resources with *Sketchpad*, Figure 14 shows an excerpt from one of Brenda's observations.

Excerpt from Brenda's class:

[00:41:19.13] Teacher: Alright, next question on this one here. looking at these graphs, or thinking about that break even point, if the renter of the moving truck will drive 10 miles, which company should he rent? I'm going to quick poll on this one.

(closes Sketchpad and goes to TI-Navigator screen)

(students respond via calculator)

[00:42:42.00] Teacher: Five, four, three.....

(TI-Navigator bar graph of answers displayed on screen)

[[00:43:12.26] Teacher: Alright, looking here. Stopping that and looking up here. I have a lot of people that are saying C. Actually we have 16 people with C. if I look back at my graph, If I am driving 10 miles, Which one do I want, the one that I am going to hit first? or? how do I think about which one i want. How did you guys think about which one you wanted to go with? (2.75/hr....)

Figure 14. Observation excerpt showing integrated technology difference.

Like Eileen, Brenda's students had graphing calculators attached to the TI-Navigator student response system. Brenda also had a *Sketchpad* sketch open on the SMART Board that showed several different lines representing different examples of real-world rates between three companies. Similar to Eileen, Brenda asked students to identify something from the sketch, and used the TI-Navigator to assess students understanding. The difference here is Brenda did not use the TI-Navigator in conjunction with *Sketchpad*, where she could have the students move their individual points to the appropriate lines. Instead, Brenda used the TI-Navigator as a separate tool, asking students to move out of the *Sketchpad* activity to respond to a question. She closed the sketch, so students could no longer visualize the lines, and created a multiple-choice poll question for students to identify the correct line. When students responded, instead of seeing their responses on the *Sketchpad* sketch as Eileen did, Brenda's students saw a bar graph that showed the number of students who responded to each multiple-choice response. There was no connection to the sketch, and Eileen had to close the TI-Navigator poll, reopen the *Sketchpad* activity, and then discuss the student responses.

Brenda's decision to use the TI-Navigator as a separate tool rather than in conjunction with *Sketchpad* the way Eileen did is related to her comfort level with other technology as compared to *Sketchpad*. In one interview Brenda said she used her TI-Navigator system regularly "because the students had the calculators and it was quick and easy and it's what I am comfortable and familiar with." As seen in all observations and referred to in interviews, the availability of other technology, and familiarity and comfort level with these technologies, particularly graphing calculators, made many participants such as Dave, Brenda, Connie and Fia more likely to decide to use these tools over *Sketchpad*. Part of this, as stated in several interviews, was students' access to other technology sources. *Sketchpad* use often meant whole-class demonstration only, whereas other technology allowed for hands-on use by students, helping to control student behaviors and manage engagement.

Number of students and student behaviors. A huge impediment to integrating *Sketchpad* was the number of students in the classroom, and as a result, challenging student behaviors. In Connie's classroom there were 36-42 students who spoke seven different languages without enough desks for every student. As observed, the room was very crowded, and Connie had difficulty moving around to support students. There were not enough resources for students, such as protractors and rulers, so one ruler might be shared between five or six students. The language differences appeared to cause considerable confusion, as evidenced by the constant raising of hands to ask for clarification of what Connie or other students had said. There were students talking loudly and often while Connie attempted to get around and help everyone. These behaviors slowed the pace of instruction because of the need to repeat so often. As Connie put it, "There are so many of them. There is not enough peer-teaching but that's because a lot of times they don't understand what they are to do. And there are too many."

Like Connie, Dave also had a large number of students in his classes, averaging about 30 students. Dave's classes consisted of students identified as having special needs, which included learning difficulties as well as behavioral issues. During classroom observations there were students who were not participating in the lesson and several behavior issues, which Dave said impacted the technology tools used. The decision to use the student response clicker system was Dave's way to keep students actively engaged, which impacted his decisions about integrating *Sketchpad.* Dave attributed class size and behaviors, in conjunction with resource availability, as part of the difficulty of incorporating *Sketchpad,* as he explained in this interview response:

> Everyone was kind of just sitting there. I want them to engage more and am hoping that they will feel they have an investment in the learning. It's too large a class so it's hard to deal with behaviors, so there is no consistency in lessons. We are trying to differentiate, especially with the big focus on assessment, but resources are stolen or not available so it makes it hard.

Similar to Dave and Connie, Brenda and Fia also had large numbers of students, averaging between 25-30 students. During classroom observations there were several behavior issues that occurred, with students making disruptive comments or causing other disruptions during the lesson by talking back to the teacher or challenging another student. Both Brenda and Fia attributed some of the challenges of integrating *Sketchpad* to student behaviors. According to Brenda, "Some of the students behaviors make me decide not to use *Sketchpad*." Fia said:

> The students are challenging and don't really want to do the work. As you can see, I have some behavior issues so that interrupts class a lot and it's hard to keep students focused on the board.

Similarly, Gordon also had classroom behaviors that often interrupted class. Gordon's students were special needs students with behavior issues, and these classroom behavior disruptions were evident in each of Gordon's classroom observations. In his interviews, Gordon mentioned how student behaviors influenced his classroom activities and practices. Unlike Dave, Brenda, Connie and Fia, Gordon had access to computers for student use and had much smaller class sizes. Gordon differed from Dave, Brenda, Connie and Fia in his instructional decisions around the use of *Sketchpad*. Rather than choosing not to use *Sketchpad* because of student behaviors, Gordon felt *Sketchpad* helped his students' behaviors. Gordon said using *Sketchpad* actually helped in the engagement of his students:

> Student behavior for sure influences what we do. Well, the behaviors are always a challenge. And them not listening to directions because of that. But I think having the visual on the board was helpful too and modeling for them when they were getting stuck. I think if I could get in the lab more it would be great because a lot of my students have really improved since we started using *Sketchpad*. I try to use *Sketchpad* as much as possible. It takes longer with these students but I do what we discuss in class – lead them through and model the sketch first to make sure

they understand and then give them time to work on it on their own or with a partner.

While behaviors did impact the flow of instruction, they did not prevent Gordon from using *Sketchpad.* This might be due to the fact that students were hands-on with computers. Figure 15 shows an excerpt from an observation from Gordon's classroom showing student behavior issues.

Excerpt from Gordon's classroom observation

(not transcribed: conversations w/individual students who are acting out and not paying attention to work at computer; student chatter and teacher reminding students of worksheet directions. Walking around helping and encouraging students and redirecting.)

(Not transcribed: Teacher putting students on paper and pencil when they are struggling with sketch Teacher continuing to help students).

[00:21:19.26] Teacher: ya'll got it. Now you've got to draw it.

[00:21:24.12] Teacher: Man. Ya'll are flying! Is that...Is that right? You think that's...stop, stop. Do you think that's right? Ok, first, go clear it, because look what you did with this. Ya'll got to remember to clear it every time. Go undo. Edit and undo right now. Good. Now clear it. clear it. Clear it. Now, you guys clear it. Clear it. Listen. you guys listen. you all should be doing the same thing that we did up there. ya'll should be walking in there, walking in there, walking in, it should be no guesstimation. there should be no guesstimation in this one. You should be able to walk it exactly into the number your looking for with the Sketch.

Figure 15. Observation excerpt showing student behaviors.

During this portion of the lesson, students were in pairs at the computer working on a *Sketchpad* activity, which was also displayed on the projection screen. Students were talking loudly, calling each other names, shouting out answers, and Gordon was using classroom management strategies to redirect students to the lesson. Gordon provided alternate methods of working through the activity for students who were struggling or off task. He then stopped all students and redirected them, using the activity on the projection screen to draw their attention back. These behaviors occurred throughout the lesson, but because of the small number of students and students' hands-on access to computers, they could be redirected quickly. Dave, Brenda, Fia and Connie did not have small classes or access to student computers, which influenced their decision to use the other technology resources that did allow for students hands-on access and quick redirection.

Classroom structure. Just as other technology that was available influenced participants' instructional decisions, classroom structure influenced the decision to use *Sketchpad.* Classroom structure refers to the physical set-up of the classroom or the teacher responsibility within the classroom. In Dave's situation, he was a special education co-teacher in a regular math classroom. Responsibility of classroom instruction and instructional decisions were controlled by the algebra teacher with whom Dave co-taught. Dave's classroom structure gave him control over only the first 15-20 minutes of class, where he was to review math concepts or activate prior knowledge using the presentation computer, SMART Board, graphing calculators, and student response clickers. His classroom structure limited his ability to use *Sketchpad* and explained why he used it in such a limited way, relying on screen shots of sketches to incorporate into his multiple-choice reviews. According to Dave:

> The curriculum dictates what I do, and I am a special education teacher so my part of the lesson is the warm-up and reviews. We use clickers to get feedback, so I tend to use *Sketchpad* as a visual to help with those beginning questions.

Like Dave, Connie's classroom structure impacted her decision to integrate *Sketchpad,* though due more to the large number of students crowded in a small classroom and the different languages students spoke. Connie was the math teacher in the room and had a teacher assistant, in part because her class structure was made up of a large percentage of English language learners. Her class had students from seven different countries, so the language difficulties and need to focus on helping students understand simple directions made it difficult for her to integrate *Sketchpad.* Her room was also small and had between 36-42 students, with little room for students or Connie to move around. This made it difficult for Connie and the teacher assistant to get to students who needed help. During classroom observations, when Connie tried to move about the room to help students, she often had to climb around students or have students move in order to reach a student needing help. As a result of this, Connie said in interviews that she used the SMART Board tools instead of *Sketchpad* because students understood it better and she didn't have to move around the room as much to help students. Connie stated, "There is too much time helping them and making sure they are with me. There are language difficulties so it goes slow." This slower pace of instruction contributes to the final external factor of time, which also influences participants' integration of *Sketchpad.*

Time. Time is often an influence on teachers' instructional decisions to integrate *Sketchpad.* This included the time to find and prepare activities that supported lesson content as well as time to teach with *Sketchpad* in the class with the students, as exemplified by Connie. Looking at the time it took to use Sketchpad in the classroom, Connie said, "I wish the lessons could go faster – there is too much time to use it and it's easier to go to SMART Board." Those participants who used *Sketchpad* the least were the ones who mentioned time as being a factor in their instructional decisions. Brenda stated, "Time is always something – it's hard to find the time to get activities." Combining both time factors mentioned by Connie and Brenda, Fia said,

> Using *Sketchpad* made things slow down, even though I know it can do more than the SMART Board, I am more comfortable with SMART Board and can fly through things. With *Sketchpad* it was a learning curve and I think that slowed down the lesson. If it didn't take so long to find activities with *Sketchpad* I might use it more.

The internal and external factors were just one of the four influences on participants' instructional decisions and practices around integrating *Sketchpad.* These four influences - curriculum and district expectations, professional development, teaching practices, and internal and external factors - were interconnected, working together to impact what participants planned for and implemented into practice. Each participant was affected differently by these interconnected influences, but in all cases, participants' instructional decisions to integrate *Sketchpad* in their math instruction were multifaceted. The next section describes the four influences on teachers' instructional decisions and how these work together to influence teachers decisions to integrate technology.

Developing Theory

This study generated a grounded theory with four interconnected perceived influences to explain teachers' instructional decisions to integrate technology. Participants in this study exhibited behaviors and expressed reasons for their integration or lack of integration of technology similar to the research findings reported in the literature review in Chapter 2, which will be detailed in the discussion in Chapter 5. The four influences are curriculum and district expectations; professional development; teaching practices; and internal and external factors. The interrelationship of these four influences helps explain why or why not teachers choose to integrate specific technology, like *Sketchpad*.

Curriculum and district expectations guided participants' decisions about the content to teach and when to teach that content, as evidenced in interviews, classroom observations and written lesson plans. Participants included the standards and district expectations in all of their written lesson plans and posted them on the board in all classroom observations. In all interviews, participants stated that curriculum pacing and standards guided the topics they taught. This means that curriculum and district expectations influenced all subsequent planning for activities and instructional strategies and implementation of technology-integrated lessons. The three other influences of professional development, teaching practices, and internal and external factors are dependent on the curriculum and district expectations.

Based on where teachers were in the curriculum and pacing, they planned instruction around specific content standards, like the CCSSM. Their lesson planning then focused on finding content-related activities that would support the learning of the specified content. Figure 16 diagrams the part of the grounded theory demonstrating the one-way influence of curriculum and district expectations on professional development.

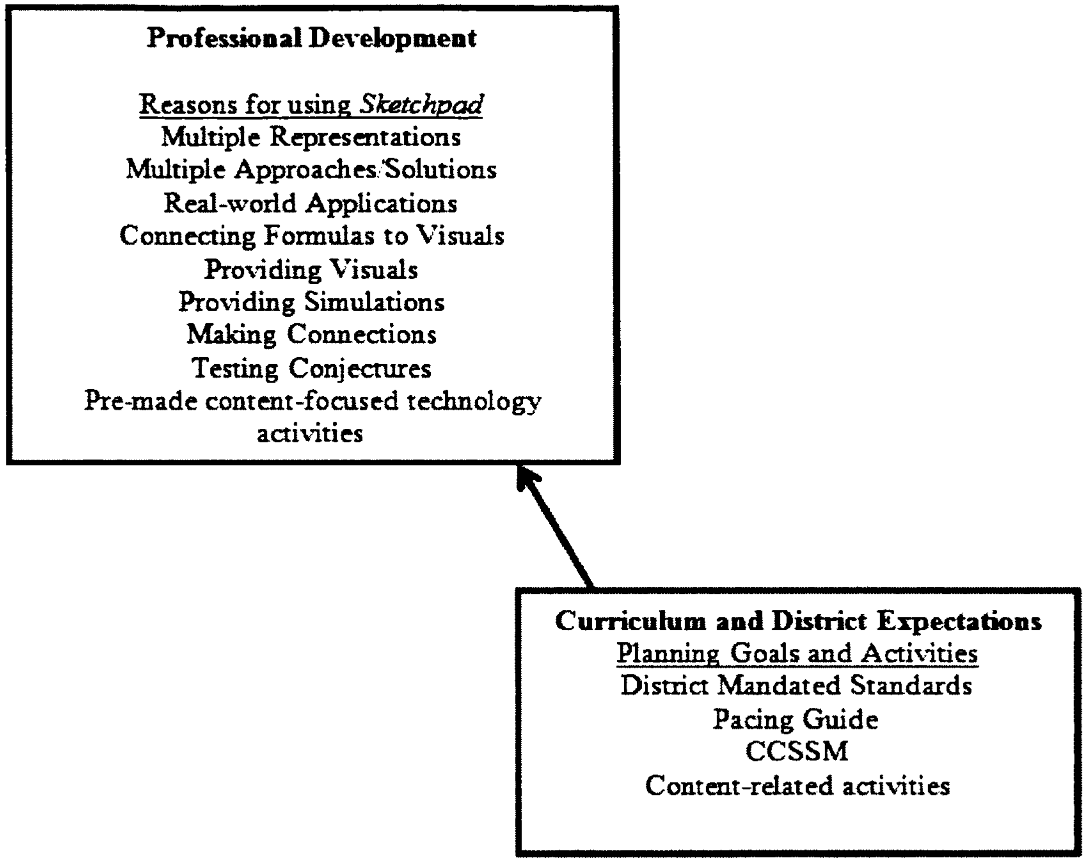


Figure 16. One-way influence on professional development.

Focusing on the content and standards, participants' instructional decisions were concerned with how best to teach that content. With the content focus as the guiding influence, they used their experiences and resources from OPD to find activities that would support the teaching of that content. Finding content-related activities that were appropriate to support student understanding of content focus was was the basis for their decision to use an activity from the OPD, as exemplified in Brenda's interview comment where she said, "The *Sketchpad* activities in the lesson were based on the content required to be covered in the pacing."

The content focus similarly influences the internal and external factors. If the learning of the content would be enhanced by using manipulatives – hands-on, concrete objects that students can interact with – and participants had access to these, they might choose those external factors. If having students hands-on at computers with *Sketchpad* was a better way to help students visualize and learn the content, and participants had access to computers for students, they were more likely to plan for using *Sketchpad.* If participants knew the content might require lots of explanation, and they were more comfortable with other technologies, as Connie and Fia were, they might be more likely to work with other technologies instead of *Sketchpad.* Figure 17 diagrams this one-way influence of curriculum and district expectations on internal and external factors from the grounded theory.

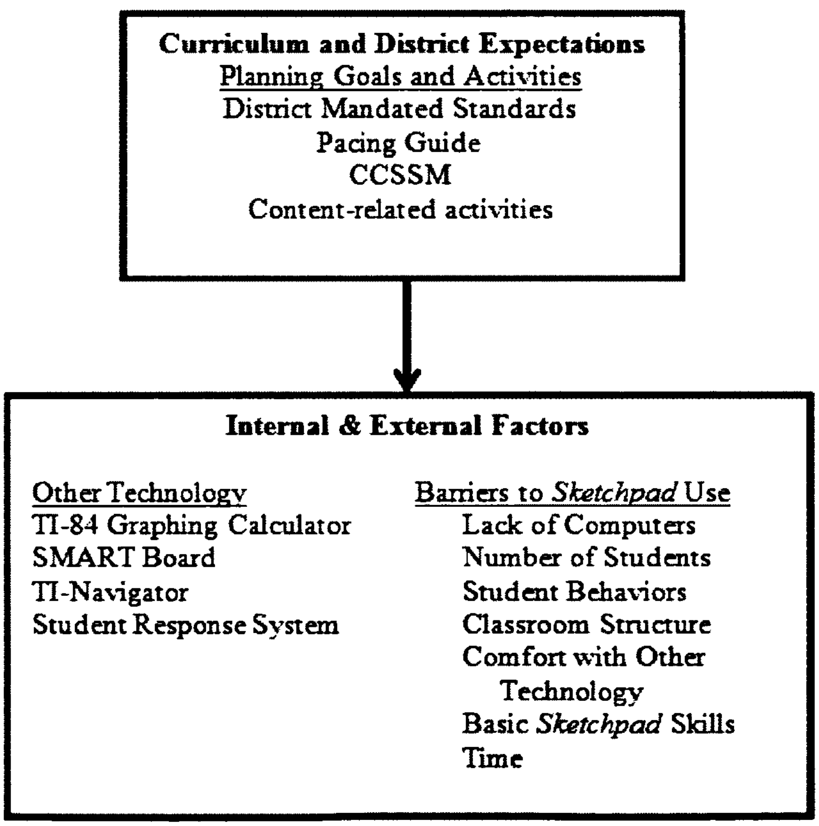


Figure 17. One-way influence on internal & external factors.

The diagram represents how the choice of what resources to use is influenced by the content focus. Participants know they must teach specific content and reach specific learning goals. Based on accessibility of technology tools, teachers' internal comfort level with technology tools, their perception of student behaviors, and their classroom structures, participants choose the resources that they feel will best support the learning of that content and goals.

This influence of curriculum and district expectations on internal and external factors can be exemplified by comparing Eileen and Brenda. In Eileen's case, knowing she had access to computers for her students made her decide to integrate *Sketchpad* to teach the math concepts. Eileen stated that she used *Sketchpad* regularly and she was able to walk around the room as students worked at their computers to ask questions, monitor progress and support learning. Brenda, on the other hand, did not have access to computers for students and had very large numbers of students in her classes that exhibited disruptive behaviors. Brenda described being "nervous about using *Sketchpad*" because she did not use it often. Instead she used other technology she had available in the classroom because she was more comfortable with these technologies. Brenda used the TI-Navigator, graphing calculators and SMART Board more often because she had access to these and she looked for "anything that can engage her students." Based on these internal and external factors, Brenda was more likely to choose not to use *Sketchpad* because her students could engage hands-on with the TI-Navigator and graphing calculators.

This engagement of students is important for teaching the math content, so curriculum and district expectations also influence the teaching practices participants planned and used in classroom lessons to engage students. Figure 18 diagrams from the grounded theory model this one-way influence.

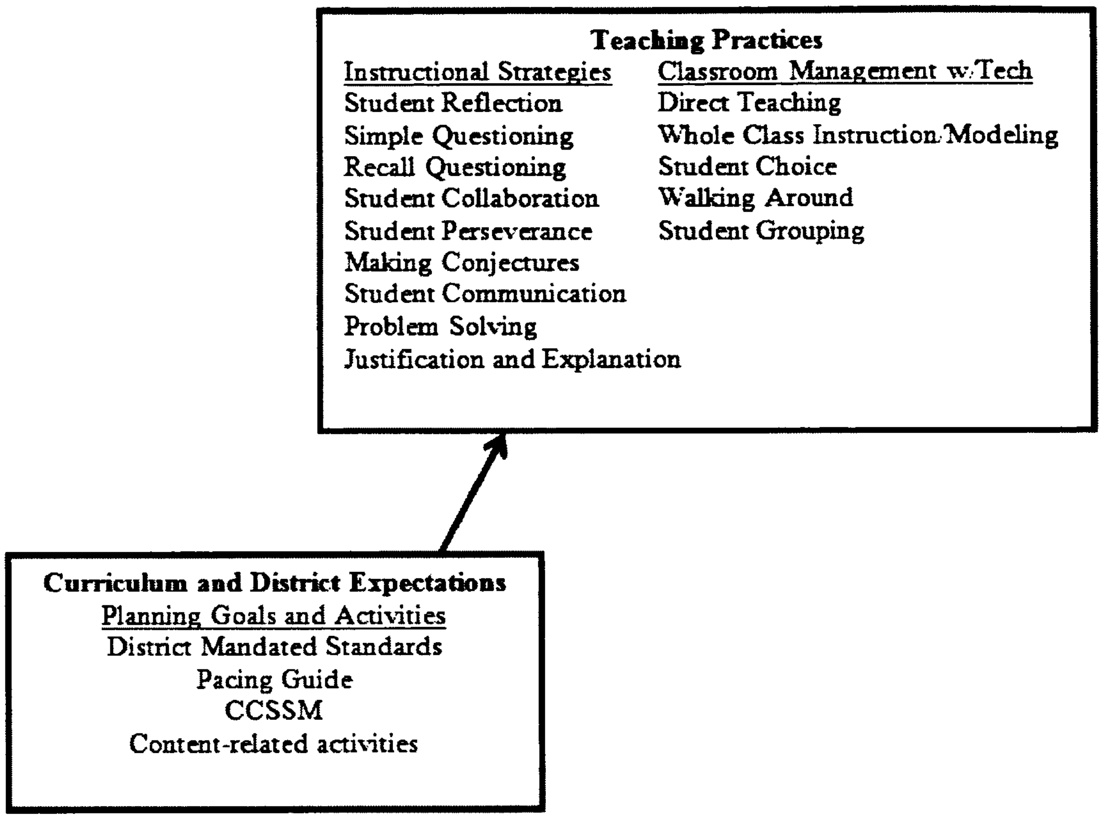


Figure 18. One-way influence on teaching practices

District CCSSM and CCSMP expectations for what students should know and understand about the specific content influenced the types of questions participants planned, the activities they chose, and how they structured student learning. For example, Eileen used hands-on 3D models to demonstrate the concept of area for students. She had students working in pairs to construct examples of different 3D areas using *Sketchpad* because these were the types of questions students were expected to answer on district assessments. Similarly, Brenda created multiple-choice questions that students answered individually, using their TI-Navigator student response system, to assess students understanding of systems of equations because these are the types of questions on the standardized tests students take at the end of the year. Knowing the content focus, participants made specific instructional decisions about which teaching practices would best help students learn, understand and be successful with the content.

Just as the curriculum and district expectations about content focus influence the three other categories related to instructional decisions, each of these three categories influences the other. Figure 19 diagrams from the grounded theory this interconnection between these three influences.

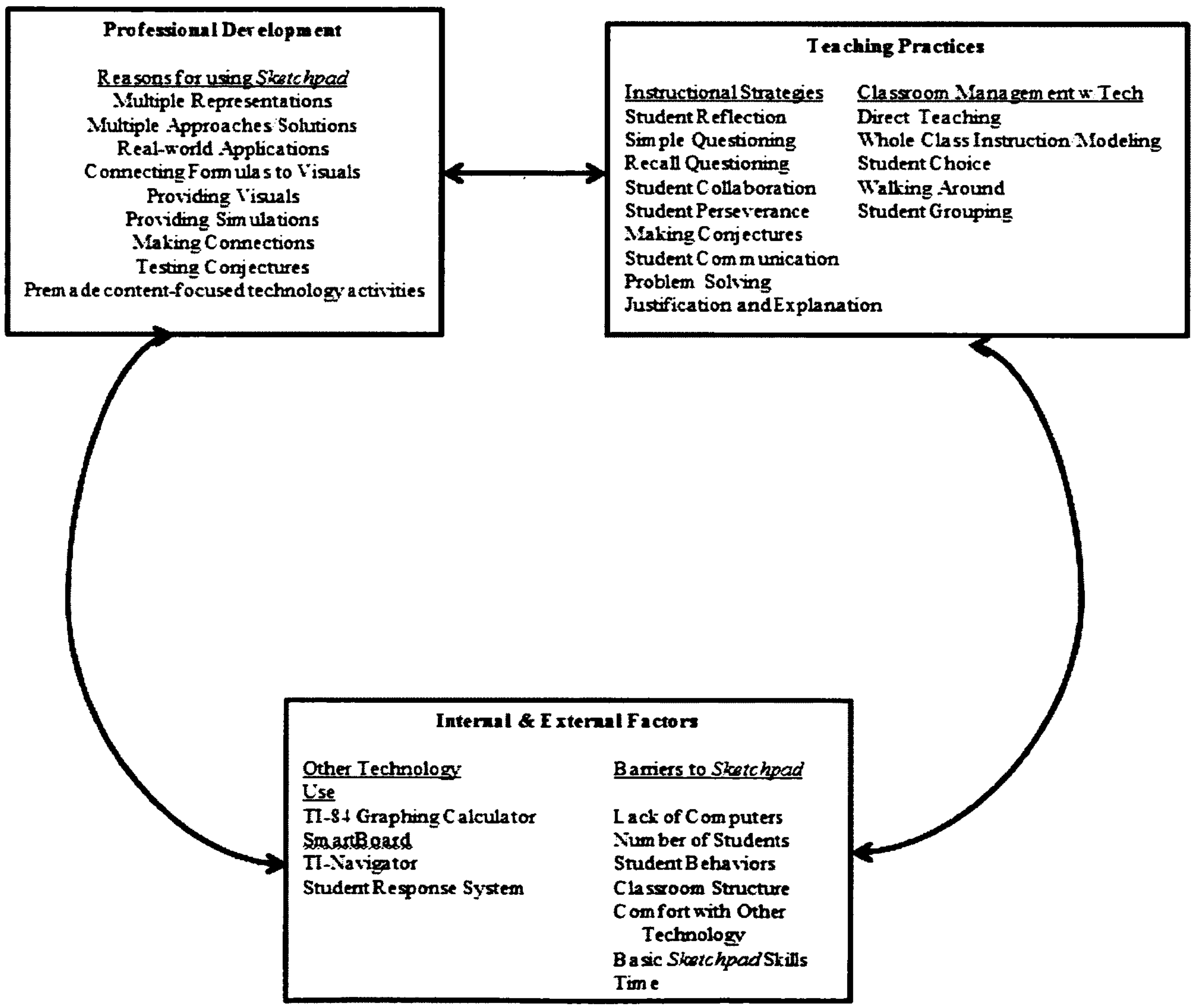


Figure 19: Diagram of Interconnected influences.

As an example of this interconnection, the modeling of questioning strategies in the OPD influenced the choice of *Sketchpad* activity and influenced the teaching practices planned for and demonstrated in class. Similarly, the lack of student computers influenced the choice of technology tools used, how to incorporate the *Sketchpad* activity chosen, which influenced the teaching practices planned for and demonstrated in classroom practice. All three of these influences influenced each other in a continuous way, and were driven by the influence of curriculum and district expectations. All four influences work together to impact what is planned for technology-focused instruction and how that instruction is implemented in practice, as the examples that follow will demonstrate.

The content drives the choice of content-related activities, which may or may not come from the professional development experience. If an activity is chosen from the professional development experience, the teaching practices used are influenced by that choice. Should the activities chosen come from another resource or tool, the teaching practices used during instruction may be different, influenced by the other resources and activities chosen. During instruction, as the teacher is implementing activities, they may change their teaching practices if they switch to another tool or in reaction to student behavior. They may ask a question that requires students to utilize other technology. The interconnectedness of these four influences contributes to teachers' instructional decisions both in planning and during classroom instruction. The following two scenarios exemplify this interconnection between all the influencing concepts, using examples from two different participants. Based on classroom observations, interviews and lesson plans, these two participants provide two perspectives on the four influences on their instructional decisions to integrate *Sketchpad* in the classroom.

From Eileen's perspective, using *Sketchpad* was an important part of her instructional decisions for technology integration. Eileen "always plans with *Sketchpad* in mind." The content topic for a lesson came from the district curriculum and pacing and Eileen "looks at what the topics are and always have *Sketchpad* in mind if it can help deepen or visualize learning." Eileen chose pre-made *Sketchpad* activities in her plans, ones that she herself experienced in the OPD. This was because she "has a whole library of activities from the PD I know are good and will support the learning of the topic." Eileen had access to student computers, an external factor that also influenced her decision to use a *Sketchpad* activity. Eileen also liked to have her students do "hands-on first and then connect it to *Sketchpad,"* so other resources such as manipulatives and graphing calculators were planned for and used in the classroom to support the learning of the topic. Eileen used several different teaching strategies, influenced by the content focus of the lesson, the PD, and the other resources she used during a lesson.

When using the pre-made *Sketchpad* activity, students were in pairs working at the computers while Eileen walked around the room asking questions, having students test their conjectures and explain their answers using *Sketchpad.* While using the manipulatives, Eileen was doing whole-class demonstrations and asking students to make conjectures, which they then tested on the computer with *Sketchpad.* There were times when Eileen was walking around the room that she realized students were struggling with the activity. During one such time, she changed her teaching practice, went to the front of the room and had students focus on the SMART Board. Eileen then used a visual from

Sketchpad and had students use their graphing calculators and the TI-Navigator student response system. Using these technologies together allowed Eileen's students to ask questions, clarify their thinking, and visually make connections and explain their understanding of the concept they had been struggling with at their computers. She integrated the *Sketchpad* activity with her other technology, changing her teaching practice to address student struggles with the content. The math topic, the resources in her room, her experiences in the OPD, and the teaching practices that would support the activities and resources chosen all influenced Eileen's instructional decisions. These influences were evident in her lesson plans and in classroom observations, combining to impact her instructional decisions in order to ensure student learning and understanding of the topic.

This influencing impact on instructional decisions was also evident in Brenda's classroom. Like Eileen, Brenda chose lesson topics based on "where the topic is in the pacing guide and curriculum." Unlike Eileen, however, Brenda did not plan her activities with *Sketchpad* in mind because "it takes too much time to find." However, "knowing a specific *Sketchpad* activity from the PD that would fit" and that she could find it quickly would be a reason she might choose a *Sketchpad* activity. Brenda normally planned and chose activities from the other technology in her room, like the SMART Board tools and the TI-Navigator activities because "I already have activities that come with those." Brenda planned and used her SMART Board tools and TI-Navigator student response system more frequently than *Sketchpad* because these other resources were available and she was "more comfortable with using them." Students also had hands-on access to the graphing calculators attached to the TI-Navigator system, which influenced her teaching practices. She was able to ask quick questions and get immediate responses back from students, which in turn helped keep students engaged and lessen student disruptive behaviors.

Student engagement was important to Brenda and because of her lack of access to computers for students, the *Sketchpad* activity she chose in one observation was more for visualization of a concept than for students to actively engage with the sketch. Because she only had the presentation computer and SMART Board, she used whole-class instruction and demonstration. She was unable to walk around the room due to the large number of students in her room and the desk arrangements. To keep students engaged in the lesson, she would use the TI-Navigator system to ask multiple-choice questions. Similar to Eileen, she used the TI-Navigator to gauge student understanding and make changes in her teaching practices. Unlike Eileen, she did not use the TI-Navigator in conjunction with *Sketchpad*, but rather separately, going back and forth between the two programs. She realized this might have caused confusion with students, since she mentioned in an interview she needed to "get *Sketchpad* to work better with the SMART Board and TI-Navigator." Brenda used *Sketchpad* more as a visual tool to help students see the connections between their math equations and real-world and graphical representations. Her teaching practices when using *Sketchpad* were focused on "good questioning and conjecturing" that came from the pre-made activity teacher notes. When she changed to SMART Board tools and the TI-Navigator, her teaching strategies changed, with her questioning becoming more basic and fact-based, influenced by the other technology tools she was using. Like Eileen, Brenda demonstrated many instructional decisions, both in her written lesson plans and in classroom observations, which were influenced throughout by the topic itself, the activities chosen, the resources available, and the teaching practices that were most effective for the given resource or activity. Influences on teachers' instructional decisions are multi-faceted and inter-connected.

Grounded Theory

The findings from this study provide a theory, grounded in data, that teachers' instructional decisions around technology integration after an OPD experience are not influenced by just one thing, but rather four interconnected influences incorporating a multitude of factors. The central influence is curriculum and district expectations, which focus instructional decisions on the required content and finding appropriate content-related activities that will support the learning goals. This content focus influences what types of activities are chosen, what resources are used, and what teaching practices are planned and implemented in classroom instruction. In turn, the activities, resources and teaching practices all influence each other, working together to create a lesson that supports student learning and understanding of the content. To help visualize this grounded theory, Figure 20 provides a diagram, as suggested by Birks & Mills (2011), that visually shows the interconnections of these four teacher-perceived influences on instructional decisions around technology integration into classroom practice after an OPD experience.

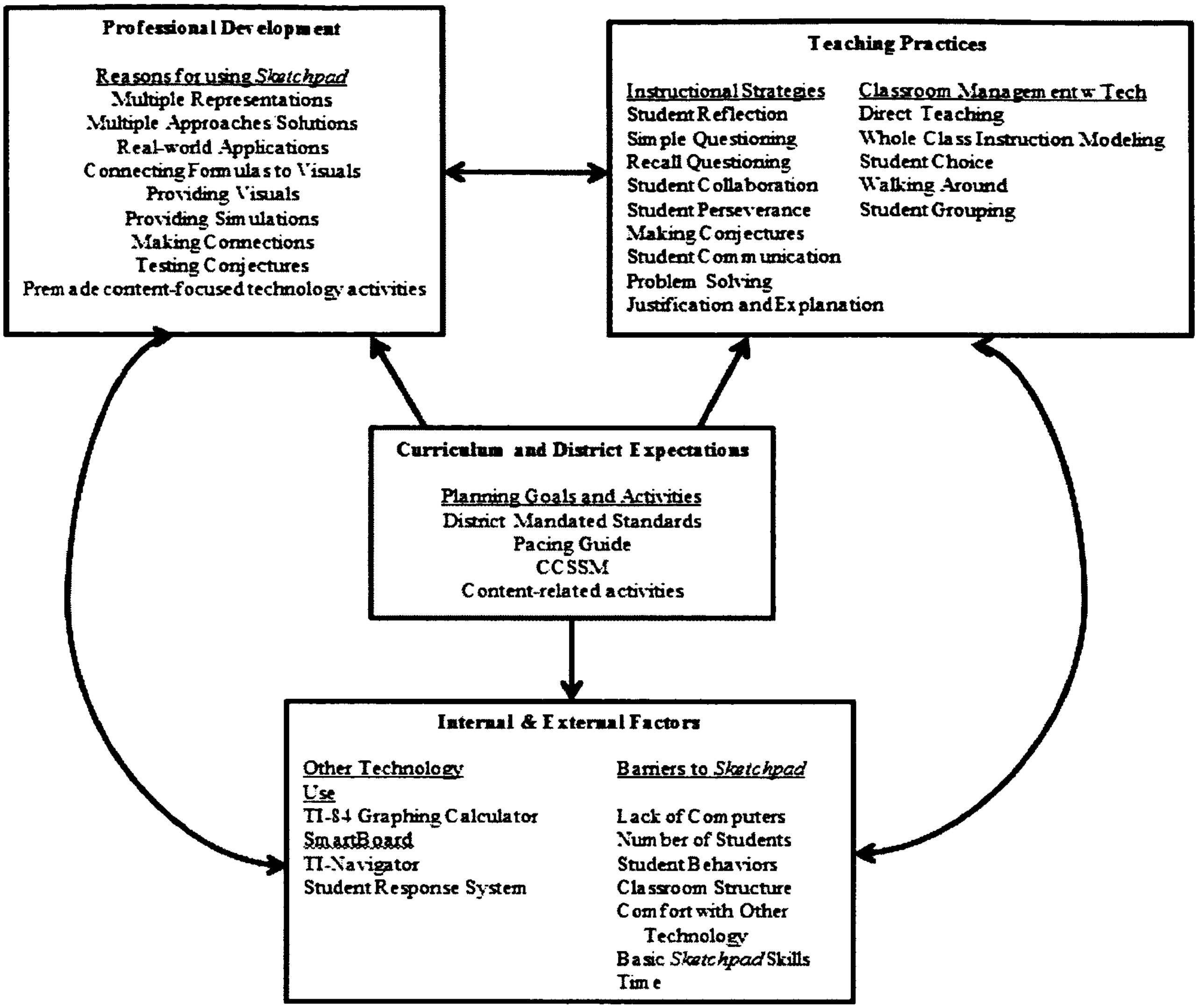


Figure 20: Diagram of grounded theory.

The key influence, curriculum and district expectations, is centered in the diagram to show its importance. The one-way arrows to each of the three other influences signifies that curriculum and district expectations are not influenced by other factors but are the underlying influences for all other instructional decisions teachers make. As described previously, written lesson plans, interviews and classroom observations showed evidence of the importance of curriculum and district mandated standards. Written lesson plans all included math content topics from the district expectations and standards from CCSSM. These learning goals and standards were evident in classroom observations, posted on the boards and also reviewed at the start of each class by the teacher. In interviews, participants all stated that district curriculum guides and pacing and CCSSM determined the lesson focus and guided the choice of activities, resources and strategies used in the lesson.

While the choice of activities, resources and strategies was influenced by the curriculum and district expectations, there is an interconnected influence of each of these on each other. The two-way arrows visually show how the influences of professional development, teaching practices and internal and external factors influence each other in a continuous way. As described previously using examples from Eileen and Brenda, these three influences together help teachers structure their classroom activities and instructional strategies, and can change as a lesson progresses. In written lesson plans, participants made instructional decisions about what activities to use to teach content, based on the external and internal factors in their rooms, such as access to computers for students, classroom structure, or graphing calculators. According to interviews, participants chose *Sketchpad* activities from professional development based on their own experiences with pre-made activities that fit the content or because they wanted a specific visual from an activity that would support the learning. Their choice of *Sketchpad* activity, in conjunction with the external resources chosen, determined the teaching practices they planned for and implemented in the classroom. In the case of Adam, for example, he chose a *Sketchpad* activity students worked on in small groups at computers, since he had access to computers for students. He walked around questioning students and students came to the front of the room and used *Sketchpad* to justify and support their solutions to the math problems. Dave, on the other hand, used graphing calculators and a student response system, with a visual from *Sketchpad* to gauge student understanding during a review of solving slope equations. During classroom observations, participants all integrated *Sketchpad* into instruction differently. These differences, based on interview responses, were influenced by the their internal and external factors, their experiences from the professional development, and the teaching practices they incorporated that worked best with the resources and activities chosen to support student learning.

These instructional decisions participants made to support student learning are influenced by interconnected factors that support the specific content participants must teach. These interconnected factors form a grounded theory to explain the influences on teachers' instructional decisions for technology-integrated lessons using *Sketchpad*, both in planning and in practice.

Summary

In this chapter I have detailed the findings of my study, providing summary and examples from my data to support my interpretations and conclusions. Through written lesson plans, classroom observations and interviews, I generated data that provided insight into how participants' experiences in OPD influenced the planning for and implementation of technology-integrated lessons using *Sketchpad.* Data analysis using a constant-comparative method helped me to develop a grounded theory to explain the teachers' perceived influences on their instructional decisions for technology integration, which include: curriculum and district expectations; professional development; teaching practices; and internal and external factors. This grounded theory supports the idea that teachers' decisions to integrate technology into their classroom are multi-faceted, influenced by many factors, all of which need to be considered in order to support teachers' classroom technology integration.

Understanding how curriculum and district expectations, professional development, internal and external factors and teaching practices work together to influence classroom instructional decisions provides educational leaders with ability to better support teachers' technology integration in the classroom. This proposed grounded theory will provide insight into the design of future technology professional development in order to support teachers' technology integration into instructional practice. Chapter 5 will summarize my findings, make connections to prior research, discuss study implications and limits to my study and make recommendations for future research.

Chapter 5

Conclusions and Recommendations

Introduction

The purpose of professional development is to keep teachers updated on new tools, resources and instructional strategies in order to sustain and improve the profession and student achievement (Darling-Hammond et al., 2009). Professional development for teachers has been shown to influence and change teacher practice, especially when it focuses on helping teachers connect the knowledge gained in PD to their own teaching environment (Darling-Hammond & McLaughlin, 1995; Polly & Hanafin, 2010; Reeves, 2010; Silverman, 2012). Professional development, in its many forms, including OPD, has more impact when it involves active-learning, collaboration among teachers, and a focus on actively connecting content and skills, with time to learn, practice, and reflect on the process (ASCD, 2002; Darling-Hammond & McLaughlin, 1995; Dash et al., 2012; Ingvarson et al., 2005; NSDC, 2012b; Reeves, 2008; Polly & Hannafin, 2010). Longer-term PD experiences that provide continuous support and time for implementation are more likely to show sustained impact on instructional practice (ASCD, 2001; DiPaola & Hoy, 2008; NSDC, 2012a; NSDC, 2012b; Penuel, et al, 2007; Quick, et al., 2009). This is also true for ETPD, where longer duration allows for teachers to learn over time and helps increase teachers' knowledge, confidence and use of technology (Brinkerhoff, 2006; Swan, Jennings & Rubenfeld, 2002).

Several studies that focus on ETPD and OPD show an impact on teachers' instructional practices. There is evidence of increased teacher skills and confidence with using technology, and an increased use of the technology in classroom practice, though often at a basic level (Beatty, 2003; Blocher et al., 2011; Brinkerhoff, 2006; Klein & Riordan, 2009; Mouza, 2009; Polly, 2011). There does appear to be some change in teachers' pedagogical beliefs and an improvement in pedagogical and content knowledge (Carey et al., 2008; Coffman, 2004; Owston et al., 2008). Additionally, when time to practice and implement new skills is a component of the ETPD and OPD experiences, teachers show increased implementation of content which they have learned (Crockett, 2010; Dove, 2011; Furges, 2011; Vavasseur & MacGregor, 2008). However, even when ETPD and OPD experiences are structured with research-based components, there is evidence that teachers' implementation differs from what was modeled and often is not sustained over time (Klein, 2009; Mouza, 209; Owston et al, 2008; Polly, 2011). It is difficult to determine the true impact on teacher practice after any professional development since research most often relies on teacher self-reports, which can be skewed or unreliable (Pierson & Borthwick, 2010).

Lawless & Pellegrino (2007) recommended that follow-up research on the impact of technology professional development on teacher practice include data types beyond teacher self-reports. This may include classroom observations, interviews and artifacts. Also, a longer duration for data collection after ETPD may help to uncover what is actually occurring in classrooms. By observing instructional behaviors, attitudes, and knowledge in action, research is more likely to capture what factors are influencing teacher instructional decisions around technology integration (Lawless & Pellegrino, 2007). DiPaola & Hoy (2008) discuss the importance of focusing on the transference of knowledge and determining how professional development can result in more effective teachers, which means examining the influences of professional development into practice and classroom instruction.

This study sought to examine the influence of a long-term, hybrid professional development experience on the instructional decisions teachers made around integrating the mathematics software, *Sketchpad,* both in planning and in classroom practice. The OPD experience was developed using research-based components: content-focused, hands-on, active learning; extended time to learn, practice, and implement; and a focus on collaboration, peer support, and reflection on practice. Teachers in the study all participated in the seven-month long OPD experience, which was developed according to the TPACK construct to help teachers develop technology, pedagogy, and content knowledge around integrating *Sketchpad* into mathematics instruction. The content focused on The Common Core State Standards [CCSS] and the pedagogical practices focused on the Common Core Standards of Mathematical Practice [CCSMP] (NGACBP, 2010). Teachers were expected to implement these standards and practices in their mathematics instruction, and *Sketchpad* was a technology tool to support them. The study itself took place ten months following the OPD experience and involved a deliberate convenience sample of seven participants. Based on Lawless & Pellegrino's (2007) recommendations, this study used multiple sources of evidence to understand how teachers were incorporating *Sketchpad* over a three-month span of time in order to determine what, if any, components from the OPD experience influenced teachers' instructional decisions. The study was not an evaluation of the OPD's effectiveness, but rather a study to determine what teachers' perceived the influence of the OPD had on their technology integration.

My study is a grounded theory approach that generated multiple data types from the seven participants. Data included two classroom observations, two one-on-one interviews and written lesson plans for each participant for a total of fourteen classroom observations, fourteen one-on-one interviews, and thirteen written lesson plans. I used a constant comparative method to compare all sources of data, looking for patterns and themes for each participant and among all participants. I kept memos throughout all aspects of the data collection and analysis process. Member checking ensured that my inferences and conclusions were congruent with the participants' attitudes, feelings and actions. Initial coding of all data resulted in thirty-seven categories (Appendix L), which were further compared and analyzed through intermediate coding, resulting in six sub-categories: 1) planning goals and activities; 2) instructional strategies; 3) reasons for using *Sketchpad;* 4) classroom management with technology; 5) other resources and technology; and 6) barriers to *Sketchpad* use (Appendix P). Triangulation, constant comparative methods, memoing and member checking led to the further refinement of categories and development of a grounded theory on the perceived influences on teachers' instructional decisions for integrating technology (Appendix R). This theory incorporates four influencing categories to explain the teachers' instructional decisions; 1) curriculum and district expectations; 2) teaching practices; 3) professional development; and 4) internal and external factors. The next section describes how these findings connect with previous research.

Connections with Prior Research

Curriculum and district expectations. Curriculum and district expectations, which included the content and standards focus of the lesson, were the primary determinant that participants used to design all classroom activities and resources. The knowledge teachers developed in the OPD experience on how to choose specific content-focused *Sketchpad* activities played a significant part in how they planned both the observed and written lessons for this study. Understanding how to use *Sketchpad LessonLink*, the online library of content and standard-aligned activities, allowed participants to find specific content-related technology activities that would support students understanding of the curriculum and district standards. This finding supports findings from Hughes (2005), where content-focused learning yielded content-focused integration. Dove (2011) and Hughes (2005) both found that content-focused lessons and activities provided participants with relevant activities they could use in their own classrooms. When connections to specific content and curricular goals can be made, it is more likely that integration of technology will occur (Dove, 2011; Hughes, 2005; and Pierson & Borthwick, 2010).

Teachers' beliefs in the direct relevance of content used and emphasized in PD is a predictor of how they use these in technology-rich lessons in the classroom (Kanaya, Light & Culp (2005). In my study, participants all expressed and demonstrated that the experiences they had with *Sketchpad* and how it supported the CCSSM influenced how they integrated *Sketchpad* in the classroom. Using their knowledge of finding *Sketchpad* activities on the *Sketchpad LessonLink* site, participants were able to evaluate and determine what activities would be appropriate to support student learning curriculum content. The ability to find activities that focused on specific content that would address student needs made it easier for participants to integrate technology in their mathematics classroom, which is similar to findings by Bryant (2008). Depending on the fit to their particular content focus of the day, participants in my study often used the exact activities that were modeled and practiced in the OPD experience. Their own experiences with the activities provided them with the understanding of how the activities supported the CCSSM and how integrating these activities would support student understanding. Crockett (2010), Furges (2011), and Dove (2011) had similar findings in their studies, where the access to and learning of specific content-related activities helped teachers integrate the technology to support student learning. Roschelle et al., (2010) also found that content and technology integration strategies focused on in PD directly impacted what and how technology is integrated if they were directly related to the curriculum teachers are expected to teach.

Teaching practices. The teaching practices participants planned for in their lessons were tied to the curriculum and district expectations and lesson focus. The specific *Sketchpad* activities participants planned to use in their lessons incorporated both classroom management suggestions that were emphasized in the OPD experience for technology integration and questioning strategies that supported the CCSSM and CCSMP, many of which came directly from the activities themselves. Participants, through their own personal hands-on learning and practice in the OPD with many of the *Sketchpad* activities used in their lessons, demonstrated planning for specific instructional strategies to support the use of these activities and student learning of content. In particular, participants showed planning for questioning strategies around the CCSMP, which was a particular emphasis in the OPD. This supports Bryan's (2008) finding that PD influences teachers' instructional decisions and use of strategies learned through designing technology-rich lessons around essential questions.

All participants demonstrated in their planning the intent to use *Sketchpad* to model the content and provide visuals to deepen students' understanding of mathematical concepts. This was a particular emphasis in the OPD experience. Additionally, those participants who integrated *Sketchpad* on a regular basis showed planning for instructional strategies that incorporated student collaboration, emphasis on students making conjectures and problem solving, and expecting students to justify and explain their solutions. This finding is similar to findings by Bryan (2008), Beatty (2003), and Duran et al. (2012), which indicated participants' experience in the PD helped them prepare and plan for technology integration. Participants who did not use *Sketchpad* regularly did plan for these types of teaching practices, as evidenced in their written lesson plans and interviews, though in practice, these teaching strategies were less apparent, either not present at all or not the same as was modeled in the OPD. This supports Polly's (2011) and Mouza's (2009) findings that showed that the teaching strategies teachers actually demonstrated in the classroom did not necessarily always match what was modeled in the PD experience.

The OPD experience focused a great deal on appropriate pedagogical practices around integrating *Sketchpad* effectively in mathematics to enhance student understanding. Using the CCSMP as a guide, participants spent a significant portion of the OPD practicing and reflecting upon teaching strategies, particularly around questioning skills and using *Sketchpad* as a means for student collaboration, communication and justification. Activities were modeled for participants, and they had extended time to learn, practice and implement the activities in their own classroom. During the study, the influence about appropriate teaching strategies modeled and used in the OPD was evident in both written lesson plans and classroom observations. Findings from Crockett (2010), Dove (2011), Furges (2011), and Vavasseur & MacGregor support my own findings, that time to practice and implement new strategies and skills in OPD supported subsequent integration of those strategies in the classroom. In interviews, all of the participants mentioned that the OPD experience influenced how they used the *Sketchpad* activities with their students, with a particular focus on the questioning strategies. All participants showed evidence of using the teaching strategies emphasized in the OPD, though this was less evident in participants with limited access to computers for student use. Participants also demonstrated using many of the teaching strategies specifically modeled in the OPD, but modified to fit their own classroom structure and students. Teachers' use of what they learned in OPD varies and is often related to their perception of how the content directly relates to their students and classroom practice (Babette et al., 2009: Frank et al., 2001; Hughes, 2005; Klein, 2009).

Professional development. Martin et al. (2010) showed that when PD involved modeling instruction, technology utilization, connection to practice and focus on inquiry-based learning, teachers were more likely to create high quality technology lesson plans. In particular, modeling instruction was the strongest predictor of quality lesson plans. This is evidenced in my study by the OPD's influence on participants' instructional decisions to use *Sketchpad* to enhance the learning of the math content. Participants' planned for *Sketchpad* because of its ability to provide visuals, make connections between new and previously learned math concepts, suggest real-world applications of the math content, and provide multiple representations and approaches. Participants' own experiences with the pre-made *Sketchpad* activities that were modeled in the OPD played an important part in the activities they chose and how they planned to use and model these activities in their own lessons.

Active learning that engages teachers in collaboration, working with content and skills and reflecting on the process of learning and integrating that learning into practice is a key component to supporting continued integration (ASCD, 2002; Darling-Hammond & McLaughlin, 1995; Dash et al., 2012; Ingvarson et al., 2005; NSDC, 2012b; Polly & Hannafin, 2010; Reeves, 2008). The use of *Sketchpad* as a modeling tool, where teachers could visually demonstrate and explore mathematical concepts, was a primary focus of the OPD experience. The use of pre-made, content-related *Sketchpad* activities, where participants actively worked with the lessons, helped them to learn both the skills of the software and how to use these activities effectively with students. During personal interviews, participants cited pre-made *Sketchpad* activities and their personal, hands-on work with them as a significant influence of the OPD experience on their decisions to integrate *Sketchpad* in classroom lessons. The participants' learning experiences in the OPD influenced their beliefs that the use of *Sketchpad* could enhance student learning. Beatty (2003), Bennison (2010), Blocher et al. (2011), and Owston et al. (2008) showed similar findings in their studies, where the OPD experiences influenced teachers' beliefs in the ability of technology to support student learning. In their interviews, all participants in my study spoke of the power of *Sketchpad* to enhance students' understanding of math concepts, helping them make connections between new and previous understandings, and providing real-world applications in a visual way. Content and technology integration emphasized in the PD can directly impact what and how technology is integrated if they are directly related to the curriculum teachers are expected to teach (Roschelle et al., 2010).

Internal and External Factors. There are several factors that influence the impact of professional development on teacher practice according to the research. Limited access to resources is often cited as a potential barrier to integrating the tools and strategies learned in PD (Beatty, 2003; Hew & Brush, 2007; Zhao, Pugh, Sheldon, & Byers, 2002). Teacher beliefs about their students and their own learning can influence how knowledge in PD is implemented in practice (Franke et al., 2001; Hew & Brush, 2007; Klein, 2009; Mouza, 2009; Pegg & Pannizon, 2007; Turner et al., 2010). Coherence to a teacher's practice, including the particular content focus and participants' teaching situations, is a factor that can predict the likelihood of continued implementation of knowledge learned in professional development (Bryan, 2008; Bryant, 2008; Klein, 2009; Hew & Brush, 2007, Roschelle et al., 2010). Support from administrators, colleagues and technical experts have been shown to impact technology integration after professional development (Babette et al., 2009; Franke et al., 2201; Owstein et al., 2008; Polly, 2011; Smith & Sivo, 2011; Turner at al., 2010; Vavasseur & Macgregor, 2008; Zhao et al., 2002). Finally, collaboration with colleagues, both during and after professional development was important to sustained integration of technology (Franke et al., 2001; Hughes, 2005; Polly, 2011; Vavasseur & MacGregor, 2008). My results show several internal and external factors that influence teachers' instructional decisions around technology integration. Like other research studies, I found limited resources and teacher beliefs about their own knowledge and skills as influencing factors. Additionally, I found classroom structure and time as external factors that often influence teachers' decisions to integrate technology.

Limited resources. Limited access to student computers was one of the main reasons cited for lack of *Sketchpad* integration by the participants in this study. Of the seven participants, only three had regular access to computers for their students, and these participants demonstrated the most frequent integration of *Sketchpad* and the most coherence to what was learned in the OPD. None of the other four participants had access to student computers, limiting their use of *Sketchpad* and their overall comfort level with *Sketchpad.* This lack of access limited when and how they integrated the technology. These findings are echoed by Bryan (2008) and Zhao et al. (2002).

Teacher beliefs about their own knowledge and skills. According to Beatty (2003) Mouza (2009) and Polly (2011), teachers' implementation of skills learned in professional development is often at a lower level of use and integration than what was modeled in PD. This was evident in classroom observations of four of my participants. Interviews revealed that they lacked the confidence in their knowledge and skills with *Sketchpad.* This perception about their own knowledge and skills was related to their infrequent use of *Sketchpad.* This lack of use was partly explained by their superior knowledge and skills with other technologies more readily available in their classrooms. These teachers were comfortable with the existing technology in their room including SMART Boards, TI-graphing calculators, TI-Navigator systems, and student response clicker systems. Easy accessibility to other technologies and confidence in their knowledge and skill with these other technologies influenced which technology they chose to integrate. Even when *Sketchpad* might have been a more appropriate tool to support student learning, other technologies were chosen because of teachers' lack of confidence in their *Sketchpad* knowledge and skills. Polly (2011) reported something similar with a study participant who expressed comfort levels with familiar technology such as PowerPoint presentations, over newer whiteboard technology, even when the new technology would provide more student engagement.

Teachers' beliefs about their students' behaviors are a critical variable that influences their decisions to integrate technology (Mouza, 2009). According to Mouza, if teachers perceived students' behaviors as something they couldn't control, they were more likely to choose not to integrate technology. This was evidenced in my study with four of my participants, all of whom cited student behaviors as a reason they chose not to integrate *Sketchpad* into classroom instruction. They chose to work with other technology because it provided more engagement for students, since students could get their hands on graphing calculators or the student response systems, whereas *Sketchpad* on the teacher computer only allowed for demonstrations for students to watch. The participants who had large numbers of English language learners and special education students in their classes were significantly less likely to decide to integrate *Sketchpad*, because they felt there would be too much distraction and misunderstanding and potential disruption due to student behaviors.

Time. Time was an external factor that influenced many participants' instructional decisions around integrating *Sketchpad* into their lessons. Time to create materials and implement *Sketchpad* into lessons was reported as a potential barrier to technology integration by Dove (2011). Duran et al. (2012) found that time to practice and learn needed technology skills to incorporate into lessons hindered integration. In my study, the time needed to find content-related activities and the time it took to actually use *Sketchpad* in the classroom with students had a negative influence on participants' decisions to integrate *Sketchpad* in the classroom. This goes back to participants' comfort level and beliefs about their own knowledge and skills with *Sketchpad* and the other technologies in their room. It took less time to find activities and to use other technologies because they used them on a regular basis. For participants who did not use *Sketchpad* regularly, it took too much time to find *Sketchpad* activities, ensure they knew how to use the activities, and then use them with the students.

Classroom structures. Classroom structures played a key role in influencing participants' instructional decisions around integrating *Sketchpad*, including both the physical classroom set-up as well as teacher responsibility within the classroom. For those participants using *Sketchpad* regularly, their classroom structure supported the use of *Sketchpad* in several ways: students had computers for hands-on work; teachers had classroom set-ups that allowed for collaboration, meaning desks that could be easily moved and grouped, students sitting in clusters, or space for students to sit in small groups together around a computer; and teachers practiced effective classroom management strategies when working with technology. These teachers demonstrated classroom structures and management that supported the integration of technology and influenced how often they integrated technology.

Those teachers who did not integrate *Sketchpad* on a regular basis often cited class size as an external force that hindered their instructional decisions around technology integration. Class size played a big part in *Sketchpad* integration, with participants citing the inability to effectively walk around and support students, excessive inappropriate student behaviors, and lack of engagement, due to the large number of students in the room. Additionally, Dave reported being limited in his ability to integrate *Sketchpad* because of his specific classroom responsibilities. Dave was the one participant who had a very different classroom structure, where he was a special-education teacher relegated to teaching only the warm-up and review at the beginning of the class period. This structure emphasized using student response clickers and influenced his *Sketchpad* integration decisions.

Implications for School Leaders: Professional Development Collaborative Planning, Design and Implementation

The four teacher-perceived influences identified in this study impacted participants' instructional decisions around planning and practice for technology integration. These influences, as observed in classrooms and reported and confirmed in interviews, should be considered before educational leaders purchase any new technology or plan for ETPD. As professionals, teachers should have autonomy within their classrooms around their instructional decisions. Teachers are focused on the curriculum and district mandates, and will use the tools and resources they are comfortable with, that fit into their current classroom structures, and that they feel will help them best support student learning. Knowing those structures, what resources are currently available or lacking, and understanding the classroom environments teachers' face will provide educational leaders with data to make appropriate decisions around technology purchases and related ETPD. By focusing on current needs and resources, planning, designing and implementing ETPD that is relevant and sustainable becomes more likely, and more likely to result in development of teachers' TPACK.

Professional development planning. Professional development is important for providing training on new technologies, pedagogies and instructional resources that have been determined to support student learning. This study showed that long-term, hybrid technology OPD did influence teachers' instructional decisions, but that there were several other factors that also influenced those decisions. Limited resources, teachers' beliefs about their own knowledge and skills, and classroom structures are among those factors that should be studied and considered before the actual purchase or use of new technologies and before any ETPD is planned and implemented.

Systematically examining teachers' current classroom structures and technology access is a crucial first step when considering what technologies to purchase or use along with the professional development and support that is required. Other technologies in a classroom often compete with new technologies, as evidenced in this study, where *Sketchpad* competed with SMART Board and graphing calculator tools. Leaders need to analyze the technologies that are in use in teachers' classrooms and determine how any new technologies will either integrate with or compete against the current technologies. This will impact the professional development that is ultimately planned, providing appropriate TK and TPK that directly influences teachers' current technology classroom structures. ETPD can focus on either providing strategies to integrate new technologies with current technologies or providing enough new resources and support to replace existing technologies with more relevant and applicable technologies.

Part of the assessment of classroom structure should entail analyzing student access to computers or tablets, especially when new technology under consideration requires or is best utilized with regular student access. If teachers have no or limited access to the recommended resources, they will be less likely to use the technology, as participants in this study demonstrated. If it is determined that student access to computers or tablets is not possible, educational leaders should consider either not purchasing or using the new technology or, if decisions are made to proceed with a new technology, provide PD focused on strategies for use of the technology with limited student access. Understanding the types of access teachers and students have will help leaders create appropriate PD that focuses on TK and TPK targeted to their specific needs.

Classroom structures should also determine which technologies and training are developed. Classroom structures might include class size, student make-up (special education or language learners), physical layout, or teacher responsibility within a classroom (i.e. co-teacher or teacher assistant). Teachers may be overwhelmed by class sizes and mobility within their room, or limited in what and how they teach due to the types of students in their rooms, student behaviors, or their direct responsibilities within the room. These factors influence a teacher's ability to integrate technology, no matter how appropriate and relevant it is to instruction and student learning.

Educational leaders must consider these contextual factors before deciding on purchasing specific technologies and developing training programs for teachers. An important part of this process is to include teachers and IT personnel in the analysis and decision making. This means involving teachers and IT personnel in the evaluation of classroom structures, eliciting feedback, suggestions, and concerns, and allowing their voice in what resources are ultimately purchased or recommended. The collaboration among leaders, teachers and IT personnel will help ensure that the technology purchased or used will be a good fit for classroom structures and the school or district curriculum focus. Teachers will not integrate technology if they feel their classroom structure is not conducive to the use of that technology. If education leaders are aware of difficulties and potential classroom structure issues ahead of time, with input from the teachers' and IT personnel themselves, they can incorporate strategies and support systems as part of the PD that will help address these issues, with a stronger emphasis on development of PK and TPK.

Additionally, involving IT personnel in the decision process from the outset will help address potential access to resource issues, one of the key influences on teachers' decisions to integrate technology. Having IT personnel involved provides input on what technology will fit into the current school and classroom structures, what potential obstacles may be encountered, and allows educational leaders to plan for potential problems ahead of time. It allows leaders, teachers and IT personnel to work together to ensure that the necessary structures are in place beforehand, so that when it is time to implement a new technology, there are fewer obstacles, such as Internet speed or student access to computers.

Design of technology professional development. Should the decision to utilize a new technology resource be made, reasons for this decision should be made clear. Educational leaders should include as part of the process supportive documentation or modeling of the new technology's demonstrated effectiveness. More importantly, the PD experience should demonstrate how the new technology provides a relative advantage (Rogers, 2003) over other tools to support student learning. This means providing evidence of the technology's relevance to the content they teach and the benefits and differences integrating this technology may provide to instruction and student learning. If teachers are comfortable or satisfied with their current technologies, they are less likely to integrate new technologies into instruction if they believe the new technology doesn't offer anything remarkably different. If they can do similar things with the technology they are already comfortable with, they are unlikely to integrate any new technology, even if they know the newer technology is a more appropriate choice. This could be because they believe they can control students' behaviors more efficiently or effectively using current technologies, or because they can more easily find content-related activities using the current technologies. Leaders need to make a concerted effort, prior to and during any PD on new technology, to demonstrate how the new technology is a better option than what is currently in use and how it will provide better support and strategies for student learning. Additionally, including teachers in the decision-making and planning process will increase teacher buy-in and commitment. Teachers are more likely to have a vested interest in and understanding of the rationale if they were part of the process and decision-making for how the new technology supports their classroom structures and district expectations. This study and others (e.g., Bryan, 2008; Hew & Brush, 2007; Klein, 2009) suggest that curriculum and district expectations impact all instructional decisions teachers make when planning for technology-integrated lessons. Educational leaders, after providing the rationale for the new technology, should plan ETPD with a clear, content-focused agenda, including specific content-related activities and teaching practices to support teachers' use of the technology in their own classroom. Educational leaders should design ETPD to include modeling of instructional strategies that teachers can practice over time and then implement in their classroom. The TPACK teachers gain in ETPD influences their integration of technology if it directly relates to the content they teach and supports strategies for using that technology in their classroom. The designed ETPD should include hands-on, active learning around content-specific activities, along with modeling of both technology and pedagogical strategies provide teachers with a comfort level and awareness of what activities will support student learning and how to use those activities appropriately in their own classroom. If educational leaders have assessed teachers' classroom structures and access ahead of time, the ETPD will also have focused strategies that address teachers' class size, structures, and access to resources. The more relevant the ETPD is for the actual reality of a teacher's classroom, the more likely the knowledge learned in ETPD will influence her instructional decisions.

In this study, participants' greatest influence from the OPD experience on their integration of *Sketchpad* into their classrooms was the pre-made, ready-to-use activities they could match to their content, and that they had seen modeled and had practiced. Educational leaders should focus on TCK, aligning the content-specific activities addressed in the ETPD to the district curriculum map. ETPD should provide multiple experiences over time, for learning and practicing, using these content-specific activities. This allows teachers to gain a comfort level with the technology and have ready-to-use activities they can integrate easily and immediately into their own classrooms. The more ETPD incorporates TPACK and directly connects to teachers' content and classroom, the more likely the integration of technology will occur. Providing ready-to-use, pre-made activities helps teachers begin to use their new skills and technology with relative ease, helping to increase their comfort level. As they continue to use the technology and integrate it into their instruction, they gain confidence and are more likely to see the benefits of using the new technology with their students. This comfort level and confidence is more likely to lead to consistent use of the technology and teachers' desire to use the technology in more advanced ways.

To address the sustained and advanced use of technology, design of ETPD should go beyond just using pre-made, ready-to-use activities to help teachers get started with integrating new technology. As they continue to use the technology, and integrate the ready-to-use activities, they become more comfortable and more likely to move beyond these activities and begin creating and developing their own unique activities. Educational leaders should incorporate continued support and collaboration among teachers that allows them to share and reflect on lessons and work together to create new, unique instructional experiences and lessons into ETPD designs. Blocher et al. (2011) showed that providing opportunities for teachers to collaborate with others over a 3-year period during ETPD resulted in teachers ultimately feeling comfortable enough with their own technology skills to be able to design their own technology lessons.

Implementation. Teachers should know how new technologies support district mandated curriculum and content and what expectations for using these new resources and learning from ETPD are, both during and after ETPD. Teacher autonomy, where teachers make their own decisions based on their knowledge of what will work best with their students, factors in to what technology resources are ultimately used in the classroom. Without expectations for use, teachers, as demonstrated in this study, will choose the technology that they perceive will be most effective for their students within classroom structure. Educational leaders need to set clear expectations of what they expect to see in classrooms, and plan for follow-up, such as classroom observations, and support during the implementation of the ETPD itself, but more importantly, after ETPD is complete. This provides clear understanding and goals for teachers to strive for as they are learning, practicing and implementing knowledge learned in ETPD.

Expectations about the use of the technology in classroom instruction should be made clear before, during and after ETPD. If educational leaders have invested in a technology they have determined will provide needed instructional support and learning opportunities for students, then there should be built in expectations of use in the classroom. Teachers' should be a part of the decision and planning process to ensure that expectations for technology use are appropriate and realistic. These expectations should be explicit, and incorporated into curriculum documents and assessments. The ETPD that is designed should provide training, support and time for practice, with the expectation that educational leaders will be observing classrooms and assessing teachers' use and integration into classroom practice and gathering feedback from teachers.

As part of the built-in expectations, observations and assessments should be consistent, occurring throughout the ETPD and afterwards. These observations and assessments should be of a formative nature, where the information gathered is used to inform what additional support or training might be needed. This shows a commitment to the new technology and to supporting the teachers. The data gathered from observations and teacher feedback provides both insights into how teachers are progressing in their use of the technology, but more importantly, where they are struggling. The information can then be used to provide additional training and support targeted to identified areas of need. Teachers, consciously or not, make decisions about their teaching practices and instructional decisions based on how it fits their classroom needs and instructional goals. If teachers have the sense that a technology initiative is important, they are more likely to continue to learn and practice and make an effort rather than fall back on other technologies. In this study, participants did not have any accountability or continued support for *Sketchpad* use after the OPD experience. As a result, those who did not have the student computers and ease of access reverted back to their other technologies. Without some expectations for use and follow-up by educational leaders, *Sketchpad* integration was minimal or non-existent because it took too much time and effort.

Support from educational leadership and collaboration with peers, whether face-to-face or in online communities of practice, is an important part of ETPD that supported teachers' implementation of technology in classroom practice in prior research (Blocher et al., 2011; Bryant, 2008; Crockett, 2010; Duran, et al., 2012; Martin et al., 2010; Vavasseur and MacGregor, 2008). Educational leaders should consider providing continued opportunities for support and collaboration for teachers after ETPD, so that teachers continue to have opportunities to reflect on their practice, share ideas and get help as they continue to learn to integrate technology. In my study, participants had this type of support only during the OPD experience. With the exception of two participants who taught in the same school, each participant was an isolated user of *Sketchpad* in their schools, despite the program being purchased for all mathematics teachers in the district. There was no support or collaboration with others or encouragement from educational leaders to use the program. It makes sense that if there is an expectation for teachers to use a technology, where they receive long-term ETPD, then providing continued opportunities for support and collaboration can only enhance the continued integration of that technology. Educational leaders should plan for this type of support during and after ETPD, which might be something as simple as an online discussion forum for teachers to share their concerns, lessons and ask questions. As educational leaders observe classrooms and talk to teachers during implementation, they can gather information on what support is needed and consider ways to provide this support. A constant presence from educational leaders before, during and after ETPD, with expectations for use and continued support will help foster consistent use and sustained integration of technology and knowledge learned from ETPD.

Recommendations for Further Research

The purpose of this study was to generate a theory on how OPD and other factors influenced the instructional decisions teachers made regarding planning and implementation of technology into classroom instruction. There was evidence that access to resources that support specific technologies, such as student computers, had a huge impact on whether teachers continued to use and integrate technology in their instructional practice after OPD. In this study, participants had different levels of student computer access, from laptops available for all students, to shared computers in a computer lab a few times a week, to no student computer access, relying solely on a teacher demonstration board such as the SMART Board. Future studies of teachers' instructional practices and decisions around technology integration after professional development might focus on participants with similar access to resources. This will help determine if it is just the access to resources that influences continued use and integration of technology or another factor.

This study focused upon a small number of participants and a 3-month window for data generation. Future research designs that seek to substantiate or revise the theory developed in this study should consider using a larger number of participants with a longer time frame for data collection. This would allow researchers to get a broader perspective of technology integration over time after participation in PD. In addition, these studies could incorporate unplanned observations of classrooms to get a more realistic picture of technology integration practices. The increased number of participants, longer time frame, and unplanned observations may provide a wider source of data and range of use, giving a more longitudinal and realistic insight into teachers' instructional practices around technology integration after OPD.

Educational leaders, when planning for technology professional development, should consider building in this type of long-term research and sustained inquiry into implementation of knowledge learned in professional development into their initial PD plans. The data collected will provide useful insight into continued use of technology resources and knowledge learned in PD, and identify areas where additional support or resources might be needed. According to Pierson and Borthwick (2010), this type of research can provide information on what components from professional development may be influencing teachers' instructional decisions. Incorporating evaluation and instructional implementation into the professional development plan over the long term allows for a continuous information flow about what types of professional development are working and what additional types of technology professional development are needed (Dede et al., 2005; Lawless & Pellegrino, 2007).

The prior TPACK-focused OPD participants in this study were engaged in made use of pre-made, content-specific *Sketchpad* activities that supported the CCSSM and CCSMP. The instructional planning and practices demonstrated by participants during the course of this study focused on the use of these pre-made activities. Researchers interested in studying TPACK after PD could extend the focus and explore teachers' ability to take what they have learned and create their own, original content-related activities. This would require looking at teachers' appropriation and invention stages of technology use (Sandholtz et al., 1997), where they are using technology consistently and creating new approaches to the use of the tool. Mastery of technology integration (Glazer and Page, 2006) means teachers are integrating technology into instruction without support and in new and creative ways, demonstrating particularly strong TPACK. This would require research over a much longer time, as demonstrated by Blocher et al. (2011) in their 3-year study that showed that by year three, teachers were designing their own technology lessons. It would be important to determine what factors, including PD, support teachers' ability to become proficient enough with technology that they begin to experiment and create their own technology content-related activities to support their instructional practices. Educational leaders can then use these findings to create PD experiences and supports that ultimately lead to teachers' strong TPACK development.

The focus of my study was on the integration of *Sketchpad* in classroom instruction after participation in OPD. Participants' access to and comfort level with other technology resources in their classrooms influenced their decisions to use *Sketchpad*. The theory might look different if applied to different technologies. Replicating this study, but focusing on other technologies that teachers use, where they have had PD training, such as the SMART Board or student response systems (clickers), might provide different insight into teachers' technology- related instructional decisions. This type of research might reveal additional influences on teachers' instructional decisions around integrating technology. These studies could include a more diverse participant pool from multiple subject areas, since other technologies, unlike *Sketchpad,* are not necessarily content-specific.

Study Limitations

The theoretical explanations about the influences on teachers' instructional decisions around technology integration may be limited due to the qualitative nature of this study, small sample size and the focus on a specific technology integration tool, *Sketchpad*. Only those teachers with interest in continuing their use of *Sketchpad* were likely to volunteer, which may mean the *Sketchpad* integration observed is not a true reflection of the OPD participants as a whole. Because participants knew ahead of time when they were to be observed and that I was looking for some use of *Sketchpad,* they may have behaved differently than they normally would have. I suspect those who did not regularly use *Sketchpad* in instruction were more nervous and less confident in their instruction, which may have impacted observed student behaviors and teaching practices. Results might have shown different influences on teachers' instructional decisions if more observations and interviews were conducted over a longer frame of time. Additionally, if some of these had been unannounced observations, there might have been a different depiction of what was occurring in classrooms in regard to integration of

Sketchpad. The voluntary nature of participation in this study, along with the pre-scheduled observations and limited number of observations and interviews, may have impacted the findings of this study.

My presence in the classrooms during observations, as well as my use of a video camera to record the teacher, might have influenced the classroom behaviors and teacher actions. The students did notice me and ask who I was in all cases, and may have behaved differently than normal with me in the room, which might have impacted the classroom environment. The video camera also may have made some of the teachers nervous and therefore led them to behave differently than normal, impacting what I observed in the classroom. Cross-comparison of lesson plans, interviews and classroom observations sought to ensure that behaviors and actions seen in the classroom were accounted for and consistent with what was noted in the one-on-one interviews and written lesson plans.

As both the provider of the OPD and the researcher, it is possible that my personal feelings and opinions about the influence of OPD on participants' instructional decisions may have affected my findings. Through triangulation, the constant comparative method, descriptive detail, and member checking, every effort was made to limit my bias.

Conclusion

Professional development, including online professional development, is an important part of assisting teachers in gaining skills, new strategies, tools, and practices to support student learning. Professional development to support technology integration into classroom instruction involves many components, such as learning the technology skills and learning how to appropriately use the technology to teach specific content using relevant pedagogical strategies. Even when ETPD, whether face-to-face or online, incorporates research-based strategies, there are factors that professional development planners should consider to ensure that teachers have what they need to actually integrate the technology once the PD is complete. This includes access to resources, aligning to district mandated standards and curriculum, and readily accessed content-related activities that support appropriate instructional strategies.

It is important to look at teachers' access to resources, even prior to providing PD, to ensure that teachers can integrate technology as desired. It is important to include teachers and IT personnel in the collaborative decision-making process for technology in order to ensure that new technology is appropriate, fits the needs of the classroom, and all necessary access and support issues are addressed. If a technology requires student access to computers, but teachers do not have this access readily available in their classrooms, then its successful implementation is unlikely. If the new technology is similar to or competes with other technologies that teachers already use and are more comfortable with, it is more likely teachers will choose to stick with their current technologies. It is important to provide activities and the ability to find content-related activities using the new technology to influence teachers' decisions to use the new technology over other technologies they find more comfortable and more efficient. Despite knowing that a new technology is a more robust and appropriate tool for learning, teachers will revert to other technologies if they require less time to use and are more readily accessible. This is why involving them in the planning, design and implementation decisions will provide a stronger commitment to learning and integrating the technology into classroom practice.

District mandated standards and curriculum influence all aspects of teachers' instructional decisions, including the commitment to technology integration. Providing content-related activities that support teachers' ability to help students understand the specific content they are teaching using technology is crucial in teachers' decisions to integrate technology. PD should provide teachers with multiple hands-on, content-related experiences, including pedagogical strategies, which they can practice, learn, reflect on and then readily use in their own classrooms. PD activities should emphasize classroom application, pedagogy and technology skills and provide ready-to-use resources teachers can immediately utilize with their own students. The more content-related resources and instructional strategies that can transfer directly into classroom instruction, the more likely teachers are to integrate technology.

Technology integration should be a collaborative process that begins with planning for appropriate technology based on the needs of the classroom, students and teachers. Planning for technology should occur before any technology is purchased and should include educational leaders, teachers, and IT personnel to make sure classroom structures, access issues, and potential integration issues are addressed. This will help ensure that appropriate technology and resources are purchased. Collaboration should continue when designing and implementing the resulting technology professional development. This provides appropriate expectations, activities, support, and continuous feedback that are more likely to result in sustained implementation of technology after professional development.

Gray, B. (2004). Informal learning in an online community of practice. *Journal of Distance Education, 19*(1), 20–35.

Gray, L., Thomas, N., and Lewis, L. (2010). *Teachers' use of educational technology in U.S. public schools: 2009.* Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Guskey, T. (2003). What makes professional development effective? Results from a national sample of teachers. *Phi Delta Kappan, 84*(10), 748-750.

Guskey, T. & Sparks, D. (2002). *Linking professional development to improvements in student learning*. Paper presented at the Annual Meeting of the American Educational Research Association 2002, 1-5 April, New Orleans, LA.

Harp, C. & Taylor, S. (1998). Computer training and individual differences: When method matters. *Human Resource Development Quarterly, 9*(3), 271-283.

Harris, J. (2008a, February). One size doesn't fit all: Customizing educational technology professional development: Part one: Choosing ETPD goals. *Learning and Leading with Technology,* 19-23.

Harris, J. (2008b, April). One size doesn't fit all: Customizing educational technology professional development: Part two: Choosing ETPD models. *Learning and Leading with Technology,* 22-26.

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

Harris, J., Grandgenett, N. & Hofer, M. (2012). Testing an instrument using structured interviews to assess experienced teachers' TPACK. In C. D. Maddux, D. Gibson, & R. Rose (Eds.). *Research highlights in technology and teacher education 2012* (pp. 4696- 4702). Chesapeake, VA: Society for Information Technology & Teacher Education (SITE). Retrieved from http://www.editlib.org

Hew, K. & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations. *Educational Technology Research Development, 55*(3), 223-252.

Hofer, M., Grandgenett, N., Harris, J. & Swan, K. (2011). Testing a TPACK-based technology integration observation instrument. In C. D. Maddux, D. Gibson, B. Dodge, M. Koehler, P. Mishra, & C. Owens (Eds.). *Research highlights in technology and teacher education 2011* (pp. 39-46). Chesapeake, VA: Society for Information Technology & Teacher Education (SITE). Retrieved from http://www.editlib.org/p/37015

Holmes, A., Signer, B. & MacLeod, A. (2010). Professional development at a distance: A mixed-methods study exploring inservice teachers' views on presence online. *Journal of Digital Learning in Teacher Education, 27* (2), 76-85.

Hughes, J. (2005). The role of teacher knowledge and learning experiences in forming technology-integrated pedagogy. *Journal of Technology & Teacher Education, 13*(2), 277-302.

Hurt, A. (2007). *Exploring the process of adult computer software training using adragogy, situated cognition, and a minimalist approach.* Paper presented at the

International Research Conference in the Americas of the Academy of Human Resource Development 2007, 28 February - 4 March. Indianapolis, IN.

Ingvarson, L., Meiers, M. & Beavis, A. (2005). Factors affecting the impact of professional development programs on teachers' knowledge, practice, student outcomes & efficacy. *Professional Development for Teachers and School Leaders, 13*(10), 1-28.

ISTE. (2008). *The ISTE NETS and performance indicators for teachers (NETS-T).* Washington, DC: Author.

Kanaya, T., Light, D. & Culp, K. (2005). Factors influencing outcomes from a technology-focused professional development program. *Journal of Research on Technology in Education, 37*(3), 313-329.

Key Curriculum Press. (2007). *Teaching Algebra with The Geometer's Sketchpad®* [online course]. Emeryville, CA: Key Curriculum.

Key Curriculum Press. (2008). *Sketchpad LessonLink™.* [online lesson database]. Emeryville, CA: Key Curriculum.

Key Curriculum Press. (2010). *Teaching Middle School Math with The Geometer's Sketchpad®.* [online course]. Emeryville, CA: Key Curriculum.

KCP Technologies, Inc. (2011). The Geometer's Sketchpad® Dynamic Geometry® Software for Exploring Mathematics (Version 5.04) [computer software]. Available from http://www.keycurriculum.com/sketchpad/download

Klein, E. & Riordan, M. (2009). Putting professional development into practice: A framework for how teachers in expeditionary learning schools implement professional development. *Teacher Education Quarterly, 36*(4), 61-80.

Kop, R., Fournier, H. & Mak, J. (2011). A pedagogy of abundance or a pedagogy to support human beings? Participant support on massive open online courses. *International Review of of Research in Open and Distance Learning, 12*(7), 74-93.

Krefting, L. (1991). Rigor in qualitative research: The assessment of trustworthiness. *The American Journal of Occupational Therapy, 45*(3), 214-222.

Lawless, K., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research, 77*(4), 575-614.

Leach, J., Harrison, D., McCormick, B. & Moon, B. (2004). Developing teacher knowledge and pedagogy in a large-scale, electronic conference environment for professional development. In C. Vrasidas & G. Glass (Eds.), *Online professional development for teachers* (pp. 31-50). Greenwich, CT: Information Age Publishing.

Lightbody, M. & Jones, L. (1998). *Comparison of the efficacy of different models of technology instruction for inservice teachers.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching 1998, 24-29 June, San Diego, CA.

Macleod, A. (2010). Professional development at a distance: A mixed-method study exploring in-service teachers' views on presence online. *Journal of Digital Learning in Teacher Education, 27*(2), 76-85.

Martin, W., Strother, S., Beglau, M., Bates, L., Reitzes, T. & Culp, K. (2010). Connecting instructional technology professional development to teacher and student outcomes. *Journal of Research on Technology in Education, 43*(1), 53-74.

Merriam, S. (1995). What can you tell from an N of 1?: Issues of validity and reliability in qualitative research. *PAACE Journal of Lifelong Learning, 4,* 51-60.

Merriam, S. (1998). *Qualitative research and case study applications in education: Revised and expanded from case study research in education.* San Francisco: Jossey-Bass.

Mishra, P. & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108* (6), 1017-1054.

Morrow, D. (2002). *Information and communication technologies in the teaching and learning process: Does online professional development make a difference*. Paper presented at the Media 2002 World Conference on Educational Multimedia, Hypermedia & Telecommunications 2002, 24-29 June, Denver, CO.

Mouza, C. (2009). Does research-based professional development make a difference? A longitudinal investigation of teacher learning in technology integration. *The Teachers College Record, 111*(5), 1195-1241.

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics*. Washington, DC: Author. Retrieved from http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf

National Research Council, Mathematics Learning Study. (2001). *Adding it up: Helping children learn mathematics.* Washington, DC: Author.

National Staff Development Council. (2012a). Definition of professional development. Retrieved from http://www.learningforward.org/standfor/definition.cfm

Polly, D. (2011). Developing teacher's technological, pedagogical, and content knowledge (TPACK) through mathematics professional development. *International Journal for Technology in Mathematics, 18*(2), 83-96.

Polly, D., & Hannafin, M. (2010). Reexamining technology's role in learner-centered professional development. *Education Tech Research, 58,* 557-571.

Quick, H., Holtzman, D. & Chaney, K. (2009). Professional development and instructional practice: Conceptions and evidence of effectiveness. *Journal of Education for Students Placed at Risk, 14*(1), 45-71.

Ramsdell, R., Rose, R. & Kadera, M. (2006). PBS TeacherLine and Concord Consortium's seeing math secondary: Scaling up a national professional development program. In C. Dede (Ed.), *Online professional development for teachers: Emerging models and methods* (pp. 69-88). Cambridge, MA: Harvard Education Press.

Richardson, W. & Mancabelli, R. (2011). *Personal learning networks: Using the power of connections to transform education.* Bloomington, IL: Solution Tree.

Reeves, D. (2010). *Transforming professional development into student results.* Alexandria, VA: ASCD.

Roschelle, J., Schechtman, N., Tatar, D., Hegadus, S., Hopkints, B., Empson, S, Knudsen, J. & Gallagher, L. (2010). Integration of technology, curriculum, and professional development for advancing middle school mathematics: Three large-scale studies. *American Educational Research Journal, 47*(4), 833-878.

Russell, M., Kleiman, G., Carey, R., & Douglas, J. (2009). Comparing self-paced and cohort-based online courses for teachers. *Journal of Research and Technology in Education, 41*(4), 443-466.

Sandholtz, J., Dwyer, D., & Ringstaff, C. (1996). *Teaching with technology: Creating student-centered classrooms.* New York, NY: Teachers College Press.

Schmidt, D., Baran, E., Thompson, A., Koehler, M., Mishra, P. & Shin, T. (2009). *Survey of preservice teachers' knowledge of teaching and technology.* Retrieved from http://tpack.org/

Silverman, J. (2012). Exploring the relationship between teachers prominence in online collaboration and the development of mathematical content knowledge for teaching. *Journal of Technology and Teacher Education, 20*(1), 47-69.

Smith, J. & Sivo, S. (2011). Predicting continued use of online teacher professional development and the influence of social presence and sociability. *British Journal of Educational Technology,42*(1), *1*-12.

Sugar, W. & Wilson, K. (2005). Seeking alternatives to inservice technology workshops from teachers' perspectives. *Journal of Computing in Teacher Education, 21*(4), 91-98.

Swan, K., Jennings, S. & Rubenfeld, L. (2002). *Situated professional development: The CATIE model.* Paper presented at the 14th annual Ed-Media World Conference on Educational Multimedia, Hypermedia & Telecommunications 2002, 24-29 June, Denver, CO.

Turner, J., Warzon, K. & Christensen, A. (2010). Motivating mathematics learning: Changes in teachers' practices and beliefs during a nine-month collaboration. *American Educational Research Journal, 48*(3), 718-762.

Thurlow, J. (1999). *Teachers as technologists: Professional development for technology integration.* Paper presented at the Annual Meeting of the International Reading Association 1999, 2-7 May, San Diego, CA.

Vavasseur, C. & MacGregor, S.K. (2008). Extending content-focused professional development through online communities of practice. *Journal of Research on Technology in Education, 40*(4), 517-536.

Vrasidas, C. & Glass, G. (2004). *Online professional development for teachers.* Greenwich, CT: Information Age Publishing.

Wallace, M. (2009). Making sense of the links: Professional development, teacher practices, and student achievement. *The Teachers College Record, 111*(2), 573-596.

Wiske, M., Perkins, D. & Spicer, D. (2006). Piaget goes digital: Negotiating accommodation of practice to principles. In C. Dede (Ed.), *Online professional development for teachers: Emerging models and methods* (pp. 49-67). Cambridge, MA: Harvard Education Press.

Yoon, K., Duncan, T., Lee, S., Scarloss, B. & Shapley, K. (2007). *Reviewing the evidence on how teacher professional development affects students achievement.* (Issues and Answers Report, REL 2007, no. 033). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest. Retrieved from http://ies.ed.gov/ncee/edlabs/projects

Zhao, Y., Pugh, K., Sheldon, S. & Byers, J. (2002). Conditions for classroom technology innovations. *Teachers College Record, 104*(3), 482-515.

Appendix A: Informed Consent

The College of William and Mary

Title of Study: How Teachers Use Math Technology in Instructional Practice after Professional Development

Principal Investigator: Karen Greenhaus
School of Education, Curriculum and Education Technology Program
114 S. Clovergate Circle
The Woodlands, TX 77382
757-286-2451
kgreenhaus@keypress.com

Background:
You are invited to participate in a study conducted by Karen Greenhaus. I hope to learn about how you are integrating *The Geometer's Sketchpad* in your classroom practices and how, if at all, the professional development has impacted your instructional decisions and what, if any, other factors contribute to your instructional decisions. You were selected as a possible participant in this study because you are part of the cohort of teachers involved in the 7-month hybrid professional development that occurred on integrating *The Geometer's Sketchpad.*.

The purpose of this study is to document what happens in your classroom around integration of *The Geometer's Sketchpad* and what factors influence your instructional decisions around integrating this technology. This includes gathering detailed information from classroom observations, personal interviews, and lesson plans focused on technology integration. The data gathered will be analyzed for patterns that will provide insight into how technology is being integrated and what factors, including the professional development experience, are influencing those instructional decisions.

Study Procedure:
If you decide to participate, Karen Greenhaus, over a three month span of time, will observe you teaching at least 2 different times; interview you after each observation, with a follow-up phone interview. If additional observations or interviews are needed, you will be notified ahead of time. You will be asked to provide at least two different lesson plans demonstrating integration of *The Geometer's Sketchpad.* All observations and interviews will be recorded and transcribed and transcriptions will be provided to you via email for your input and confirmation of the interpretations. Data from observations, interviews, and lesson plans will be analyzed to find patterns and identify factors that influence your instructional decisions.
Risks and Benefits:

There are no known risks, discomforts, or inconveniences expected from your participation in this study; however we cannot guarantee you will receive any benefits from this study. You will be provided with the video tape of your classroom observations and the transcribed notes from observations and interviews which may inform your instructional practice.

Confidentiality:
Every effort will be made by the researcher to preserve your confidentiality including the following:

1. Assigning code pseudonyms for participants that will be used on all researcher notes and documents.
2. Notes, interview transcriptions, and transcribed notes and any other identifying participant information will be kept in a locked file cabinet in the personal possession of the researcher. When no longer necessary for research, all materials will be destroyed,
3. The researcher and the members of the researcher's committee will review the researcher's collected data. Information from this research will be used solely for the purpose of this study and any publications that may result from this study. Any final publication will contain the names of the public figures that have consented to participate in this study (unless a public figure participant has requested anonymity): all other participants involved in this study will not be identified and their anonymity will be maintained
4. Each participant will obtain a transcribed copy of their observations and interviews. These will be provided via email and all participants have the opportunity to read and check the researchers analysis and provide feedback and comments as to the plausibility of the interpretations..
5. Each participant can obtain a transcribed copy of this study if they so desire.

Person to Contact:
Should you have any questions about the research or any related matters, please contact the researcher at kgreenhokie@gmail.com.

Institutional Review Board:
If you have questions regarding your rights as a research subject, or if problems arise which you do not feel you can discuss with the researcher, please contact the Institutional Review Board Office at 801-863-8455.

Voluntary Participation:
Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you do decide to take part in this study, you will be asked to sign a consent form. If you decide to take part in this study, you are still free to withdraw at any time and without giving a reason. This will not affect the relationship you have with the researcher.

Unforeseeable Risks:
There may be risks that are not anticipated. However every effort will be made to minimize any risks.

Costs to Subject:
There are no costs to you for your participation in this study.

Compensation:
There is no monetary compensation to you for your participation in this study.

Consent:
By signing this consent form, I confirm that I have read and understood the information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Signature ______________________________ Date ____________________________

Appendix B: Observation Protocol

Teacher Name ____________________
Date of Observation ____________________
Start Time __________ End Time __________
Observer (s) ____________________________
Subject/Level ____

<u>Observation Notes</u>

Guiding Questions/Look For:	Notes/comments on classroom activity, student/teacher actions and behaviors, especially those related to Sketchpad use and CCSSM/SMP
Lesson focus • **Math content or topic?** • **CCSSM** • **Goal?**	
Technology Use • **Sketchpad?** • **Other Technology?**	
Pedagogical Practice • **Teaching strategies?** • **Student engagement?**	
Other • **Classroom structures?** • **Other factors?**	

Appendix C: Semi-Structured Interview Questions

1. What was the CCSS/math content/topic focus for this lesson and why did you choose this topic?
2. What prior experience did your students have with this content/topic?
3. Please explain your planning process and choice of activities. (Be sure to ask about Sketchpad and how it fits the lesson).
4. What prior experience have your students had with Sketchpad in the classroom?
5. Did you plan for or focus on any specific standards of mathematical practice? If so, which ones and why those?
6. Were there any concepts or materials from the professional development experience that helped you plan for or implement this lesson? If so, which ones, and why did you choose those to use?
7. How do you feel the lesson went?
8. What challenges, if any, did you encounter during the lesson?
9. Was there anything you would alter from the lesson, and if so, what and why?
10. Beyond your own instructional planning and decision making, were there other factors that influenced the activities and strategies you chose for this lesson?

Appendix D: Lesson Plan Template

LESSON PLAN

Course: _____ Teacher(s): _____

Chapter and Lesson _____ Lesson Name _____ Date(s): _____

Common Core Math Standard (s):

Materials to be used, including technology:

Assessments:

Common Core Standards of Mathematical Practices: Please explain how these are addressed, if applicable.

1. Make sense of problems and persevere in solving them:
2. Reason abstractly and quantitatively:
3. Construct viable arguments and critique the reasoning of others:
4. Model with mathematics:
5. Use appropriate tools strategically:
6. Attend to precision:
7. Look for and make use of structure:
8. Look for and express regularity in repeated reasoning:

The Plan	CC Mathematical Practices/Notes/Questions (identify CCSMP by #1, 2, …#8)
LAUNCH (Introducing)	
EXPLORE (Making, Investigating, Finding . . .)	
SUMMARIZE (Closing the Lesson, Discussing, Writing)	
APPLY (Solving in a New Context)	
Assignment/Assessment	

Appendix E: Sample Coded Observation Transcript

Premade model
Technology - basic skills of Sketch.

[00:24:01.27] Teacher: Here we are going to be looking at the lines. We can turn them on and off when we want to. We can find out intersection points from here. So that's going to be really helpful. Uh, depending on what we are using we can do different things with it. so this one we are going to be using systems of equations. But they have all different kinds where you can do all different activities with them, so it's pretty nice.

Modeling → Connections
Visual representation
Other Technology - Smart Board

[00:24:21.04] Teacher: There's actually some where. so this one here I'm going to show you guys, Im gonna have you. We're going to kinda go through it togehter and work out together. There's ones where you can actually get a sheet and start out with a blank page or maybe some stuff that they start you off with and work through it and actually do some really really cool math with it. So this is kind of our start here of um getting to use it, but we are going to be using it more as the year goes.

Not familiar w/ technology (sketch pad)
Premade
Modeling; Technology Basic skills

[00:24:44.01] Teacher: So, this right here is, we're going to deal with a situation where we have two rental systems, alright? So, the end of the month is a popular time to move so many people rent moving trucks. Each truck renting company has it's own formula for determin the price for renting a truck. The rental rates depend on two factors: the drive off fee and the price per mile driven. So on these....

Real world connection
Visual modeling
Connections - visual to formula

(teacher writing on smart board - getting equations up - irrelevant conversation occurring)

Other technology - Smart Board

[00:26:10.12] Teacher: So write these inyour notebook please. Write these in your notebook. We are going to do solving systems of equations as your title.

Classroom management - note taking

[00:26:56.27] Teacher: Alright, so here we have the two different companys. Cercano and We haulit are two company's. This is the rates. Automatically once they drive off the lot they charge $12 for this one and each additional mile they charge 2 dollars and 75 cents. Here at wehaulit they charge 42.50 but only .40 cents per mile. So looking at these right here, which one do you think you would go with?

Real world connections
Conjecturing

(we haul it)

Analyzing situation
Modeling with technology
Asking questions.

Appendix F: Sample Coded Observation Protocol

[redacted]

Appendix A: Observation Protocol

* Premade sketch
* giving them a reason for solving
* [illegible] tool → did alot of work
* Use Smart in conjunction w/ Sketch
* Quick polls for assessment
* Sum Up → CC → #1, #2
* making connection to tomorrow's lesson; How to find w/out

Observation Notes

Guiding Questions/Look For:	Notes/comments on classroom activity, student/teacher actions and behaviors, especially those related to Sketchpad use and CCSS/SMP	Coding – CCSS/SMP, Sketchpad
Lesson focus • **Math content or topic?** • **CCSS?** • **Goal?**	systems → Review and application of linear equati In the curriculum; CCSS → real world application. Real world app → solidifying understanding.	CCSS → standards conjectures Real-world – SMP
Technology Use • **Sketchpad?** • **Other Technology?**	TI-Navigators/hubs @ each desk → clicker/quick checks SMART BOARD; Navigator (class mgmt) -Poll Results to catch misunderstanding -CC - going over reasoning & logic -making conjecture. good support of kids.	-modeling -other technology -Premades -Basic use
Pedagogical Practice • **Teaching strategies?** • **Student engagement?**	-clickers for a formative assessment -Routine → learning check as they come in/timed -Questioning - relatively simple -States goal	-Making connections Real world -conjectures -questioning - simple
Other • **Classroom structures?** • **Other factors?**	-Large class → -Good questioning -Why would I want to - getting kids to make conjecture	-Class size -Tech desks

- excited to use Sketchpad cause its quick, easy and really visual.
- kids engaged; using clicker to keep kids in control,
* students taking notes in "notebook" →
* kids asking good questions
* what do you notice - excellent / rate is less 40

-Modeling
-Engagement
-Communication & conjectures
-Problem solving

Appendix G: Sample Coded Interview

P#2 [redacted] Interview #1

1. What was the CCSS/math content/topic focus for this lesson and why did you choose this topic?
   - Solving systems of equations using graphs and point of intersection. — MPS/CCSS Standards
   - Real-world examples of systems of equations — Real World Connection
   - This topic is in the pacing guide and curriculum and is where we are right now in the lesson — MPS standards | district pacing

2. Explain a little bit about your planning process and choice of activities. (Be sure to ask about Sketchpad and how it fits the lesson).
   - The activities in the lesson were based on the content required to be covered in the pacing — District Pacing
   - The use of Sketchpad was because I knew Karen was coming, so it forced the issue and activity — Tech basics — Premade, observation stress, Forced
   - The Sketchpad activity actually turned out to be a really good fit and I think worked great to help reinforce what they had learned and prepare them for solving with substitution that is coming up — Connections; modeling; visual

3. Did you plan for or focus on any specific standards of mathematical practice? If so, which ones and why those? — questioning
   - I didn't plan specifically for the practices, but I focus on good teaching strategies, which include the questioning and conjecturing. These are part of the practices, but for me it's just good teaching strategies. — Conjecture — SMP awareness

4. Were there any concepts or materials from the professional development experience that helped you plan for or implement this lesson? — Premade
   - It's really helpful having the premade lessons and, when I have specific content areas I am planning to teach, knowing specific Sketchpad activities that will fit is something that the PD helps me plan for. — Ease of use — Time saver — Awareness of content fit

5. How do you feel the lesson went?
   - It went really well. I think they really got it and could see how the graphs and the point of intersection were able to get a close answer. — Model — connections — visual

6. Any challenges from the lesson?
   - Some of the student behaviors. — class structures - behaviors
   - Getting Sketchpad to work better with the SMartboard, but I could just go to the computer to fix that. — other technology — Comfort level w/ other tech.

7. Was there anything you would alter from the lesson, and if so, what and why?

Maybe having the kids come up with more examples of real-world things. But overall I thought it went really well.

- Real world
- Making connections (SMP)

8. Were there other factors that influenced the activities and strategies you chose for this lesson?
Time is always something – it's hard to find the time to get activities, so I tend to use the things from the book or that I already have on the TI navigator or smart board.

- Time for planning/
- Other technology – comfort level
- Ease of use

Appendix H: Sample Coded Lesson Plan

LESSON PLAN

Course: 6th bilingual [redacted]

Chapter and Lesson Chapter 10, Lesson 1 **Lesson Name** Ratio, Proportion and Percent **Date(s):**

Common Core Math Standard (s): 6R.P.3 Ratios and Proportional Reasoning: Use ratio and proportional reasoning to solve real-world and mathematical problems. – MPS + CCSS standards
– Real World
– Problem solving

other resources

Materials to be used, including technology: Graph paper, pencil, laptops with Geometer's Sketchpad, Graphic Calculator TI-84 – Other technology Technology Sketchpad

Assessments: Unit/Chapter Assessment / Math Forward Curriculum TI-73 and TI-84 Warm-Up Exercises Other Technology

Common Core Standards of Mathematical Practices – explain how these are addressed, if applicable

1. Make sense of problems and persevere in solving them: – Planning for SMP
2. Reason abstractly and quantitatively:
3. Construct viable arguments and critique the reasoning of others:
4. Model with mathematics: Students compare the price of 4-pack and 8-pack batteries. They use rates and proportional reasoning to solve the problem arithmetically. They also find a simple equation for each pack, tabulate their values, and graph their solutions. Students find a linear equation, measure the slope, and realize that the slope is the unit rate of each battery. Students create a graph in Sketchpad illustrating this problem. They contrast their manual graph and operations with the ones created with Sketchpad. They use Sketchpad to evaluate their solutions using paper and pencil. (They can also use TI-84 to check their coordinate values, and their graphs>) – Other technology – Modeling – Other Resources – Students w/ technology
5. Use appropriate tools strategically: Students must be able to navigate from paper and pencil, to Sketchpad, to TI-84, and setup the applications properly. They must be able to compare the three representations, and evaluate the usefulness of each. – Other Resources – other technology – Making connections
6. Attend to precision:
7. Look for and make use of structure:
8. Look for and express regularity in repeated reasoning:

The Plan	CC Mathematical Practices/Notes/Questions (identify CCSMP by #1, 2, ...#8)
LAUNCH (Introducing)	
Battery Problem What is the best buy a 4-battery pack for $3.60, or a 8-battery pack for $6.80?	2, 3 – Questioning - Conjecture – Real-world
EXPLORE (Making, Investigating, Finding . . .)	
Find the unit rate by dividing. Write this problem as a proportion equation. Create two simple equations that relate the unit rate times the number of batteries (y = 0.90x and y = 0.85x). Construct a table with x=number of batteries, y = total price, for each of the equations. Graph both equations: one line for the 4-pack and the other for the 8-pack. Use Sketchpad to graph the 4-battery and the 8-battery tables. Measure slope and find the equation. Compare both representations. Use TI-84 graphic calculators to plot the equations, and analyze the table of values and the graphs.	3, 5 – Making connections (visual to formula) – Real world – Modeling (SMP) – Technology use - students – Other technology to compare. – Making connections – Other technology
SUMMARIZE (*Closing the Lesson*, Discussing, Writing)	
Analyze the slope of both equations. Relate the slope with the unit rate. Visualize how the more or less slope of lines in these kind of problems will always mean the best buy. Reinforce the concept of unit rate, and the method to calculate it.	– Making connections – Real world application. – Technology - visual model
APPLY (Solving in a New Context)	
Students can use the same model to solve any everyday problem of difference in prices.	4 – Use technology to model – Make connections
Assignment/Assessment Graphs: Sketchpad and paper-and-pencil. Sketchpad extended response of why their answer is reasonable. Solve new problem comparing prices of snacks (tostitos and potato chips)	4 – Other Resources – Justification / conjecture – Problem solving

- Planning for SMP

Appendix I: Sample Memo

Memos

- Seems to be used as demo more than anything
- Very little student interaction w/the program
- Improved Questioning seems to be biggest change

* Teachers focus on pre mades (emphasized in training)
* Smartboard/TI - tend to revert to smart tools/tech they are familiar with
  - ease of putting it in their notes?
* Short, quick visuals seem to be predominant approach.
* Class size and access to tools determine usage.

Disappointed - use of Sketchpad @ such a basic level + minimal use

- Is it the school culture?
- Classroom size?
- Make up of students?

Resources available seem scarce

- manipulatives
- technology

* Class size seems to have really impact what they do.

Appendix J: Sample Memo

Memos

[illegible] Sketchpad is used for modeling often
- as a visual to review or introduce math content
-

- Teachers w/out computer access for students use it wholely as a demonstration.
  - Students rarely get their hands on Sketch.

4/13 - Other technology predominant
  - Graphing calculators
  - SB by teachers.

10/13 - Classroom Structure determines use of tech?
  - Open, collaborative classrooms have more interaction w/software and more student communication amongst each other.
  - Larger classes w/ less tech seem to be more traditional in structure + instruction; less student collab + communication

Appendix K: Sample Participant Summary and Member Check

Excerpt from Summary 1:

5) When you use Sketchpad in a lesson you are usually pleased with how it works and how it engages the students. You make a conscious effort to use hands-on materials as well as the technology. You feel Sketchpad provides them a way to extend what they have done hands on and helps them understand better. The visuals really help the students make connections better. Being able to use Sketchpad regularly has made the students very comfortable with it.

6) When you use Sketchpad in a lesson, it can be frustrating when not all the computers work due to the version of Sketchpad that is on it. Students are also engaged in the activities more sometimes too since Sketchpad is more interactive, though sometimes there are those who are not catching on. But using partners is very helpful with this and gets the students talking about math with each other.

7) While you know Sketchpad really helps engage the students and allows more visuals and understanding of some difficult concepts, finding the pre-made activities takes time. You have a good library of activities but you would like to have the time to find more. And you are still not comfortable doing something completely from scratch with Sketchpad because you haven't had the time to practice that.

Member Check/Feedback:

I went through the transcripts and the videos, and I admire how you could come up with your summary, when there were so many scattered words. Great job in making sense of all the rambling there. Now these are my comments:

I also use Sketchpad to deepen concepts where visualization is indispensable. For example, students construct their own triangles and quadrilaterals (following the Sketchpad rules for construction) and then take measurements and prove basic axioms (for example, sum of internal angles, sum of internal and external angles). I use Sketchpad very much to teach geometry (angles, lines, triangles, quadrilaterals and circles).

I also use Sketchpad all the time to teach rates, ratios and proportions, linear equations and quadratic equations.

For all these free applications of Sketchpad, students are expected to do paper and pencil graphs and calculations and use technology (Sketchpad and TI-84) to confirm their answers. A good reason to do this is that kids have expressed that they cannot do things manually, only with technology. This is why I try to use technology as the most powerful addition, but never substituting students' calculations and reasoning.

Excerpt from Summary 2:

1) The Common Core standards and MPS curriculum/pacing influence what content you teach on a daily basis. You choose the topics you teach based on the subject you are teaching and the pacing guides given from the district. These include specific CC standards.

2) When you plan, your content determines the activities you use. You have had a lot of training in the TI-84 and navigator, so you use that a lot to engage your students. You also use the SMART Board and SMART Board tools because it is the major technology you have in your classroom and you are very familiar with it and comfortable with it. Sketchpad and what you learned in the Sketchpad PD was very helpful and you want to use that more, but it takes time to find activities that match the content you want to teach. You like the pre-made activities and they work out really well when you find one that fits. However, unless you know of an activity that fits, you won't necessarily go to Sketchpad first in your lesson plans because it takes more time to find something. You would like to use it more though because it does really reinforce things and show them things that are hard to demonstrate with something else.

3) The Common Core content standards determine what you will teach. The CC Standards of Practice are also used, but are not something you specifically plan for, like you do the content. You do focus on good teaching strategies, which include the Standards of Practice focus on questioning and conjecturing. You try to help the students think critically, use tools appropriately, and make sense and persevere in problem solving. You make a conscious effort to use good questioning techniques and teaching strategies. The PD helped make you more aware of these practices.

4) You would like to incorporate more Sketchpad, but unless someone is there observing and looking for it (like Karen), you are more likely to stick with the SMART Board and TI-Navigator. While you know Sketchpad really helps engage the students and allows more visuals and understanding of some difficult concepts, finding the pre-made activities takes time. And you are still not comfortable doing something completely from scratch with Sketchpad because you haven't had the time to practice that.

Member Check/Feedback:

I agree with all my comments and wouldn't really add much EXCEPT now that I'm not teaching geometry, I haven't used it thus far this year, but know I will with linear and systems. I really loved it with properties in geometry.*

*This member check was done in October, 2013, after the study was complete, so this participant is referring to the current school year.

Appendix L: Initial Coding by Categories

Instructional Decisions	
District mandated standards	Student Perseverance
Pacing Guide	Making Conjectures
Common Core State Standards	Student Communication
Content Related Activities	Problem Solving
Pre-made content-focused technology activities	Justification and explaining
Simple Questioning	Recall Questioning
Student Reflection	Student Collaboration
Technology Strategies	
Multiple Representations	Multiple Approaches & Solutions
Real-world Applications	Direct Teaching
Connecting Formulas to Visuals	Providing Visuals
Whole Class Instruction/Modeling	Student Choice
Providing Simulations	Making Connections
Walking Around	Testing Conjectures
Student Grouping(pairs/small groups)	
Other Influences	
TI-84 Graphing Calculator	SMART Board
TI-Navigator (student response system)	Other Student Response System
Lack of Computers (student)	Number of Students
Student Behaviors	Classroom Structure
Comfort with Other Technology	Time

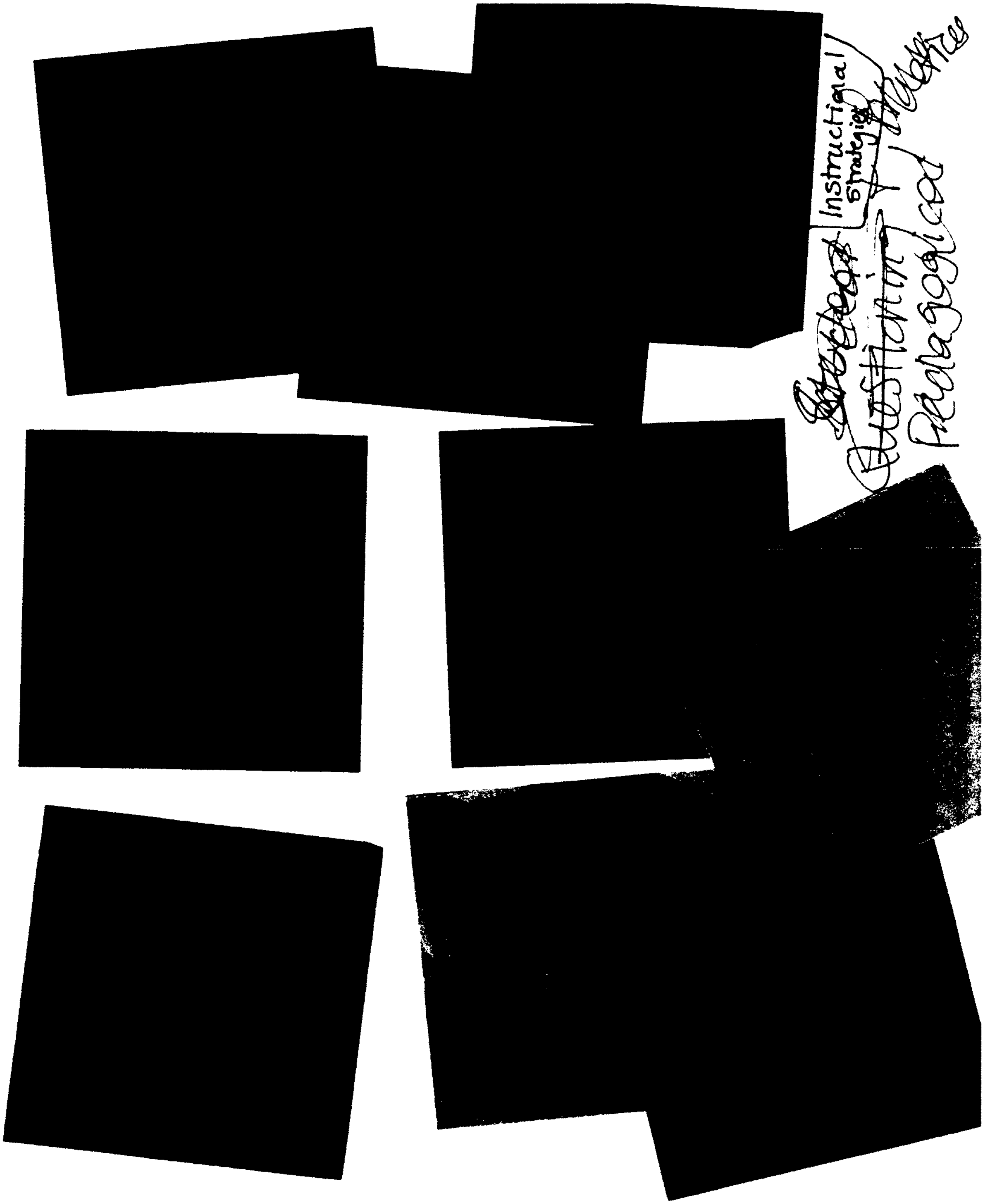
Appendix M: First Categorization of Initial Codes

Initial Codes	Type of Decision
Classroom Structure	Other Influence
Comfort with other Technology	Other Influence
Common Core State Standards (CCSS)	Instructional
Connecting Formulas to Visuals	Technology
Content Related Activities	Instructional
Direct Teaching	Technology
Districted mandated standards	Instructional
Justification and explaining	Instructional
Lack of computers (student)	Other Influence
Making Conjectures	Instructional
Making Connections	Technology
Multiple Approaches & Solutions	Technology
Multiple Representations	Technology
Number of Students	Other Influence
Other Student Response system	Other Influence
Pacing Guide	Instructional
Pre-made content-focused technology activities	Instructional
Problem Solving	Instructional
Providing Simulations	Technology
Providing Visuals	Technology
Real-world Applications	Technology
Recall Questioning	Instructional
Simple Questioning	Instructional
SMART Board	Other Influence
Student Behaviors	Other Influence
Student Choice	Technology
Student Collaboration	Instructional
Student Communication	Instructional
Student Grouping (pairs/small groups)	Technology
Student Perseverance	Instructional
Student Reflection	Instructional
Testing Conjectures	Technology
TI-84 Graphing Calculator	Other Influence
Time	Other Influence
TI-Navigator (student response system)	Other Influence
Walking Around	Technology
Whole Class Instruction/Modeling	Technology

Appendix N: Snapshot of Post-it Note Intermediate Coding Organization

Appendix O: Sample Post-it Category

[redacted]



Appendix P: Intermediate Coding Categories

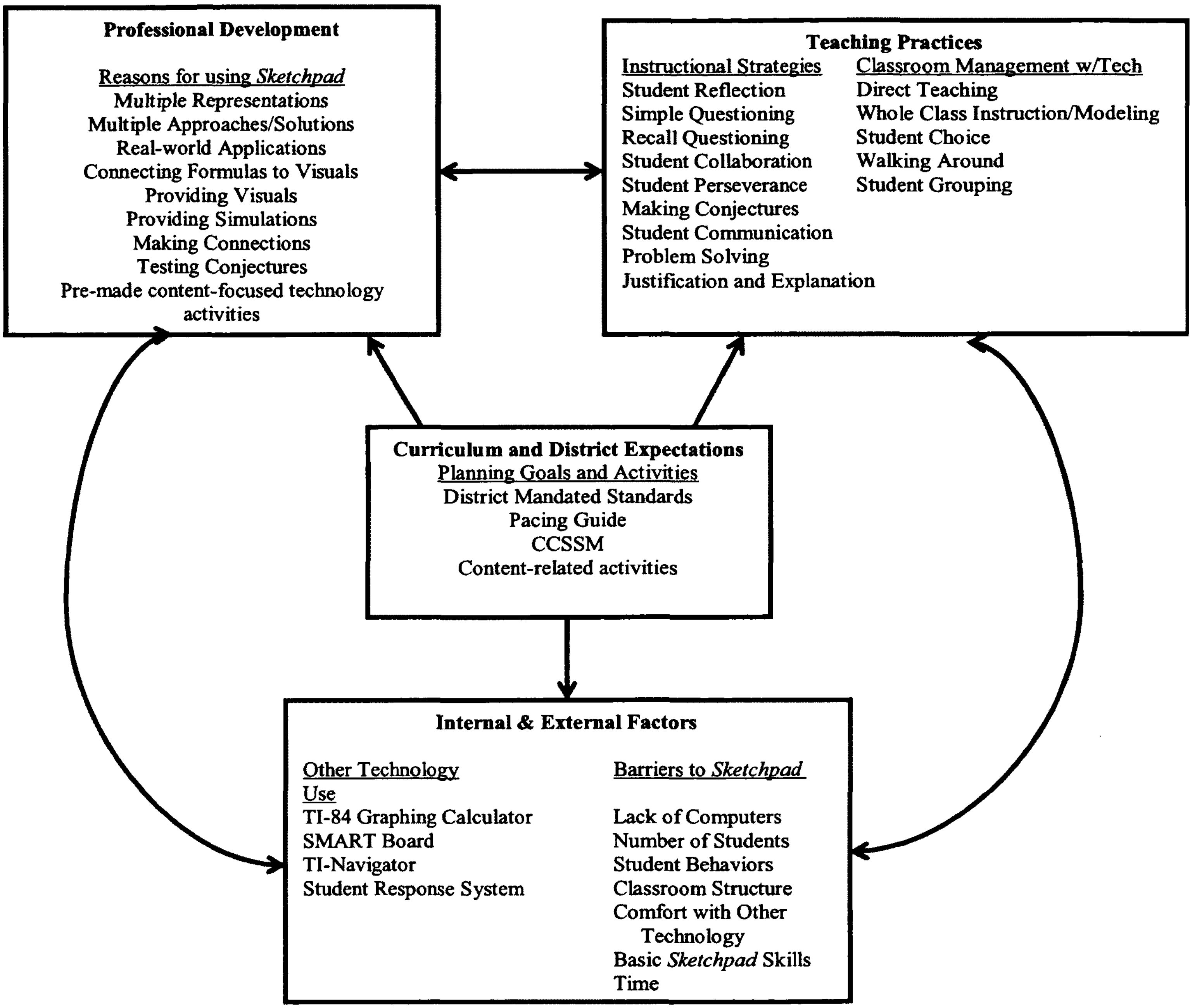
Initial Categories	General Organizing Sub-Categories
District mandated standards Pacing Guide Common Core State Standards (CCSS) Content related activities	Planning Goals and Activities
Student Reflection Simple Questioning (facts, yes/no) Recall Questioning – formulas, definitions Student Collaboration Student Perseverance Making Conjectures Student Communication Problem Solving Justification and explanation	Instructional Strategies
Multiple Representations Multiple Approaches/Solutions Real-world Applications Connecting Formulas to Visuals Providing Visuals Providing Simulations Making Connections (other content) Testing Conjectures Pre-made content-focused technology activities	Reasons for Using Sketchpad
Direct Teaching Whole Class Instruction/Modeling Student Choice Walking Around Student Grouping (pairs/small groups)	Classroom Management with Technology
TI-84 Graphing Calculator SMART Board TI-Navigator (student response system) Other Student Response System - Clickers	Other Technology
Lack of Computers Number of Students Student Behaviors Classroom structure (co-teaching, language barriers) Comfort with Other Technology Basic Technology (Sketchpad) Skills	Barriers to *Sketchpad* Use

Appendix Q: Influencing Categories

Codes	Influencing Categories
District mandated standards Pacing Guide Common Core State Standards (CCSS) Content related activities	Planning Goals and Activities
<u>Instructional Strategies</u> Student Reflection Simple Questioning (facts, yes/no) Recall Questioning – formulas, definitions Student Collaboration Student Perseverance Making Conjectures Student Communication Problem Solving <u>Classroom Management with Technology</u> Direct Teaching Whole Class Instruction/Modeling Student Choice Walking Around Student Grouping (pairs/small groups)	Teaching Practices
Whole Class Instruction/Modeling Student Choice Walking Around Student Grouping (pairs/small groups) Providing Visuals Providing Simulations Making Connections (other content) Testing Conjectures Pre-made content-focused technology activities	Professional Development
<u>Other Technology</u> TI-84 Graphing Calculator SMART Board TI-Navigator (student response system) Other Student Response System - Clickers <u>Barriers to *Sketchpad* Use</u> Lack of Computers Number of Students Student Behaviors Classroom structure (co-teaching, language barriers) Comfort with Other Technology Basic Technology (Sketchpad) Skills	Internal & External Factors

Appendix R: Diagram of Grounded Theory

Teachers' Perceived Influences on Instructional Decisions for Technology Integration



Vita

Karen Larsen Greenhaus

Birthdate:	December 19, 1964	
Birthplace:	Brooklyn, NY	
Education:	2005 – 2014	The College of William and Mary Williamsburg, Virginia Doctor of Education, Curriculum and Educational Technology
	1990 – 1993	Virginia Commonwealth University Richmond, Virginia Masters of Education, Curriculum and Instruction
	1983 – 1988	Virginia Tech and State University Blacksburg, Virginia Bachelors of Arts, Math Education
Professional Experience:	2012 – 2013	Product Sponsor and Director of Edtech Outreach McGraw-Hill Education Columbus, Ohio
	2007 – 2012	Director of Edtech OutReach and Professional Development Manager Key Curriculum Emeryville, California
	2005- 2007	Secondary Math Specialist Virginia Beach City Public Schools Virginia Beach, Virginia
	1990 – 2005	Secondary Math Teacher Chesterfield Public Schools, Chesterfield, Virginia Hanover Public Schools, Mechanicsville, Virginia Chesapeake City Public Schools, Chesapeake, Virginia