

UC Berkeley

UC Berkeley Electronic Theses and Dissertations

Title

From Instrumental Genesis to Digital Exodus: Supporting Urban Elementary Teachers Through Technology-Mediated Systemic Reform

Permalink

<https://escholarship.org/uc/item/7c39206v>

Author

Guneratne, Elizabeth

Publication Date

2016

Peer reviewed|Thesis/dissertation

**From Instrumental Genesis to Digital Exodus:
*Supporting Urban Elementary Teachers Through Technology-Mediated Systemic Reform***

By

Elizabeth Katherina Guneratne

A dissertation submitted in partial satisfaction of the
requirements for the degree of

Doctor of Education

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Dor Abrahamson, Chair

Professor Heinrich Mintrop

Professor Alex Saragoza

Summer 2016

From Instrumental Genesis to Digital Exodus:
Supporting Urban Elementary Teachers Through Technology-Mediated Systemic Reform

© 2016

By

Elizabeth Katherina Guneratne

ABSTRACT

From Instrumental Genesis to Digital Exodus: *Supporting Urban Elementary Teachers Through Technology-Mediated Systemic Reform*

By

Elizabeth Katherina Guneratne

Doctor of Education University of California, Berkeley

Professor Dor Abrahamson, Chair

This dissertation is a story about instrumental genesis, or the lack thereof, and digital exodus in technology-mediated systemic reform in urban elementary education. The purpose of this design study was to develop a support-oriented intervention for exploring new practices aimed at organizational change in K-12 schools, in particular, the case of teachers adopting mandated digital assessment technology and developing new data use practices. The intervention was job-embedded, locally situated, and specific to the needs of a small group of three urban elementary school teachers. Through structured professional learning sessions emphasizing peer modeling and reflection, the ADAPT model created space for instrumental genesis and the potential adoption of the educational technology. While ADAPT proved effective in increasing teacher use of the new technology, it failed in terms of changing teachers' practices regarding data use and assessment. The design failed to support teachers through instrumental genesis (specifically, the instrumentalization of the new technology) because of a perceived mismatch between the objective and the artifact: the intended systemic reform objective of the technology adoption did not align with the selection of the digital artifact itself for teachers. Findings from the iterative development and evaluation of ADAPT suggest a need to reframe teacher resistance to technology adoption as a resource in systemic reform, and a need to improve the alignment of data visualization models embedded in technology tools with teacher professional vision. The instrumental genesis model is elaborated to account for the social and dynamic nature of systemic reform with technology in education.

DEDICATIONS AND ACKNOWLEDGMENTS

This journey has not been endless. It has lasted five years, and has changed me intellectually and holistically as a leader and thinker. I am so grateful for the opportunity to have struggled at Cal, and I am excited to finally complete this dissertation. I am honored to have had the support of so many wonderful people who made this journey a success for me.

For Rick, who maintains such precise clarity with only the most occasional foray into sentimentality, I thank you for everything. Thank you for your acceptance and guidance. Thank you for creating this program. Perhaps I bought the Cadillac, but I finished, and it is because of the encouragement you offered - and orchestrated - through incredible folks like Dr. John Hall and Dr. Liz B. I thank you for the leadership you give to each of us in LEEP and for your unwavering commitment to equity.

For Dor, my brilliant advisor. I wish I had been your student from the beginning of my life in schools. I have learned so much from you about not only design research and learning theory, but effective teaching and communication. Thank you for welcoming me into your world and asking me what I care about. Thank you for reminding me about the importance of curiosity and levity in learning. Your thoughtful, respectful, and collaborative style is an inspiration to me. You are exactly what I imagined professors at Berkeley to be. Thank you for shepherding me through this.

TABLE OF CONTENTS

ABSTRACT	1
DEDICATIONS AND ACKNOWLEDGMENTS	I
CHAPTER 1: DESIGN CHALLENGE AND THE PROFESSIONAL KNOWLEDGE BASE.....	1
Introduction	1
Problem of Practice	2
Design Challenge.....	2
Consulting the Professional Knowledge Base.....	3
Technology In Schools.....	3
Teacher Data Use.....	10
Formative Assessment.....	12
Teacher Professional Learning	14
Instrumental Genesis.....	16
Conclusion.....	17
CHAPTER 2: THEORY OF ACTION.....	19
Introduction	19
Problem of Practice	19
Design Challenge	19
Intervention Design.....	20
Theory of Action	20
Theory of Change.....	21
Comparing ADAPT to Traditional Professional Development	23
Conditions for Design Study.....	26
Sequence of Activities.....	26
Conceptual Framework.....	26
Conclusion.....	27
CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY	28
Introduction	28
Methodological Choices	28
Intervention Design.....	31
Study Participants and Unit of Treatment.....	31
Types of Data	31
Design Process.....	33
Data Collection and Analysis Strategies.....	35

Data Analysis.....	37
Validity, Reliability & Transferability	38
Avoiding Bias & Ensuring Rigor	40
Conclusion.....	42
CHAPTER 4: FINDINGS	43
Introduction	43
Organization of Data Analysis	43
Pilot Study	43
Beta ADAPT	45
ADAPT.....	46
Data Analysis: ADAPT Impact Data.....	47
Impact Data Findings	49
Data Analysis: ADAPT Process Data.....	50
Process Data Findings	51
Conclusion.....	58
CHAPTER 5: DISCUSSION	59
Introduction	59
Summary of the Study.....	59
Meeting the Design Challenge & Design Principles	60
Understanding the Findings within the Context of the Literature	60
Reexamining the Theory of Action	61
Expanding the Instrumental Genesis Framework.....	62
Study Limitations.....	63
Implications for Practice.....	64
Final Thoughts & Conclusion.....	65
REFERENCES	66
APPENDICES	73

List of Figures

FIGURE 1: TPACK.....	9
FIGURE 2: INSTRUMENTED ACTIVITY MODEL	17
FIGURE 3: LOGIC MODEL FOR ADAPT	22
FIGURE 4: TPD vs. ADAPT	25
FIGURE 5: INSTRUMENTED ACTIVITY MODEL FOR ADAPT.....	27
FIGURE 6: INSTRUMENTED ACTIVITY MODEL FOR ADAPT, BREAKDOWN #1	50
FIGURE 7: INSTRUMENTED ACTIVITY MODEL FOR ADAPT, BREAKDOWN #2	51
FIGURE 8: INSTRUMENTED ACTIVITY MODEL FOR ADAPT, BREAKDOWN #3	53
FIGURE 9: INSTRUMENTED ACTIVITY MODEL FOR ADAPT	62
FIGURE 10: EXPANDED INSTRUMENTED ACTIVITY MODEL FOR ADAPT	63

List of Tables

TABLE 1: TRADITIONAL PROFESSIONAL DEVELOPMENT (TPD) vs. (ADAPT)	24
TABLE 2: DETAILED DESIGN CALENDAR OUTLINE	33
TABLE 3: IMPACT DATA COLLECTION METHODS SUMMARY	36
TABLE 4: PROCESS DATA COLLECTION METHODS SUMMARY	37
TABLE 5: DESIGN EFFECTIVENESS VARIABLE OPERATIONALIZED FOR ADAPT	39
TABLE 6: ADAPT TEACHER DEMOGRAPHICS	47
TABLE 7: ADAPT IMPACT BY DATA TYPE	48
TABLE 8: EXTERNAL VALIDITY RESULTS FOR ADAPT	57

List of Appendices

APPENDIX A: COMPARISON OF STRUCTURED PROFESSIONAL LEARNING OPPORTUNITIES	
TO FACILITATE ADOPTION OF EDUCATIONAL TECHNOLOGY	73
APPENDIX B – ADAPT INTERVENTION SURVEY FOR TEACHERS	74
APPENDIX C – ADAPT INTERVENTION—PRELIMINARY INTERVIEW QUESTIONS	76
APPENDIX D - ADAPT INTERVENTION—TEACHER THINK-ALoud PROTOCOL	78
APPENDIX E – ADAPT DETAILED DESIGN CALENDAR OUTLINE	79

CHAPTER 1: DESIGN CHALLENGE AND THE PROFESSIONAL KNOWLEDGE BASE

Introduction

The advent of No Child Left Behind (NCLB) ratcheted up accountability expectations for K-12 schools; reform is now implemented in a more public and measurable sphere than ever before. The desire to assess student achievement and use such data to drive decision-making is far outlasting the sunset of NCLB. New technologies and assessments have enabled the collection of a plethora of data about our schools and students, and the call to use such data to improve teaching and learning is the battle cry of politicians, ed tech investors, and principals alike. The pressure and opportunities for data use and data-driven decision-making are growing. The policy emphasis on using data to inform practice is growing. The amount of available data about student learning is growing exponentially. Yet what has not grown accordingly is the attention to the human capacity needed to use this data (Coburn and Turner, 2011; Lachat and Smith, 2005; Wayman, 2010; Mandinach & Gummer, 2013; Young, 2006). What type of support is needed for teachers so that they may access, understand, and respond to new data about student performance? What skills do teachers need to harness the data powered by new educational technologies? How can school leaders shape opportunities for teachers to actually use data as a formative artifact and technology as an instrument to improve their practice?

The assumption of effective data use is woven into policies from NCLB to the American Recovery & Reinvestment Act (2009) and explicitly demanded and enshrined in Race to the Top and Common Core State Standards initiatives. Practitioner literature affirms that teachers must indeed make evidence-based decisions and use data to “drive their instruction” (Bambrick-Santoyo, 2010; Marzano, Waters & McNulty, 2005), although little explanation is provided for how they should accomplish this laudable objective. The unstated assumption is that more data is better, and available data is actionable data. Yet scant funding has been directed to test these assumptions or to explore the impact of data use on teacher practice. There is little extant research regarding investigations of what teachers actually do when they are using data and how these individual interactions with data may shift organizational routines (Coburn and Turner, 2011; Little, 2012). While new educational technologies offer the promise of providing more data about student learning more quickly than ever before, there are significant challenges with the successful adoption of these digital tools by teachers in K-12 schools, including how to understand and use the data they provide.

Traditionally, these challenges are met with more training for teachers. Yet across the board, both teacher preparation and professional development programs fail to prepare teachers to use technology in effective ways (2016, National Ed Tech Plan). While \$4 billion was spent last year alone in K-12 schools (McCandless, 2015) on new technology and \$18 billion is expended annually on professional development, teachers report that too many current professional development offerings are not relevant, not effective, and most important of all, not connected to their core work of helping students learn (Gates, Teachers Know Best). As digital tools proliferate in schools, more strategic, evidence-based support is needed to help teachers adopt the new technology and use it to enhance and transform their practice.

Problem of Practice

One school system is struggling with the challenge of teachers adopting new technology. As part of a blended learning reform initiative, the central office of a large, urban Diocese in California mandated its elementary schools to use STAR Enterprise, a new digital student assessment system from Renaissance Learning. The web-based, adaptive student assessment focuses on Math and English Language Arts and is aligned with the Common Core Standards. After an approximately twenty-minute multiple-choice exam, the technology makes the student test data immediately accessible to teachers and affords a new visualization of student performance. As part of the technology-oriented systemic reform initiative, teachers were mandated to use the digital system for formative assessments three times during the school year. To facilitate the adoption of this reform, teachers participated in a single, system-wide professional development workshop provided by STAR Renaissance to learn the basics of how to use the new system. Little attention was given to the concept of understanding, analyzing, or using the data from this system to improve their teaching and the learning experiences of their students. This attention is critical to the success of this reform initiative; this is the hypothetical missing link to the adoption of the new educational technology, thus shifting practice, and effecting organizational change. This design development study is an effort to intervene and collaboratively create, refine and implement an intervention at the level of teacher practice to facilitate the successful adoption of the new educational technology. Through close attention to the points of pain in data use, this study seeks to not merely understand but to remedy the breakdown in the successful adoption of educational technology through the iteration and honing of a support-based intervention for teachers.

Design Challenge

I proposed to develop a support-oriented intervention for exploring new practices aimed at organizational change in K-12 schools, in particular, the case of teachers adopting assessment technology and developing new data use practices through peer modeling. I implemented and refined this intervention, paying particular attention to its utility in under-resourced, urban K-12 schools. The intentional focus on urban schools with underserved populations is for two reasons. First, a preliminary needs assessment in the school system in which this study is situated revealed that the new technology was less frequently used by teachers in urban schools in comparison to their colleagues in more affluent schools. Secondly, a plethora of research chronicles the disproportionate lack of access and opportunities that students experience in urban schools like these related to health, wealth, school funding, and quality of educational experience (Ladson-Billings, 2006; Oakes, 1997; Noguera, 2001). Technology could promote equity, but substantial digital inequities currently exist; for low-income families, many students are under-connected, with mobile-only internet access, slow connection speeds, and aging devices (Rideout & Katz, 2016). This finding parallels my observation of the schools in this study; while all of the schools in the system were subject to the same mandate to use the new digital technology, the schools varied in terms of connectivity, number and condition of devices, dedicated tech support, and teacher time allocated to learning about technology. Thus, my design challenge was to create an intervention to support teachers in adopting the new technology in these particularly challenging situations; a solution is most needed here and a solution designed in the more affluent schools might not be scalable to these urban schools.

Drawing from research in the areas of technology integration in schools, teacher data use practice, formative assessment, and teacher professional learning, this design development study seeks to create and evaluate an intervention process for educational technology adoption, refine a theoretical model related to instrumented activity, and contribute to the growing research base of design principles. Evidence will demonstrate if quality, support-oriented professional learning experiences with expert teacher colleagues correlate with teacher adoption of technology, analysis and use of student assessment data and growth in student achievement scores. Implications will be considered for equity-minded school leaders as they strive to transform and improve education through the adoption of educational technology as well as for designers of educational technology, professional learning providers, and teacher preparation programs who seek to strengthen student learning through strengthening teaching with technology.

Consulting the Professional Knowledge Base

In consulting the professional knowledge base, I have identified areas of research that relate to my problem of practice and have informed my design development study. I have consulted topics including technology in schools, teacher data use practices, formative assessment, and teacher professional learning. This literature provided a foundational understanding of technology and teacher practice, and some of the conditions that facilitate the formative use of data in schools operating in complex environments. The literature also exposed factors that inhibit teacher learning and the adoption of technology. I conclude my review of the professional knowledge base with a brief cognitive domain analysis of theories relevant to my problem of practice including sociocultural learning theory and instrumental genesis. Together these theories, in particular the instrumented activity model, serve as constructs to frame the issues underlying the problem of practice and inform the design of the intervention; these models will be revisited during the iterative stages of the intervention's development.

Technology In Schools

"A number of things blow the mind - perhaps most of all, the fact that school, the institution entrusted with learning, is the laggard in our society, in the course of a genuine revolution in learning that is taking place."

Prof. Seymour Papert, 2004

In a 2004 talk he gave in Sydney, Professor Seymour Papert shared this pointed comment when considering technology in education, noting that schools seem to be tardy to- or possibly altogether skipping - the learning revolution. Although he clearly identified schools as laggards, Papert acknowledged that there is a "schizophrenic tension" between making systems work and making systems new. While schools are indeed the institutions entrusted with learning, the school's organizational learning – particularly regarding the integration of technology and participating in the digital revolution– seemed shockingly absent to Papert. Over a decade later, his comment is more relevant than ever. Even though over four billion dollars was spent last year alone on technology in K-12 education (McCandless, 2015) and technology is now considered commonplace in schools, it is not consistently used to foster deep learning aligned with national standards (Krajcik & Soloway, 2004) and achievement gaps in student performance persist. This is the story of technology in schools: despite new tools and the constant pressure for reform, it

seems an equal force exists to keep the current system functional and constant (Cuban, 1986). In order for technology to be truly integrated in K-12 schools, significant changes are required in teaching practices, curriculum, and classroom organization; these deep changes will take place over time and require significant professional development and support for teachers (Kleiman, 2000). Yet how can these deep changes take place, when the pressure to change may be matched by a desire and expectation for stability?

Nested within a hierarchical educational eco-system, schools must respond to the articulated demands of district, state, and federal policies. Teachers in schools must adapt to these continuous changes in governance, curriculum, and local expectations. In addition to responding to the changing landscape of external pressures, local actors such as superintendents and principals often choose to adopt multiple initiatives that they believe will improve student learning in their schools (Hess, 1999; Fullan, 1993). Motivated to respond to accountability regimes, schools veer back and forth between adopting externally imposed new reforms, adopting internally chosen new reforms, and struggling to maintain consistency for students and staff amidst the changes. Despite a desire to improve, a school's capacity likely diminishes with the frenetic adoption of multiple accountability policies and mandates; this "reform churn" within schools may increase pressure upon teachers and ultimately reduce their ability to enact any of the intended improvements (Cuban & Usdan, 2003; Mintrop, 2004; Trujillo, 2012). Thus, it is rational that schools – and the teachers in them – experience or intuit this and are reluctant to adopt new tools and new reform initiatives. While some researchers contend that as social organizations, schools are resistant to change and directly at odds with new technologies (Zhao and Frank, 2003), others suggest that conflicting ideas about the educational value of technology (Cuban, 1999) and the need to balance change with stability (Cuban, 1986) explains teachers' perceived lack of technology adoption.

To explore the relationship between the adoption of new instructional technology and potential predictors such as previous experience with technology, Sahine and Thompson (2007) surveyed 43 faculty members of a college of education at a large Midwestern university. They found that the use of self-directed informational sources, collegial interaction, and the use of data analysis tools were significant predictors of technology adoption levels. The importance of collegial interaction is further underscored in the work of Buckenmeyer. Through surveying 144 educators who participated in a professional development study, Buckenmeyer (2010) found that teacher attitudes toward technology and teacher professional development both positively influenced technology adoption, while availability of resources had no significant relationship to use or adoption of technology. Professional development in particular mattered: the correlation between Professional Development and the criterion of Adoption/Use was significant ($r = .329$) and indicated that technology tends to be more readily adopted in the presence of relevant professional development activities or experiences. In practical language, this study would affirm that teacher training and teacher collaboration matter more for technology adoption than the availability of the actual technology itself. This is promising news for resource-constrained environments like urban schools, where there may not be as much technology as in more affluent schools. Buckenmeyer comments on the digital divide and its implications for those considering equitable outcomes in education, stating that "the challenge is not getting appropriate technology into classrooms, but getting those in classrooms prepared to use those technologies, and facilitating greater willingness to incorporate changing technologies as they emerge." (2010, p. 27).

Zhao and Frank, 2003, citing diffusion literature (Rogers, 1995) state that teacher attitudes' matter for technology adoption; unless teachers have a positive attitude toward technology, they will not use it. In their study of technology use in 19 schools, they identified that teachers who perceived their school as implementing many new innovations were less likely to introduce new student uses for computers (Zhao and Frank, 2003). This finding suggests that technology adoption can be enhanced by positive attitudes of educators but diminished by overwhelmed schools and educators. Teachers' attitudes toward new reforms, perhaps, are influenced by the quantity of initiatives that a school is currently adopting.

But is not just the number of new initiatives that seems to matter to educators. Venkatesh (2000) studied technology acceptance models in organizations and concluded that there are limits to the use of organizational mandates as a lever for increasing the use of technology. The technology needs to be perceived to be useful, both individually and collectively. This finding is particularly salient to this study, since this study focuses on the adoption and use of new digital assessment tools, which were a top-down, mandated technology reform.

In his critical book *Teachers and Machines: Classroom Use of Technology*, Larry Cuban explores the adoption of technology in education through the lens of the paradox of constancy and change in schools. In defense of teachers accused of blocking progress by resisting technology, Cuban points out that teachers must navigate conflicting messages in schools, including tensions between socializing all children while nurturing individual creativity, balancing the demands of historical curriculum with workplace readiness skills, requiring obedience while teaching critical thinking, and cultivating cooperation while preparing students for competition (Cuban, 1986, p. 2). Teachers thus develop a practical pedagogy which influences their use of tools. While technological innovations have been creeping into the classroom for years (Cuban reports on film and television), teachers have been working to maintain constancy while incorporating new devices. Although Cuban's work here is several decades old, the themes resonate with struggles that teachers face today. In light of all of the demands of the profession, is the forced adoption of technology a digital interruption, or a technology invasion, or a not-so-secret Trojan horse for reform?

Ready or not, digital learning is expanding in K-12 education. According to a study published by the Babson Survey Research Group, over 6.1 million higher education students were taking at least one online course during the fall 2010 (Allen, Survey, & Seaman, 2011). While the growth rate has slowed somewhat, this number still represents an increase of 560,000 students over the number reported from the previous year. Thirty-one percent of all higher education students now take at least one course online; this shift impacts elementary and secondary schools as they are ostensibly expected to prepare students for higher education. Outside of the traditional, physical, boundaries of higher education, student enrollment in massive, open, online courses (MOOCS) has skyrocketed, with the total number of students throughout the world who signed up for at least one course exceeding 35 million in 2015, doubling the 2014 estimate (Shah, 2015).

Yet while the field of education is teeming with pioneering schools and new technology tools and service providers, there is little research that tests the assumption that digital instruction is superior – or even equivalent - to high quality traditional “brick and mortar” instruction. The area of K-12 education has a particular dearth of empirical research regarding quality and design of technology-enhanced learning (Yates, Bakia, & Means, 2008)(Tallent-Runnels et al., 2006). A challenge then for educational technology is the empirical establishment of the quality of its tools, including the academic rigor, alignment with core curricular standards, and promotion of

21st century skills.

Additionally, school leaders and teachers are lacking in guidance for the design, assessment, and use of digital tools. In order for technology to support the high achievement of all students, such issues must be considered. Teachers will integrate technology only when prepared to do so, and may be motivated by both the value of integration as well as their own technical competence. As Cuban pointed out in his analysis of technology reform, infrastructure issues and teacher training are imperative components to implement any reform successfully (Cuban, 1998). And while Christensen, Horn & Johnson (2008) assert that online learning has the power not just to disrupt education, but to transform it, it is unlikely that the potentially transformative power of technology will make it into the traditional classroom and improve student learning through the exclusion of teachers and professional development. How does teaching and learning change with the integration of technology?

Technology in Schools: Student Learning

An unexpected finding of a meta-analysis exploring evidence-based practices in online learning was the small number of rigorous published studies contrasting online and face-to-face learning conditions for K–12 students (Yates et al., 2010). The researchers report that “...few rigorous research studies of the effectiveness of online learning for K–12 students have been published. A systematic search of the research literature from 1994 through 2006 found no experimental or controlled quasi-experimental studies comparing the learning effects of online versus face-to-face instruction for K–12 students that provide sufficient data to compute an effect size. A subsequent search that expanded the time frame through July 2008 identified just five published studies meeting meta-analysis criteria.” With so little empirical evidence to rely on, any effects and effectiveness of online learning must be viewed with caution in regard to generalization. The rapid development of digital tools complicates matters further; the concepts and tools of online learning have evolved so much in recent years that prior studies are almost measuring something else altogether.

Perhaps this is why research universities like Harvard, MIT and UC Berkeley offer free online courses; the ability to collect and analyze large data sets will contribute greatly to the emerging field of research on effectiveness of online learning. With this disclaimer in mind, we turn to the extant evidence for clues about the effects and effectiveness of online learning for students.

One scholarly review of the literature explores the existing evidence about effectiveness. Means’ review of evidence-based practices in online learning was informed by four questions (Means, 2010):

1. How does the effectiveness of online learning compare with that of face-to-face instruction?
2. Does supplementing face-to-face instruction with online instruction enhance learning?
3. What practices are associated with more effective online learning?
4. What conditions influence the effectiveness of online learning?

Through a systematic search for empirical studies of the effectiveness of online learning and a meta-analysis of those studies from which effect sizes that contrasted online and face-to-face instruction could be estimated, the researchers gleaned that students in online conditions performed modestly better, on average, than those learning the same material through traditional

face-to-face instruction. Learning outcomes for students who engaged in online learning exceeded those of students receiving face-to-face instruction, with an average effect size of +0.20 favoring online conditions. The mean difference between online and face-to-face conditions across the 50 contrasts is statistically significant at the $p < .001$ level.

The researchers further elaborate that it was the combination of elements in the treatment conditions that produced the observed learning advantages. For example, it is possible that the online learning was in addition to face-to-face instruction; it may be that the additional support was effective, not the mode of support. Students essentially had more learning time and more learning experiences with the online programs. Means concluded that factors including the blend of instruction, the content, and the type of learner mattered a great deal related to student outcomes. Overall, teachers were still needed and it appears that collaboration was better than independent learning.

In another review of the limited literature on online learning outcomes, Tallent-Runnels examined 40 quantitative studies to explore four major themes: course environment, learners' outcomes, learners' characteristics, and institutional and administrative factors (Tallent-Runnels et al., 2006). Their findings included evidence that learning in an online environment can be as effective as that in traditional classrooms and that students' learning in the online environment is affected by the quality of online instruction. Not surprisingly, students in well-designed and well-implemented online courses learned significantly more, and more effectively, than those in online courses where teaching and learning activities were not carefully planned and where the delivery and accessibility were impeded by technology problems. According to the researchers, this finding challenges online instructors to design their courses in accordance with sound educational theories. No recommendations are made for which theory should be employed. It is also interesting to note that half of the studies were case studies, and many lacked the rigor of historical qualitative design. It appears that in an effort to generate conclusions and recommendations, the researchers allowed studies that would be dismissed for a topic with a richer field of available research.

Further research suggests a similar conclusion that online learning can be effective. Factors affecting effectiveness are detailed in Sun's study (Sun, Tsai, Finger, Chen, & Yeh, 2008). According to the researcher, online learning should be designed with an integrated model considering six dimensions: learners, instructors, courses, technology, design, and environment. This is supported by Tallent's research that posits consideration of course environment, learners' outcomes, learners' characteristics, and institutional and administrative factors are critical (Tallent-Runnels et al., 2006). It seems that these factors are not just essential in isolation, but it is necessary to "get the mix right" (Van Bruggen, 2005). The combination of social factors, cognitive factors, and teacher presence all matter and are essential to support successful online learning. Interaction and student-centeredness are also listed as key components of effective online instruction (Van Bruggen, 2005) (Tallent-Runnels et al., 2006).

Whether student engagement and student satisfaction are correlated with effective instruction is beyond the scope of this knowledge base, but it is worth noting that effects of online instruction for students also include higher levels of student engagement and reported increased satisfaction (Tallent-Runnels et al., 2006). Whether these effects are related to the novelty of the curriculum is unknown.

Technology in Schools: Teacher Practice

There is not enough research on student outcomes for technology-enhanced learning in K-12 education, and there is even less on teacher practices using technology in education for K-12 students. This fact was lamented by a teacher in a Kappan article (Journell, 2012). Too often, Journell shares from his own experience as a practitioner, instructors are asked to teach online because they have been recognized by administrators as being exceptional classroom teachers or being particularly adept at technology, neither of which automatically translates into effective online pedagogy. Journell further elaborates that online instruction necessitates a different mindset and a different set of skills. The research he cited and I reviewed unfortunately does not identify what those different mindsets and skills look like.

A deeper probe into the research provides some sparse details about teacher practices. For example, Laurillard exhorts in a theoretical piece that teachers should be designers and developers of learning experiences for students (Laurillard, 2013). Dede suggests that teachers strive for balance in instruction and co-design of curriculum (Dede, 2004). iNACOL created incredibly long teacher standards for online instruction that somehow elude specificity, for example...

“The online teacher knows and understands the current best practices and strategies for online teaching and learning and their implementation in online education.” – rate 0-4

This standard assumes that there are current best practices and strategies for online teaching and learning, and that the teacher and administrator are able to observe them. I am unable to find solid empirical evidence regarding such practices.

There is, however, a framework that exists to inform the development of teacher practice with technology. Integrating three important aspects of teacher knowledge including Pedagogical Knowledge, Content Knowledge, and Technology Knowledge – an extension of Schulman’s PCK (1986) – was developed by Mishra & Koehler (2006) to consider how teachers integrate technology to support content-specific pedagogical strategies. This framework is useful for exploration of how teaching and teacher knowledge changes in the digital learning environment. Negotiating technology, pedagogy and content is complex and requires a different type of expertise from teachers. The cultivate of this sort of expertise will be further considered in the teacher learning section of this chapter.

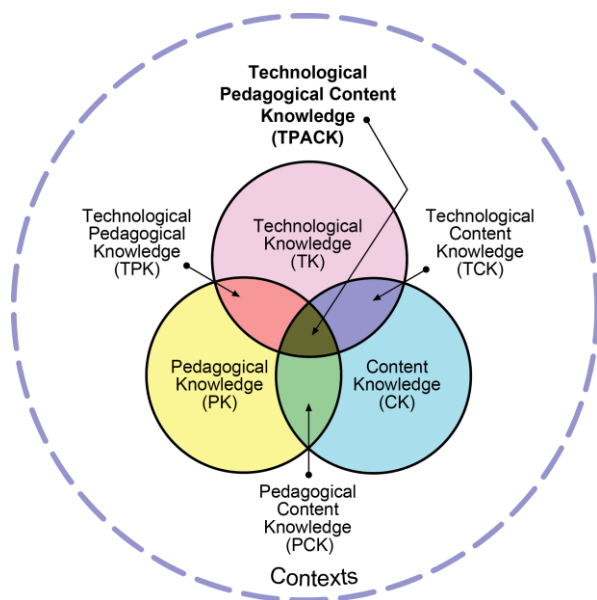


FIGURE 1: TPACK Reproduced by permission of the publisher, © 2012 by tpack.org

An Equity Issue

Rhetoric around the power of technology in education frequently references the equity that appears inherent in access. Digital learning is “the great equalizer” (Digital Learning Now). Access to online instruction is touted as a silver bullet to address underserved populations of students. Students will now have access to limitless course offerings and will be guaranteed a rigorous curriculum. An underlying assumption here is that online learning is “teacher-proof” and that students will now have access to success. This conceptualization of the achievement gap – the idea that students of color and poor students are not achieving success in school because they do not have online learning – is far too simplistic. Technology “is not a vitamin whose presence in schools catalyzes better educational outcomes” (Dede, 2010).

Blended learning and technology-oriented education, just like traditional instruction in brick-and mortar schools, has the same potential for inequities and injustice. Teachers are still very much a part of digital, technology-enhanced instruction, and how will we be assured that underserved students will have competent, qualified teachers? In a digital eco-system where quality has yet to be firmly established, how will we be assured that underserved students will have the best education technology that truly foster the necessary skills for success? In chronically underfunded schools, the potential savings of online education will be quite alluring. How can we know that these savings are not detrimental to student growth? What version of education technology will underserved students access? And how we will ensure its adoption? As we learned after *Brown V. Board of Education*, access does not mean equity. Access does not always lead to excellence. Unless directly addressed, inequities will persist.

A further equity issue is the application of the currently embraced notion that all students can learn in the emerging field of online education. The new medium of technology-enhanced education should be offered to all and should serve all students. Yet the inclusion of a range of learners has not been addressed. What sort of assistive technology or content considerations are given to students with special needs? What thought has been given to the success of English

learners in the digital space? While digital learning has the potential to transform our educational system, it could also become yet another aspirational reform in the preservation of our existing system. How can the transformative potential of digital learning be leveraged to support equity and high achievement for our students in K-12 schools?

It is entirely possible that the best digital tools will be adopted to enhance the already strong education provided in elite institutions and high-performing schools, and replace the meager resources directed to our underserved students. The reform could widen the gap rather than promote equity.

This should not stop us from embracing this change; rather, we must direct resources and efforts to establishing quality, standards and best practices, rooted in sound empirical research, to guide the development of digital learning and instruction. This disruption could ignite the innovation we need to affirm what works in teaching and develop new practices to better meet the needs of our students today.

In summary, there is an acknowledgement in the literature that something changes between teachers and students with the introduction of technology and in the realm of technology-enhanced learning. How to navigate this change, adapt practices, and mediate effective instruction through technology are questions unanswered. From reviewing the effects of technology-enhanced learning, it seems that there is a positive potential for student achievement, but teacher professional learning is needed. Since the technology that is the focus of this particular study is geared toward formative assessment and teacher data use, I turn to the literature on teacher data use practices before exploring teacher professional learning.

Teacher Data Use

The pressure and opportunities for data use and data-driven decision-making are growing. The policy emphasis on using data to inform practice is growing. The amount of available data about student learning is growing exponentially. Yet what has not grown accordingly is the attention to the human capacity needed to use this data (Coburn and Turner, 2011; Lachat and Smith, 2005; Wayman, 2010; Mandinach & Gummer, 2013; Young, 2006). What type of support is needed for teachers so that they may access, understand, and respond to new data about student performance? What skills do teachers need to harness the data powered by new educational technologies? How can school leaders shape opportunities for teachers to actually use data as a formative artifact and technology as an instrument to improve their practice?

The assumption of effective data use is woven into policies from NCLB to the American Recovery & Reinvestment Act (2009) and explicitly demanded and enshrined in Race to the Top and Common Core State Standards initiatives. Practitioner literature affirms that teachers must indeed make evidence-based decisions and use data to “drive their instruction” (Bambrick-Santoyo, 2010; Marzano, Waters & McNulty, 2005), although little explanation is provided for how they should accomplish this laudable objective. The unstated assumption is that more data is better, and available data is actionable data. Yet scant funding has been directed to test these assumptions or to explore the impact of data use on teacher practice. There is little extant research regarding investigations of what teachers actually do when they are using data and how these individual interactions with data may shift organizational routines (Coburn and Turner, 2011; Little, 2012). While new educational technologies offer the promise of providing more data about student learning more quickly than ever before, there are significant challenges with the successful adoption of these digital tools by teachers in K-12 schools, including how to

understand and use the data they provide.

Underlying processes of evidence use are mediated by individual and collective beliefs and worldviews (Coburn et al., 2009) and affect how data is accessed, noticed and interpreted. Focusing on the individual as sensemaker, Spillane & Miele (2007) contend that evidence use is about evidence construction; that is, no information or source of evidence is completely neutral or universally understood in the same way. People process information and interact with it in order to understand it. Leaders influence evidence before they are influenced by evidence (Kennedy, 1984). Therefore, asserting that teachers and school leaders should all adopt the same technology and use data in the same way may be unrealistic. Or, perhaps it is unrealistic to think that teachers can collaborate with data since they all construct evidence differently?

So, what accounts for how people influence evidence? Spillane & Miele explore the role that knowledge representations play in the process of understanding and decision making. Mental models, sophisticated knowledge representations that demonstrate our beliefs about how things work (Spillane & Miele, 2007), can be activated to interpret information, influence evidence and shape decisions. A person may have multiple mental models and may or may not be aware of them. A dual mental model that is particularly relevant to this study is an espoused mental model and an in-use mental model. The espoused mental model accounts for how an individual explains his or her behavior, understanding or decision making to another person; the in-use mental model guides the individual's behavior when responding directly to the phenomenon (Spillane & Miele, 2007) and may even contradict the espoused model. While they are hardly static and may be continually shaped and reorganized, mental models are helpful to understand how individuals mediate the evidence they encounter and make decisions.

Individuals make sense of and construct evidence in social settings. In complex environments such as school districts, context factors influence the processes of decision making. According to Coburn (2009), it is not only the working knowledge and practices of educators that shape their decisions; context factors including organizational structure, content knowledge of key leaders, resource constraints, and leadership turnover influence decision making processes. These factors may influence the use of tools, the consistency of routines, the evolution of shared understandings and the extant mental models of the individuals in the organizations.

The influence of these context factors may be overt or subtle; leaders may or may not be aware of the impact they have upon decision making. Their influence may be particularly obscured during times of less formal decision making. According to research by Carol Weiss, in a large number of cases decisions are made without a formal decision process (Weiss, 1988). While describing how evaluation evidence is not used during decision-making, Weiss captures how, through a series of small steps, a line of action takes place which in retrospect is viewed as a decision (Weiss, 1988). In other words, we can't assume a decision is not being made just because it is not identified as such in advance. In these cases, the decision makers may be individually and collectively unaware of both the decision making process and the factors influencing the process. They may ostensibly maintain a "big picture" focus on planning and respond to factors influencing and impeding the process, but they may actually be taking tiny steps to find out where they are going. How effective can such decisions be?

Spillane (2012) points out that while data use is considered to be a means to transform practice, the very practice of data use is underconceptualized. Perhaps the teacher practice of data use could be expanded to include the practice of formative assessment.

A qualitative study examining districts' attempts to create a culture of data use suggested that schools and districts should invest in leadership, professional development, and structured time for

collaboration to ensure that teachers, principals, and school and district staff have a thorough understanding of their roles in using data, and that they possess the knowledge and skills to use data appropriately (Hamilton et al, 2009). To strengthen teacher data use, schools might need to invest in additional resources including technology. In the case in this study, the adoption of technology was the primary resource driving the reform initiative to promote teacher data use and formative assessment; this research suggests that attention to other factors such as leadership, professional development, and collaboration time is critical to “create a culture” where the technology could be adopted and the reform might actually change practice. Since the stated objective of the reform in the case of this study was to help teachers use data to improve formative assessment, I now briefly turn to the literature on the teacher practice of formative assessment.

Formative Assessment

In the current era of high stakes accountability, the term assessment may evoke a specific, standardized test in the minds of educators. Substantial evidence exists of the connection between learning and assessment, specifically the kind of assessment *not* addressed in the accountability movement – formative assessment. In a sense, formative assessment is a teacher data use practice, and a powerful one. Black and Wiliam’s (1998) review of the literature on formative assessment synthesizes several studies which link the feedback students get about their learning with “substantial learning gains”. Indivisible from instruction, formative assessment includes myriad strategies that teachers use to gather evidence about student understanding; the assessment is formative when the evidence is actually used to adapt the teaching to meet student needs (Black and Wiliam, 1998).

An assessment is formative “to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited.” (Black & Wiliam, 2009 p. 9). An essential component of formative assessment is feedback from teachers to students; it is among the most critical influences on student learning (Hattie, 2007; Kluger and Denisi, 1996). In their seminal work on the power of feedback, Hattie and Timperley define feedback as information provided by an agent regarding aspects of one’s performance or understanding (Hattie & Timperley, 2007). Such information is provided in the context of instruction, and usually aims to reduce the discrepancy between what is understood and what is aimed to be understood. Practitioner literature further expounds upon the meaning of feedback, adding action-oriented qualities such as facilitating improvement in a timely fashion, giving value-neutral information about progress, and having results-driven dialogues between students and teachers (Reeves, 2007; Wiggins, 1998; Marzano, 2003).

While the practitioner literature assumes that feedback promotes student learning, empirical research analyzed by Hattie and Timperley explored the effect of feedback on student achievement through a synthesis of over 500 meta-analyses from 180,000 studies; the researchers concluded that feedback matters – the effect size was among the top 5 variables influencing student achievement. Yet upon closer examination, the researchers found that variability exists among the effect size related to the type of feedback; for example, cues and reinforcement were positive and powerful shapers of learning, while corrective feedback was less helpful but still positive, and praise and punishment were not helpful. Another study found

that cognitive feedback was superior to outcome feedback; elaborate, personalized information that cued deep processing was more helpful to students than correct-answer feedback (Butler & Winne, 1995). The only instance identified in the research where negative feedback had a beneficial effect was at the self level of internal feedback (Kluger & Denisi, 1996). The type of feedback that is most effective may vary by the task as well as the learner.

There is a strong relationship between feedback and time students spend on task. Students who receive regular, frequent feedback are much better at self-regulation and overall make better progress. (Gibbs and Simpson, 2004) There is a large body of evidence showing that learners who are more self-regulated are more effective learners. Also, research shows that all students, even those labeled “at-risk”, can learn to become more self-regulating (Pintrich & Zusho 2002). Effective feedback is still mediated through learners’ knowledge, beliefs, and thinking; this process of confirmation, correction, and restructuring is an account of how knowledge is constructed for learners (Butler & Winne, 1995). Therefore, feedback is not simply a transmission of information, but a learning dialogue.

Despite the power of effective feedback, feedback is not always leveraged to improve student learning. There is a “thorny” issue, according to Hattie, related to timing. Delayed feedback loses its effectiveness. This idea has powerful implications for online learning, where feedback could be given to students in an individualized, faster way by teachers or by computers. With the adoption of the new education technology in this study, feedback can be provided immediately to teachers and students regarding student learning, and therefore may be much more useful and effective.

Evidence suggests that effective teacher feedback empowers learners, providing strategically useful information and supporting self-regulation (Butler & Winne, 1995; Nicol & Macfarlane-Dick, 2006; Gibbs and Simpson, 2004). While general guidance exists for feedback practices, the literature on external feedback is undeveloped in terms of specifics; the quantity, framing, context and method of feedback that teachers give students lacks a solid research base (Nicol & Macfarlane-Dick, 2006). Despite the power of effective feedback, feedback is not always leveraged to improve student learning. Implications for teachers, school leaders and policy makers include how to privilege formative assessment in the current context of accountability, how to develop teachers’ capacity to provide feedback, and how to design opportunities for teachers to reflect upon and develop formative assessment practices. Despite the potential power of formative assessment to strengthen instruction and aid student learning, few teachers have been prepared to make effective use of it— or to create the kind of classroom instructional environment that is compatible with it (Little, 2006, p.10). Thus, professional development for teacher must be a critical component of any reform initiative that requires an increase in teacher formative assessment practices.

While technology designers might embed opportunities to engage in formative assessment in their design, teachers may or may not use or even identify this affordance. In the case of this study, the mandated technology was ostensibly being forced upon the teachers to enhance formative assessment. Therefore, while professional learning regarding how to use the new technology appears to be a necessary component of technology adoption, inclusion of the teacher practice of formative assessment – the teacher practice that in this case, the technology in intended to enhance - may be an additional necessary component of the professional learning. Since professional learning will be a critical part of the intervention design in this study, it is important to consider the knowledge base on teacher professional learning. Since teachers often experience ineffective professional learning, I will focus on research highlights of qualities of

effective professional learning.

Teacher Professional Learning

In order for a reform effort to be successful, teachers need to be provided with professional development. Yet despite its critical importance to the effective implementation of any reform, professional development in education is often less than ideal. Professional development activities frequently occur in the form of teachers attending a one-day workshop and then returning to their school to implement the practices they have learned; they move from a disconnected workshop site back to the isolation of their classroom (Garet, Porter, Desimone, Birman, and Yoon, 2001). Teachers experience these sorts of episodic activities as superficial and irrelevant; the workshops do not align with the teachers' own interests or problems of practice (Little, 2006). In a study that included data from 1,300 surveys and interviews, researchers found that large majorities of teachers do not believe that professional development is helping them prepare for the changing nature of their jobs, including using technology and digital learning tools, analyzing student data to differentiate instruction, and implementing the Common Core State Standards and other standards (Gates, 2015). This same study asked teachers what effective professional development would look like to them; the teachers stated that the ideal professional development would be relevant, interactive, delivered by someone who understands their experience, sustained over time, and would treat teachers as professionals (Gates, 2015).

Despite the evidence that teacher learning could occur with a different model such as the one described by the teachers in the Gates study, and that teachers would prefer this different model, schools have historically embraced a training paradigm of "knowledge consumption," and less support for inquiry and a problem-solving paradigm built around "knowledge production" (Little, 1993). Teachers have limited opportunities to learn in these workshops, and they are generally ineffective in developing the changes needed to meet the goals of a reform initiative or increase student achievement (Garet et al., 2001).

There are alternative professional development opportunities to traditional workshops, including study groups, collaboration, professional learning communities, and mentoring. These alternatives include both structured and unstructured learning opportunities embedded with a teacher's job and hold great promise for teacher learning (Garet, et al., 2001; Peterson, 2002). Concluding an analysis of research related to professional community and professional learning for teachers, Little noted that successful schools implementing these models shared certain characteristics, including "teacher learning arises out of close involvement with students and their work; shared responsibility for student progress; access to new knowledge about learning and teaching; sensibly organized time; access to the expertise of colleagues inside and outside the school; focused and timely feedback on individual performance and on aspects of classroom or school practice; and an overall ethos in which teacher learning is valued and professional community cultivated" (Little, 2006, p.22).

Key features of effective professional development are further described in a study exploring the relationship between professional development and self-reported changes in teachers' knowledge, skills and instructional practices. Exploring a sampled population of 1,027 mathematics and science teachers, Garet, Porter, Desimone, Birman, and Yoon (2001) identified a statistically significant relationship between six features of professional development and enhanced teacher knowledge and improved practice. Effective professional development designs

should include the following key structural and core features:

- responsive learning activity
- sustained duration of activity
- collective participation
- a focus on content
- promotion of active learning
- fostering of coherence.

Little (2006) also summarizes features of effective professional development, citing that effective professional learning develops the pedagogical content knowledge (Shulman, 1986) of teachers when it is content-focused, active, collective, coherent, and sustained. These characteristics affirm the list above and provide specific details to guide the development of effective professional learning. So why don't we use them?

Research exploring why these models have not been implemented more frequently in schools suggest that there are resource constraints on schools related to trust (Bryk and Schneider, 2013), capacity, time, and expertise (Bloom, 2005). The trust is a prerequisite to the joint work (Little, 2006) which is essential for teacher collaboration. Capacity, time and expertise are critical for teachers to learn from peers in an active, coherent way. In order to have the occasions for discourse (Little and Horn, 2010) that allow teachers to discuss and grapple with problems of practice, you need to have capacity for professional learning teams, time to meet, and expertise to leverage.

Expertise related to educational technology in particular may be a deficit in schools. PISA data reveal that, despite increasing investment in information and communication technologies (ICT) for schools, teachers are not using these tools systematically. Teachers who participated in the 2012 OECD Teaching and Learning International Survey (TALIS) reported that one of the areas in which they most need professional development is developing ICT skills for teaching (OECD, 2012). Defined as “the characteristics, skills and knowledge that distinguish experts from novices and less experienced people” and the characteristics, skills and knowledge that underpin “superior reproducible performances of representative tasks”, i.e. expert performances (Ericsson et al., 2006, p. 3), the cultivation of expertise is a goal of professional development. Learning theory suggests that expertise might be cultivated through cognitive apprenticeship (Brown, 1991), a constructivist approach where a person is guided by an expert through experiences that allow him or her to develop cognitive skills through the example of the expert. Cognitive apprenticeship is referred to as a way of “making thinking visible” (Collins, Brown and Holum, 1991). While much more labor-intensive than the strategies employed in a traditional teacher workshop, cognitive apprenticeship is possible within small groups of teachers in professional learning communities.

Cognitive apprenticeship includes both modeling and reciprocal teaching. Learners can see expert solve problem; they are let in on the process (Collins, 1988). It can integrate what is happening with why it is happening, thus building a critical understanding of process for the learner. It makes known parts of the process that are normally unseen. Reciprocal teaching instantiates tacit practice, so teachers can see it and reflect on it. The modeling in particular is important for teachers, who trust other teachers. They share professional vision (Goodwin, 1994) a specialized way that members of a professional group look at the phenomena of interest of them. Since teaching and learning are complex endeavors, shared professional vision can be both developed during and facilitate the cognitive apprenticeship process.

As John Dewey stated, "We do not learn from experience. We learn from reflecting on experience." Thus it is critical that professional learning experiences and cognitive apprenticeships provide space and time for reflection. Research confirms that professional development programs that engage participants in a deeper level of analysis includes a strong element of reflection (Peterson, 2002). Reflection, along with modeling and learning within a community of practice, are key features of cognitive apprenticeship in education (Collins, Brown and Holum, 1991).

The work of Schon also highlights the critical role that reflection plays in professional growth. Carefully studying the performance of extremely competent professionals and engaging in a "dialogue of thinking and doing through which I become more skillful" (Schon, 1983) is a powerful method to promote learning. Reflective practice – including activating the experiences of professionals and providing an occasion to examine and think about it together – should be a critical component of any professional development initiative.

In conclusion, research suggests that teacher professional learning is a critical component of the successful implementation of school reform. To be effective, professional development needs to be high quality, active, job-embedded, collective capacity-building, and sustained by leadership in the school. Such professional learning could be facilitated through cognitive apprenticeship with an emphasis on modeling by experts and reflection on practice.

Instrumental Genesis

Technology enhances learning only through transformed social practices (Hakkarainen, 2009). Professional learning can transform social practices through myriad ways, including instrumental genesis (Vérillon and Rabardel, 1995). This framework is particularly salient when considering the adoption of new technology in schools. The framework models the process by which an artifact can become an instrument. In order to work as an instrument of learning and teaching, educational technologies have to be integrated, "fused," with the social practices enacted by participants (Ritella & Hakkarainen, 2012, p. 240). The work of Rabardel (Béguin and Rabardel 2000; Vérillon and Rabardel 1995) suggests that this can happen through a process of instrumental genesis, where artifacts such as technology can be appropriated to meet the needs or challenges of the situation. Through use, the artifact becomes an instrument; the use of this instrument then changes the user of the instrument in some way. The graphic below shows the instrumented activity model from Verillon and Rabardel (1995). In the case of ADAPT, the subject is the teacher, and the object is to improve the use of assessment. The instrument is the technology – the new digital assessment tool. It is noteworthy that the subject already had a relationship with the object before the instrument was introduced; teachers have always been engaged in student assessment. However, the new instrument should enhance the teachers' ability to influence the object of assessment and student learning. The technological artifact becomes an instrument as teachers use it to extend and amplify their existing assessment practices. Through instrumental genesis, instrumentation and instrumentalization are combined to facilitate the adoption of technology.

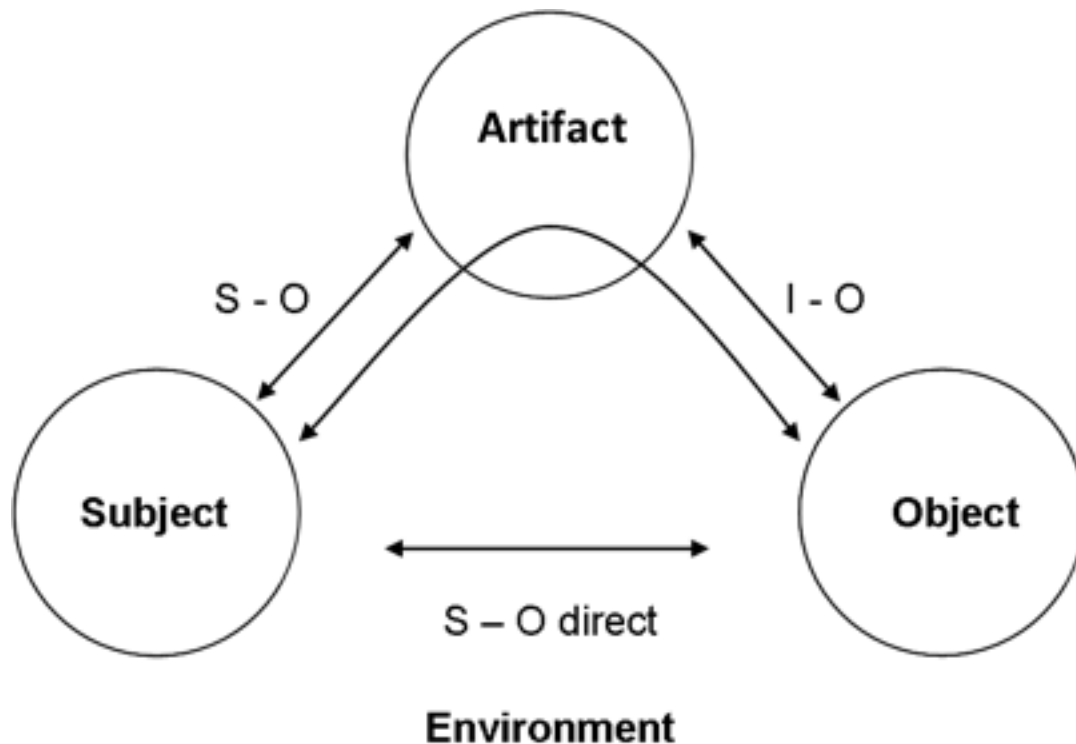


Figure 2: Instrumented Activity Model from Verillon and Rabardel (1995)

Conclusion

The problem of practice this study addresses is difficulty with and resistance to the adoption of education technology for teachers in K-12 schools. Teachers in the Diocese are now struggling to use the new, mandated digital assessment system; principals are struggling to enforce compliance with the central office mandate that the system must be used. The design problem is that teachers are not adopting the new education technology; teachers are having difficulty using or not using the new digital assessment system. Many teachers, especially those in urban schools, are not using the data from the new assessment system about student learning to improve student learning. A needs assessment and pilot study revealed somewhat low levels of resistance, but high levels of frustration and confusion regarding the reform initiative itself with low levels of actual use of the new digital assessment system. Teachers expressed confusion over how to read reports, how to use data, and what to share with whom. Principals also expressed feeling uncertain, confused and unable to lead the initiative. The main factors that seem to generate this problematic behavior include a mismatch between the experience and support that school actors need to adopt the new educational technology and the training provided, a lack of clarity regarding the purpose of the technology reform, and lack of opportunities for teacher reflection.

The design challenge is to create a support-oriented intervention for exploring new practices aimed at organizational change, in particular, the case of teachers adopting assessment technology and developing new data use practices. Specifically, this intervention will replace and

improve the traditional professional development associated with the implementation of a technology reform initiative and must work in the under-resourced environments of urban schools. The intervention will improve teachers' understanding of the purpose of the educational technology as well as increase their ability to implement the technology to improve student learning.

CHAPTER 2: THEORY OF ACTION

Introduction

In the following section, I will discuss the theory of action for this study. In response to my problem of practice, I have engaged in design research. This study had three main purposes: to design an intervention to facilitate teachers' adoption of new educational technology, to assess and iteratively refine this intervention, and to investigate the design process and reflect upon the tacit practices and assumptions of both the designer and the professionals under examination in this study. This chapter focuses on the first purpose and highlights the concepts upon which the design of the intervention is premised. First I will review the problem of practice, design challenge, and intervention design for the study. I will then discuss the theory of action and theory of change for the intervention. Next, I will compare the intervention model of professional learning to the current, traditional model of professional learning that was in place in the system in which this study is situated, and is quite common throughout K-12 education. I will then explore the conditions needed for the design study. I will briefly review the sequence of activities for the intervention and conclude with the synthesized theory of action, emphasizing the innovative and quintessential aspects of ADAPT.

Problem of Practice

The problem of practice this study addresses is difficulty with and resistance to the adoption of education technology for teachers in K-12 schools. Teachers in the Diocese are now struggling to use the new, mandated digital assessment system; principals are struggling to enforce compliance with the central office mandate that the system must be used. The design problem is that teachers are not adopting the new education technology; teachers are having difficulty using or not using the new digital assessment system. Many teachers, especially those in urban schools, are not using the data from the new assessment system about student learning to improve student learning. A needs assessment and pilot study revealed somewhat low levels of resistance, but high levels of frustration and confusion regarding the reform initiative itself with low levels of actual use of the new digital assessment system. Teachers expressed confusion over how to read reports, how to use data, and what to share with whom. Principals also expressed feeling uncertain, confused and unable to lead the initiative. The main factors that seem to generate this problematic behavior include a mismatch between the experience and support that school actors need to adopt the new educational technology and the training provided, a lack of clarity regarding the purpose of the technology reform, and lack of opportunities for teacher reflection.

Design Challenge

The design challenge is to create a support-oriented intervention for exploring new practices aimed at organizational change, in particular, the case of teachers adopting assessment technology and developing new data use practices. Specifically, this intervention will replace and improve the traditional professional development associated with the implementation of a technology reform initiative and must work in the under-resourced environments of urban schools. The intervention will improve teachers' understanding of the purpose of the educational

technology as well as increase their ability to implement the technology to improve student learning.

Intervention Design

The intervention design is a structured, support-oriented intervention for teachers to facilitate the adoption of new education technology. This innovative professional learning intervention is called ADAPT: Advancing Data Analysis Through Peers and Technology. This intervention is a new alternative to professional development; the model includes a series of sessions with peer modeling by expert colleagues and reflection on learning situated in practice. The model simulates cognitive apprenticeship at the most local level of teacher practice. Through three one hour sessions, teachers will work in small grade-level groups to practice analyzing data from the digital assessment together. This design promotes not just the basic use of the new technology, i.e. simply administering the assessment to the students, but facilitates the focused adoption of the technology to promote data analysis and use of the assessment to improve teacher practice. The intervention is job-embedded, locally situated, and specific to the needs of this small group of urban elementary school teachers. Through peer modeling and reflection, the ADAPT model creates space for instrumental genesis and the potential adoption of the educational technology.

Theory of Action

The construct of a theory of action originated with the work of Argyris and Schon (1974) and is premised upon the notion that humans are designers of action and can influence change. According to Argyris (1978), designing action requires that agents construct a simplified representation of the environment and a manageable set of causal theories that prescribe how to achieve the intended consequences. This often takes the form of an “if, then...” statement, or follows the form “In situation *s*, to achieve consequence *c*, do action *a*” (Argyris and Schon, 1974). As a model to explain the hypothesized connection between the problematic state and the move toward a more desirable state, a theory of action is different from a conceptual framework in that it is situated in a context and open to change. It is also “testable”, and may be challenged and modified through iterative design research.

The theory of action for the ADAPT intervention is as follows:

If teachers participate in a supportive, reflective, structured, professional learning experience about data use with expert teacher colleagues, they will learn how to both analyze and act upon the student assessment data that emerges from the new educational technology.

Essentially, if teachers apprentice with expert teachers through actively using the new educational technology tool, they will be able to adopt, instrumentalize, and use the tool successfully on their own to improve teaching and learning.

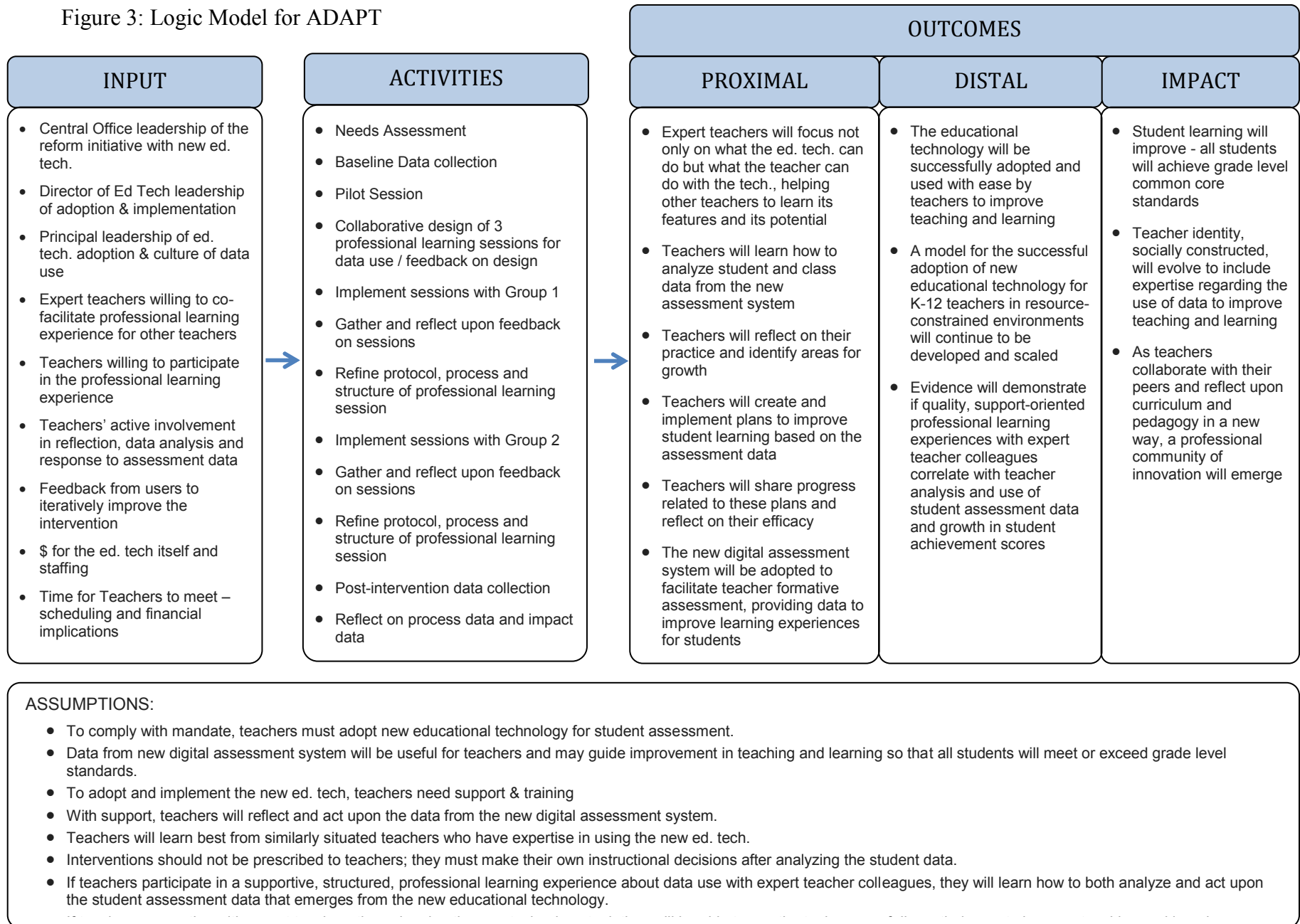
This theory of action will be tested through the implementation of the intervention ADAPT through multiple iterations and the collection of impact and process data as described later in Chapter 3.

Theory of Change

Weiss (1995) defines a theory of change quite simply and elegantly as a theory of how and why an initiative works. While the theory of action explains the general premise for the design, the theory of changes explores the desired outcomes of the study and the actual means and avenues by which these outcomes occur. Theories of change also consider assumptions, inputs and outputs of initiatives. For this intervention, I used a basic logic model (Kellogg Foundation, 2004) to both strengthen the intervention design and to articulate the theory of change for this intervention. According to Kellogg (1998, p. 43) most of the value in a logic model is in the process of creating, validating, and modifying the model; the clarity of thinking that occurs from building the model is critical to the overall success of the program. Thus, the logic model included below was developed prior to the implementation of the intervention but was reflected upon and revisited during the course of the study.

The logic model depicts how the inputs and outcomes of the intervention are premised upon certain assumptions. It also includes details regarding the inputs, activities of the intervention, proximal and distal outcomes, and intended impact upon the community.

Figure 3: Logic Model for ADAPT



Comparing ADAPT to Traditional Professional Development

Since I hypothesize that the problem of practice – the lack of urban teachers adopting the new digital assessment technology – is due to a mismatch between the experience and support that the teachers need to adopt the new educational technology and the training provided, it is helpful to compare the ADAPT intervention model with the traditional professional development model. The traditional model was provided to teachers and was insufficient to drive the adoption of the new technology. The ADAPT model is in stark contrast to the traditional professional development model in several key aspects. Although this study was situated in a particular set of schools, and therefore the traditional professional development observed in this case may be particular to this regional area, the professional development literature suggests that the traditional model is quite pervasive in PreK-12 education and reinforces isolation and disconnection of learning from practice (Garet, Porter, Desimone, Birman, and Yoon, 2001; Little, 2006).

The traditional model of professional development in schools is quite different than the ADAPT model across several salient dimensions, including the focus, purpose, motivation, duration, pedagogy and design. The table below illustrates these differences through a comparison of the two models.

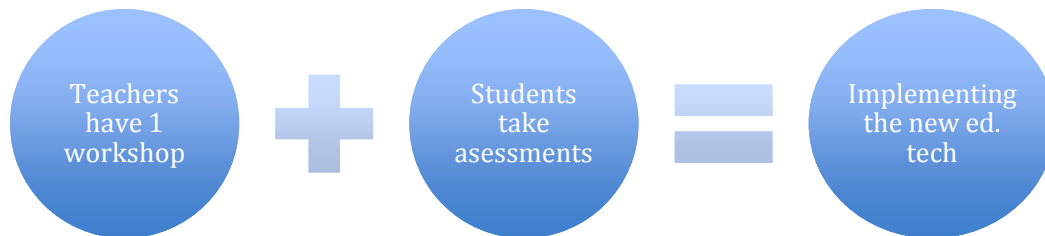
Table 1: Traditional Professional Development (TPD) vs. Proposed Intervention (ADAPT)

Feature	TPD	ADAPT
Focus	how to use this new instrument in general	why you would use the instrument, what you can use it for, how to use it specifically to meet your needs
Purpose	purpose not explicit, mandated use, assumed or mysterious intentionality	purpose is explicit and discussed
Teacher “Buy-In”	Assumed through compliance with a mandate	Teacher beliefs will be engaged through testimonials; teachers will be motivated by working with real colleagues & real data; iterative design will empower and motivate
Duration	one shot, no follow-up <i>“Good luck... do it.”</i>	3 sessions with reflection <i>“Let’s figure it out together.”</i>
Leader of PD	OUTSIDER (individual) Industry trainer (provided by the company that sold the product)	INSIDERS (team) Expert teachers (collaborating with Ed Tech Director and Asst. Sup).
Pedagogy & Process	teachers are passive recipients of direct instruction in a large group, transmissive activities include listening, participating in assessment as student, and looking at generic test data and report options	teachers are actively engaged in small groups, codesigners in the learning, constructing meaning activities include peer modeling by expert teachers, individual analysis, planning, reflecting, and discussing assessment with real student data
Design of PD	standardized, one size fits all, static; workshop model	rapid-prototyping, iterative development peer modeling / ad hoc PLC
Fiscal Impact	efficient, fixed cost of time for teachers (1 day) plus fee cost of presenter	potentially more expensive, ongoing (research suggests that costs could be the same if this type of PD supplants traditional PD)
Theory of Action With Data	if students TAKE the test, teachers will use the data to improve instruction	if teachers engage in support-oriented prof. learning experiences with expert teacher colleagues regarding new ed. tech., teachers will analyze and use student assessment data to improve instruction
What’s New?	does not identify what is the same or different, e.g. the same educational objective and same practice (assessment) but it will be enhanced by leveraging new tech	Identifies what is the same – objective and assessment practice - and highlights what is new – the tech to enhance this process

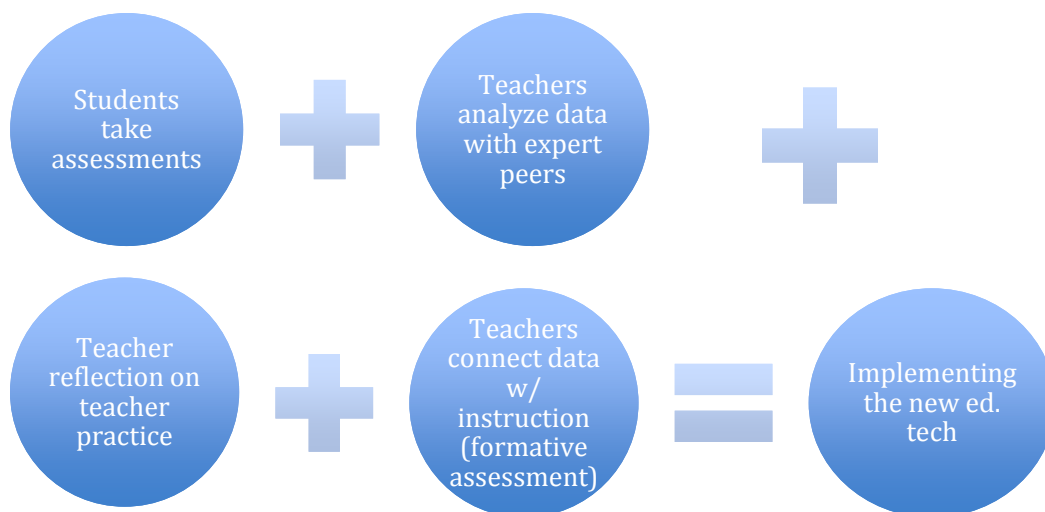
The operationalization of adoption in the traditional model, although not explicit, is that if teachers attend one workshop with all the other teachers, and students take the new digital assessment, teachers will use the new technology and the initiative will be adopted. This model, which the researcher observed during a pilot study, led to a very low-impact level of adoption. Many teachers, especially in urban schools, did not use the new technology at all, and those who did used it in a very superficial manner. In contrast, the theory of action for ADAPT includes a more nuanced conceptualization of adoption which will lead to a different, higher level of impact. Through peer modeling and reflection, the ADAPT model creates space for instrumental genesis, which is necessary for the authentic, purposeful, successful adoption of the educational technology.

FIGURE 4: TPD vs. ADAPT

Theoretically, how the adoption of education technology occurs with TPD...



Theoretically, how the adoption of education technology occurs with the ADAPT model...



Conditions for Design Study

The conditions necessary for this design study include the support of the school system leadership, including the educational technology director and principals. It is also critical to have the involvement of teachers in the urban schools that have been mandated to adopt this technology. To comply with the mandate, teachers must adopt new educational technology for student assessment. It is asserted by the school central office leadership that data from new digital assessment system will be useful for teachers and may guide improvement in teaching and learning so that all students will meet or exceed grade level standards. To adopt and implement the new technology, teachers need support & training. With support, teachers will reflect and act upon the data from the new digital assessment system. Since the ADAPT model asserts that teachers will learn best from similarly situated teachers who have expertise in using the new educational technology, the identification of local teacher experts, and their willingness to engage in the study, was a condition for this study as well.

Sequence of Activities

The ADAPT series consisted of three workshops of sixty to ninety minutes each held monthly during the course of the intervention between January and June. The workshops occurred on the participating teachers' school site during regularly scheduled level meeting time (the school had a structure to facilitate professional learning communities by grade level groups that already existed; leveraging this structure allowed ADAPT to be job-embedded and less arduous for teachers to join). The primary focus of the workshops was to create time and space for use of the new technology, reflection on practice, and learning from expert teacher colleagues. In between the workshops, teachers applied their learning to the classroom. Throughout the process, it was necessary to make adjustments to the intervention to meet the needs of the participants and of the design. These changes, and the impact of the ADAPT intervention, are explored further in Chapter 4.

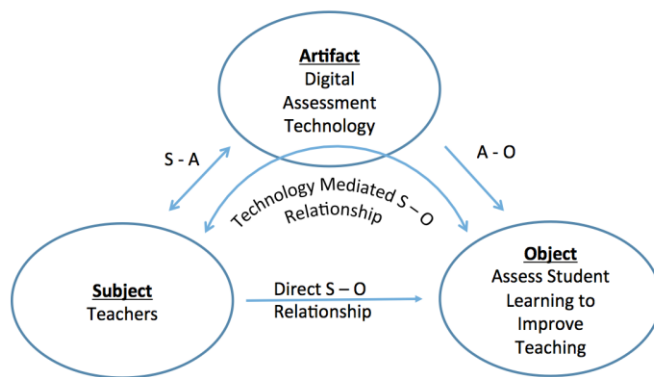
Conceptual Framework

The conceptual framework underpinning the theory of action for ADAPT is the model of instrumental genesis. As stated by Hakkarainen (2009), technology enhances learning only through transformed social practices. While the adoption of new technology in this school system was ostensibly to improve teaching and learning, the teachers who were actually going to use the new technology did not receive the training needed to transform their social practices. The technology was an artifact but not yet an instrument. In order to work as an instrument of learning and teaching, educational technologies have to be integrated, "fused," with the social practices enacted by participants (Ritella & Hakkarainen, 2012, p. 240). The work of Rabardel (Béguin and Rabardel 2000; Vérillon and Rabardel 1995) suggests that this can happen through a process of instrumental genesis, where technological artifacts can be appropriated to meet the needs or challenges of the situation. Through use, the artifact becomes an instrument; the use of this instrument then changes the user of the instrument in some way. The graphic below shows the instrumented activity model from Verillon and Rabardel (1995). In the case of ADAPT, the subject is the teacher, and the object is to improve the use of assessment. The artifact is the technology – the new digital assessment tool. It is noteworthy that the subject already had a relationship with the object before the artifact was introduced; teachers have always been

engaged in student assessment. However, the new artifact – once instrumentalized - should enhance the teachers’ ability to influence the object of assessment and student learning. The technology – an artifact– becomes an instrument as teachers use it to extend and amplify their existing assessment practices. Through instrumental genesis, instrumentation and instrumentalization are combined to facilitate the adoption of technology.

Figure 5: Instrumented Activity Model for ADAPT

Instrumented Activity Model for ADAPT



Conclusion

This design study was built upon the theory of action that if teachers apprentice with expert teacher colleagues through actively using the new educational technology tool, they will be able to adopt and use the tool successfully on their own to improve teaching and learning. Through participation in a supportive, structured, professional learning experience about data use with expert teacher colleagues, teachers will learn how to both analyze and act upon the student assessment data that emerges from the new educational technology. Through the ADAPT intervention, instrumental genesis is possible: the newly adopted technology will shift from an artifact to an instrument for teachers, facilitating improved practice and implementation of the systemic reform.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

Introduction

In the following section, I will discuss my research design and methodological choices for this study. In response to my problem of practice, I have engaged in design research. This study has three main purposes: to design an intervention to facilitate teachers' adoption of new educational technology, to assess and iteratively refine this intervention, and to investigate the design process and reflect upon the tacit practices and assumptions of both the designer and the professionals under examination in this study. To accomplish these objectives, I have selected design research as my tradition of inquiry. I will begin with a discussion of design development research both abstractly and specifically applied to this study. I will then detail my intervention design, study participants, and types of data. After reviewing data collection and analysis procedures, I will conclude by considering issues of validity, reliability, transferability, bias and rigor. Given the increasing emphasis in K-12 education on evidence-based decision-making, particularly with quantitative indicators of success, it is of quintessential importance to articulate and defend the need for a qualitative, design-based approach in this study.

Methodological Choices

Design Research

I selected design-based research (Brown, 1992; Collins, 1992) as my tradition of inquiry for this study. My goal is not to find a silver bullet or promote a panacea, but to assist an organization that is struggling with a real problem, and collaboratively design a solution that may serve as an innovative model for change in an incredibly complex system. Design research has roots in engineering research; an early approach included a hybrid cycle of prototyping, field testing, and laboratory study (Brown, 1992). It has been further characterized as including preliminary investigation, theoretical embedding, empirical testing, documentation, analysis and reflection on process and outcomes (van den Akker, 1999). It is premised upon the idea that research should address the complexity inherent in educational problems through particular, structured means including iterative cycles that allow for refinement of prototypes. Designing prototypes and systematically and iteratively implementing interventions is a hallmark of design development study (van den Akker, 1999). Through continuous cycles of design, enactment, analysis, and redesign (Cobb, 2001; Collins, 1992), the design-based research approach offers frameworks to systematize the interdependent development of theory and design (Abrahamson, 2015). As a practice-oriented approach to investigate the complexity of educational process (Abrahamson and Chase, 2015, p.3), design-based research can facilitate authentic exploration with actual teachers, leaders and learners in schools. Through an iterative process, designers can hone artifacts while exploring process, and possibly create something useful, from tools to theories. While creation and refinement is important in design research, reflection on the design process is also critical. Design-based research necessitates reflection, and the documentation of this reflection is as important as the creation of something new.

According to Cobb, Confrey, diSessa, Lehrer, & Schauble (2003), design research is differentiated from other research with 5 crosscutting features, including that it is rooted in problems of practice, is highly interventionist in nature, has both a strong theoretical as well as pragmatic orientation, is iterative and evolves to reflect current conjectures about learning and

the means to support it, and aims for generalizability. These five features are illustrated in my study. My design is rooted in a real problem in schools with teachers struggling to adopt educational technology and the design itself is highly interventionist; I develop an innovative professional learning model to address the mismatch between the support teachers need to implement the new technology and the training they have received in the system. My study has a strong theoretical as well as pragmatic orientation; my model for professional learning is rooted in empirically derived learning theory which is seldom applied in actual professional learning programs, while also being attuned to the realistic issues that teachers face in under-resourced, urban school environments. My model changed throughout the cycles with feedback from practitioners in the system and with my awareness as a designer regarding what was working or failing. Finally, my model is potentially generalizable, in that it is a prototype that could potentially be used in other resource-constrained schools to facilitate teacher adoption of new tools. The specific technology and the specific program may not be scalable, but the model itself may be generalizable to new contexts.

Advantages of Design Research

There are many affordances and advantages of design research that make it a suitable methodology for this study. Cobb et al (2003) identify one of the strengths of design research methodology: it enables researchers to explore what is possible in students' or teachers' learning. Rather than measuring one or even multiple quantifiable variables in an experimental or quasi-experimental design, design research allows researchers to explore creative, innovative solutions that question or expand boundaries of possibility. Based on evidence from the empirical knowledge base in education, the design of innovations enables us to create learning conditions that learning theory suggests are productive, but that are not commonly practiced or are not well understood (Design Based Research Collective, 2003). For example, cognitive apprenticeship is rarely if ever included in teacher professional development. Design research, such as this study, can facilitate the structured exploration and evaluation of what it would look like to embed cognitive apprenticeship in professional development for teachers. In general, the collaborative nature of design research is mutually beneficial; it supports practitioners in addressing real problems, and is of value to researchers as it generates theory. For those attempting to bridge theory and practice, design research – situated in authentic settings - decreases the distance that the bridge needs to span.

Another advantage of design research is that it intentionally creates space for discovery. The structures of other traditions of inquiry preclude that a researcher would find something that she is not looking for. In contrast, design-based researchers may develop new constructs called ontological innovations (diSessa & Cobb, 2004) that generalize beyond the study and add to the knowledge base of the field of education. Through the process of exploration and reflection, we may reveal unknown aspects of how designers design, potentially illuminating corresponding aspects of how students learn or how teachers think (Abrahamson, 2013, p.3). This is a different type of discovery, but one that is incredibly important as we continue to engage in refining the craft of education.

A final advantage of design research which drew me to this methodology is that design research can make the invisible visible. Like a reverse magic trick, design research causes hidden aspects of practice to appear rather than disappear. Tacit knowledge is instantiated through the creation, use, and refinement of the design. Reflecting upon how the design works, how it

embodies theory, how it fails, and why this happened allows researchers and practitioners to see their own biases and test their assumptions about the world. This is a way to dig beneath the surface of common language and rhetoric, and explore how members of a community interact with and shape artifacts of their trade. According to Kuhn (1962), tacit knowledge is acquired through practice and while it can't be articulated explicitly, it can be analyzed. Design research affords occasions to concretize the tacit knowledge of teacher practice so that we can look deeply at it, better understand it, and possibly improve upon it.

Design research may support “liberating education” – it facilitates “acts of cognition rather than transfers of information” (Freire, 1972, p. 53) and encourages attention toward dialogue and reflection in both research and practice. Elaborating upon Schon's influential work on reflective practitioners, Abrahamson asserts that “reflective educational designers are uniquely positioned to generate theory of learning, teaching, and – reflexively – design” (2013, p.2). Abrahamson further suggests that by reflecting on the designs we create, we may discover hidden aspects of creativity and demystify our design process. The mystification and privatization of practice are known, entrenched issues in the education profession; design research may direct much-needed effort and thought to counter these tendencies.

Challenges of Design Research

Some of the advantages of design research, from a slightly different perspective, are its disadvantages as well. The benefit of making the invisible visible so that it can be studied creates a space for manipulation. According to Suchman (1995, p.63), “Things are made visible so that they can be seen, talked about, and potentially, manipulated. It is the last that constitutes the power, for better and worse, of the construction of representations of work. With agendas of intervention come questions of interests, questions that need to remain central and lively elements of research and design.” The neutrality of interventions cannot be assumed, and the interests of all partners involved in design research must be considered.

Although design research is a powerful tool, it may present further serious challenges according to Collins and Joseph, (2004, p.16), including the following:

- *Difficulties arising from the complexity of real-world situations and their resistance to experimental control.*
- *Large amounts of data arising from a need to combine ethnographic and quantitative analysis.*
- *Comparing across designs.*

In this study, I addressed these challenges through acknowledging them and recording experiences around them. The issue of comparing across designs was quite difficult as the design changed each time; however, the changes resulted from comparison between the design itself and the experience of the users / teacher participants. Because a goal of design research is to improve the way a design operates in practice; it is critical to document the failures and revisions, as well as the overall results of the experiment (Collins & Joseph 2004). Through documentation, I have attempted to address the challenges posed here.

Another challenge noted by the Design Based Research Collective (2003) is maintaining a productive and collaborative partnership with participants in the research. Since design research can include multiple iterations and span many months and even years, it may be difficult to keep a positive relationship to sustain the commitment over time. In my design study for this paper, this challenge was not a concern. Pre-existing positive relationships and

transparency in the process helped to sustain collaboration. In fact, participants frequently expressed gratitude for being invited to participate and “listened to.”

A final weakness of design research, according to Cobb et al (2003), is its failure to address issues of equity. The design study in this dissertation addressed this weakness directly; the study is situated in an urban school with underserved students with a goal to support teachers in adopting new technology, thus the design is specifically prototyped in under-resourced environments that face the most challenging issues and barriers in education. With an emphasis on improving teacher practice to support student learning in underserved schools, and designing in and for the under-resourced environments in which these students spend their days, the entire study has been undertaken and reported through the lens of equity.

The American photographer Diane Arbus once said, “It's what I've never seen before that I recognize.” Design research has allowed me to step back from my accumulated experience in education, and see and name what I did not notice before. For this reason, I believe that design research is not for the faint of heart or the certain of mind. It is a tradition for those who sense the inherent complexity of the systems we create and wish to see it named and nudged. Despite methodological challenges, design research is an evolving, rich tradition that affords structured inquiry about incredibly important and incredibly complex processes – like teaching and learning - in context.

Intervention Design

The purpose of this particular design study was to develop a support-oriented intervention for exploring new practices aimed at organizational change in K-12 schools, in particular, the case of teachers adopting assessment technology and developing new data use practices. The intervention design for ADAPT, as described in Chapter 2, included three small group sessions with peer modeling and reflection to facilitate teacher learning and instrumental genesis.

Study Participants and Unit of Treatment

Elementary school teachers in under-resourced, urban schools are the participants and unit of treatment for this study. To purposefully engage in design study in the context of systemic reform, I bound the case selection by affiliation within one northern California Diocese. All elementary schools in this school system, as part of a systemic reform initiative with an emphasis on blended learning, were mandated to use new digital assessment technology as part of a blended learning reform initiative. The Diocese currently includes 44 Catholic elementary schools representing great socioeconomic, linguistic, and ethnic diversity. There are seven urban schools with underserved populations from which I invited 3rd-5th grade teachers to participate.

I used criterion sampling (Patton, 1990) to review potential participants and limit the group to teachers who currently taught 3rd-5th grade as part of their regular duties in one of the seven qualifying schools. It was important that the teachers had a desire to participate in a professional learning experience, and that they had some prior experience with teaching and assessment so that they could reflect on their existing process. It was also important that they were teachers were required, as part of their job duties, to carry out the mandate for the implementation of the new technology. I eliminated brand-new, first-year teachers as they have less experience with assessment and are frequently overwhelmed with the daily tasks of teaching and navigating the culture of their new school. I did however, extend the invitation to second-

year teachers and beyond, in an attempt to maximize the diversity within the group. There is a pervasive misconception in education that relatively new teachers all know how to effectively integrate technology in their instruction, and I wished to challenge and confirm or dispel this idea regarding this particular case.

I decided to focus on 3rd-5th grade teachers for two reasons: due to the structure of self-contained classrooms in elementary schools, teachers in this grade level would all teach English Language Arts and Math. These are the two areas that the new digital tool assessed, and therefore limiting the selection to teachers of this grade would ensure that all of the teachers were using or were expected to use the new technology, possibly for two subjects. The second reason I chose to focus on 3rd-5th grade teachers is that this group aligns with a natural grade level band grouping in the schools within this system. The teachers already have a Professional Learning Community established and it is natural for them to work together. The schedule of the school is structured to permit time for these teachers to meet bimonthly. My intention was to innovate a job-embedded solution that fit well within the confines of the organizational structures and routines of urban school teachers; therefore, leveraging a natural group of 3-6 teachers who already have a rapport together and are expected to collaborate on teaching and learning seemed to hold potential for my design. Creating a new group would have been arduous and artificial, and the small size of this group was ideal for the peer modeling and reflection that are part of the intervention process.

Types of Data

The issue of adopting new technology and improving teacher practice is a problem of a human and social nature, and better understanding of this issue may be possible through a paradigm that can capture the complexity of human interactions in natural settings (Creswell, 2009). Thus, this design study uses primarily qualitative methods but also some quantitative methods to assess the prototype designed within the context of the organization. There are two types of data collected and analyzed in this study: impact data and process data. Impact data is used to explore the efficacy of the design itself – does it meet the design challenge? Does it “work”? Process data refers to data collected during the development and reflection upon the development of the intervention prototype. It can inform improvements during multiple iterations. Process data is used to explore the refinement of the design, reflect upon theory, and inform design principles. Documentation, analysis, and reflection on the impact data as well as process data are critical steps I took in adherence with design research. A detailed outline of the design process is provided below followed by further details on my data collection and analysis strategies.

Design Process

Below is the detailed design calendar outline:

Table 2: Detailed Design Calendar Outline

Timeline	Design Activity
August	Develop draft design elements drawing from research about technology integration, teacher learning, and instrumental genesis
September	Conduct needs assessment for support in adopting education technology
October	Pilot teacher professional learning workshop to support the adoption of the new, mandated education technology
November	Create ADAPT design based on feedback from pilot
November	Seek expert teachers within system to serve as models for peer learning to support the adoption of the education technology
December	Include input from advisor, expert teachers, Ed Tech Director, and peers in LEEP to finalize the ADAPT model
January	Present opportunity to 3-5 th grade teachers to solicit volunteers via email
February	Baseline data collection • Survey teachers to elicit understanding of their current use of technology and current formative assessment beliefs and practices • Individual interview with each participating teacher to elicit understanding of their current use of technology and current formative assessment beliefs and practices • Pre-intervention measure of technology use (teacher login and student use of the digital assessment) • Pre-intervention measure of student achievement score
March	After school ADAPT session 1 with teachers (60 minutes) Agenda: 1. Welcome, introductions and objective for session 2. Presentation on ADAPT model 3. Mini-presentation of research on formative assessment 4. Highlighting how the new education technology enhances the existing teacher practice of formative assessment 5. Data analysis demonstration - Model teachers “thinkaloud” looking at data and analyzing data

	6. Response demonstration – Model teachers “thinkaloud” making decisions about what to do / how to connect data to classroom practice 7. Reflection demonstration- Participating teachers reflect individually, then collectively share reflections / ask questions 8. Time for participating teachers to experiment/ play with the educational technology 9. Identify 1 classroom level instructional response to the data and commit to it in writing 10. Peer feedback on commitment 11. Peer feedback on the design of the session 12. Reflection on process
March	After school ADAPT session 2 with teachers (90 minutes) Agenda: 1. Welcome and objective for session 2. Mini-presentation of research on the instrumented activity model 3. Highlighting how the new education technology requires data analysis and reflection to be useful / efficacious – highlight teacher role 4. Data analysis demonstration - Participating teachers “thinkaloud” looking at data and analyzing data 5. Response demonstration – Participating teachers “thinkaloud” making decisions about what to do / how to connect data to classroom practice 6. Reflection demonstration- Participating teachers reflect individually, then collectively share reflections / ask questions 7. Peer feedback from model teachers and participating teachers on the participating teacher demonstration 8. Revisit the 1 classroom level instructional response to the data commitment from the last session and share progress 9. Peer feedback on progress and suggestions for alternative instructional responses to the data 10. Participating teacher commitment to 1 new instructional response 11. Peer feedback on the design of the session / Reflection of process
April	After school ADAPT session 3 with teachers (90 minutes) Agenda: 1. Welcome and objective for session 2. Mini-presentation of research on teacher reflection and data use 3. Review NEW student data (2nd assessment) together 4. Data analysis demonstration - Participating teachers “thinkaloud” looking at data and analyzing data

	5. Response demonstration – Participating teachers “thinkaloud” making decisions about what to do / how to connect data to classroom practice 6. Reflection demonstration- Participating teachers reflect individually, then collectively share reflections / ask questions 7. Peer feedback from all on the participating teacher demonstration 8. Revisit the 1 classroom level instructional response to the data commitment from the last session and share progress 9. Peer feedback on progress and suggestions for alternative instructional responses to the data 10. Preview performance task – “Data Guru Teacher Tips” create 2 minute video of 1 way to use the assessment data formatively to improve student learning 11. Peer feedback on the design of the session / Reflection of process
February-May	Concurrent Data Collection 1. 15 minute individual debriefing interviews with participating teachers 2. focus group session on what went well with ADAPT, suggestions for improvement, potential for use with other new reforms 3. Participating teacher feedback on the usability and usefulness of the new educational technology and the role, if any, that ADAPT played in it
May	Summative Data Collection Post-intervention surveys for teachers Post-intervention interviews with participating teachers Post-intervention measure of technology use (teacher login and student use of the digital assessment) Post-intervention measure of student achievement score

Data Collection and Analysis Strategies

The following table summarizes the methods utilized to collect impact data throughout the design study:

Table 3: Impact Data Collection Methods Summary

<u>Surveys</u> Participants will complete pre and post-surveys regarding adoption and use of the new technology and professional learning in their school
<u>Interviews</u> Semi-structured clinical interviews of participants will occur before and after the ADAPT intervention
<u>Performance Task</u> The participants will complete a performance task at the end of the ADAPT intervention (teaching another teacher how to use the new technology) which will serve as a measure of the impact of the intervention <u>Observation</u> The researcher will observe participation in the ADAPT intervention and measure any changes in the use of the technology
<u>Technology Use</u> The researcher will quantify and measure changes in the basic use of the technology including number of times a teacher logs in and the number of times the students take the assessment
<u>Technology Adoption</u> The researcher will observe teachers' discussion of using the technology as a formative assessment and seek evidence of teachers responding to and integrating the new technology in their classroom practice
<u>Student Achievement Scores</u> The researcher will observe teachers comparing student scores on the digital assessment pre and post implementation of the ADAPT intervention

The following table summarizes the methods utilized to collect process data throughout the design study:

Table 4: Process Data Collection Methods Summary

<u>Memos and Field Notes</u> Collecting of researcher observations and reflections at each stage of the activity sequence through memos, journaling and field notes
<u>Audio Recording</u> Sequence of activities, interviews, and observations will be audio recorded with some clips transcribed to report out on data collected and to facilitate the exploration of the ADAPT protocol in use
<u>Critical Friend</u> Person outside of the study participants was selected to engage in weekly check-ins to allow the researcher to reflect on data collection processes throughout the design study

Data Analysis

During design research, data analysis occurs continuously during the iterative cycles of refinement of the intervention. For this research project, I organized and prepared the data for analysis as I acquired it. My observation field notes were typed, interviews transcribed, and all identifying information was removed from the data. I reviewed recorded sessions of the intervention as a whole creating memos in order to develop a tentative set of codes and allow themes to emerge. I used these notes to supplement the memos and notes that I took during the actual intervention sessions. I compared the collected data and measured against the coding structures and themes that were emerging. I also compared this to the desired outcome interventions and analyzed the impact data to consider whether intervention outcomes were realized, using the process data to consider how these changes may have occurred. In order to be open as a researcher and a designer to change, I structured my data analysis but avoided rigidity. I embraced problems that emerged during the implementation of ADAPT, believing as Abrahamson asserts that transformational change to my own conceptualization of learning can only occur through my willingness to solve problems as they emerge in the analysis of empirical data gathered in the implementation of designs (Abrahamson, 2015).

Validity, Reliability & Transferability

To assess the quality and significance of my findings, it is necessary to consider how my research design and study address issues common to educational research including validity, reliability and transferability.

Validity

Validity refers to the accuracy and credibility of findings in qualitative research (Creswell, 2009) as well as the trustworthiness of the instruments and research design (Bernard, 2000). It is necessary for this design development study to address validity through collecting multiple sources of evidence (Yin, 2013) and staying firmly rooted in effectiveness and practicality. Design development studies are often used when there are few validated principles from research; in fact, the purpose is not simply to validate existing instructional theory but to innovate an intervention. Rigor, relevance and collaboration (Plomp, 2010) are critical elements to facilitate systematic reflection and increase validity. Validity is also supported in this study through triangulation, member checking, and reflection with a critical friend.

Internal validity seeks to establish a causal relationship to link certain conditions with other conditions or outcomes (Yin, 2013). In this design study, I endeavored to establish a relationship between the intervention – the professional learning model - and the intended outcome, the teachers’ adoption of the educational technology. Internal validity is addressed through the establishment of a causal connection between my tool, the intervention, and the outcome. It is important to attribute the outcome to the intervention. In this study, the teachers’ adoption of the educational technology must be traceable to the implementation of the innovation. Process data will be used to demonstrate internal validity and connect the design and the impact. Impact data may validate the theory of action of this study. The theory of intervention will be collected to increase the validity of this study.

External validity generally refers to the range and limitations for application of study findings, beyond the context in which the study was done. It demonstrates that study findings are realistic, relevant, and speak to the real world (Plomp, 2007). In this study, it will be addressed through the actual outcomes of the innovation and the potential of the model to “work” in other schools and other teachers outside the context of the study. In order to determine if the model works, I will evaluate it in light of three variables that demonstrate effectiveness in design research, including climate variables, learning variables, and systemic variables (Collins & Joseph, 2004).

Table 5: Design Effectiveness Variable Operationalized for ADAPT

Climate variable	Teacher engagement: <i>Evidence will include teacher participation in intervention, teacher interview on perceptions of participation in intervention, researcher observation of teacher engagement, principal interview on perceptions of teacher participation in intervention</i>
Learning variable	Teacher skills and dispositions: <i>Evidence will include teacher self-assessment, demonstration of performance task , researcher analysis of teacher conversation during intervention sessions, observable increase of teacher use of technology, reported increase or evidence of change in classroom practice in response to use of technology</i>
Systemic variable	Sustainability, scalability, ease of adoption and cost: <i>Evidence will include researcher analysis of change in teacher use of technology, check on whether change is sustained, principal interview on perceptions of scalability, and researcher analysis of cost</i>

In design research, external validity also concerns the issue of transferability, which is addressed in a later section of this chapter.

Reliability

Reliability is concerned with consistency and potential repeatability in measurement. Lincoln and Guba (1985) assert that reliability in qualitative research is best characterized by dependability; this can be examined by an inquiry audit which looks at the process and the product of the research. In design research, reliability is supported through careful planning of the intervention and activities and meticulous documentation of the process and outcomes. Reliability is also established through the use of common research methods. In this study, reliability will be established through explicitness in design and consistency in adherence to design development principles.

Since trustworthiness of a study is also a critical component of reliability (Seale, 1999), I also endeavor to be as transparent as possible regarding my protocols, process and interpretation of findings. In an effort to strengthen the reliability of my study, I used clear protocols for data collection including semi-structured interview questions, observation notes, and field notes. My prolonged engagement (approximately 14 months) with participants also increases the

trustworthiness of the study. While the context of my study is specific and it is unlikely that using the protocols or even the prototyped model in another setting would yield the exact same results, the possibility exists for transferability.

Transferability

Transferability demonstrates that findings have applicability in other contexts (Lincoln and Guba, 1985). For design development studies specifically, transferability refers to the extent to which an intervention can potentially be transferred to a different context and result in similar findings (van den Akker, 1999). The thorough documentation of assumptions, process, and cycles of iteration support the possibility of transferability for design studies. While my study is situated in the specific context of under-resourced, urban elementary schools, the prototype and model created for teacher professional learning may be useful for other researchers who are studying and designing for schools where teachers are adopting educational technology and using data to improve student learning.

In detailing naturalistic inquiry, Lincoln and Guba (1985) note that transferability is more the responsibility of the person wanting to transfer the findings to another situation or population than that of the researcher of the original study; the responsibility of the original researcher is to present descriptive data that is specific and rich enough to allow comparison. If the researcher does this, then she has increased the trustworthiness of her work and accounted for transferability. I have attempted to provide this level of thick description in this design study.

This design study includes a micro-level of transferability as well as an eye toward a macro-level of transferability. As described by Cobb et al (2003), the intent of a professional development design study is to engage teachers in activities in one setting (the professional development sessions), with the explicit goal of supporting their reorganization of their activity in another setting, the classroom. Ideally, the work of the teacher group in the ADAPT model is transferable to their classroom practice, and the model that is developed is transferable to groups of teachers in other schools. Demonstrating an impact such as learning gains or increased adoption of technology however is not enough, according to Barab & Squire (2004); we must also strive to demonstrate the usefulness or consequentiality of our work. Design scientists should draw connections to theoretical assertions and claims that transcend the local context.

Avoiding Bias & Ensuring Rigor

Design development studies enables researchers to identify, investigate and respond to real problems of practice. Because the design and refinement of solutions takes place in the same messy world in which the problems reside rather than a controlled, clinical setting, it is of critical importance to consider issues of bias and rigor. As a former assistant superintendent in the school system, I have tremendous access to data and the advantage of long-established rapport with the leaders in the system. As a member-researcher (Datnow & Yonezawa, 2004) and known investigator (Lofland & Lofland, 1995), I am keenly aware of the need to constantly check my biases and assumptions, as well as stay firmly rooted in the empirical methodology of my work. By anchoring my work in the principles of the design development tradition, I will be able to be structured, rigorous, and explicit about my choices. I will systematically address my design challenge using established procedures. I will engage my participants as co-designers and clearly and explicitly document our process, decision-making, and reflection on the intervention.

The fact that I have connections in the school system is not merely a potential source for bias, it is also advantageous in design research. Plomp (2007) cautions that researchers may be cultural strangers in the world of their participants, and this may affect the quality of the partnership for design as well as the information elicited from people. I was able to minimize the distance between the people who were the subjects of my research and myself as researcher (Creswell, 2009). I capitalized upon the relationship that I had with the subjects of my study and the existence of expert practitioners who are willing to co-design. Engaging in reflexivity (Ruby, 1980), I continuously considered the influence of my own background, perceptions and interest upon my interpretations. By working with people with whom I have a positive connection while paying careful attention to remaining in the role of designer and researcher rather than change agent, the study was strengthened without compromising boundaries.

Yet it is still a potential concern around my role as designer and researcher that I personally have experience teaching, working and leading in urban school environments. I believe that this familiarity served me well in establishing rapport with the teachers and principal who participated in this study, but it may also have impeded my ability to observe impartially regarding the teachers. To counter this, I did check in with a critical friend from LEEP to review my observations and findings during my data collection. I endeavored to remain open to the adoption or lack of adoption of the technology, and to provide neutral support to the teachers to help them adopt and implement the new technology.

An additional concern regarding my role as designer and researcher is that I previously worked with members of the central office team. This prior connection was useful in terms of securing interviews and permission to conduct research in the school system. Clearly, my prior experience working in the central office did not inhibit the teachers from sharing their perspectives and critical comments regarding the central office. It also may explain why the central office leaders with whom I spoke were honest, forthright, and somewhat critical of the teachers in the urban schools as well. My outsider-insider perspective facilitated access and nurtured trust, while also enabling me to appear neutral and unbiased to all actors in the school system.

My final concern as designer and researcher is a potential bias to believe that my intervention is working even when it may not be. Advocacy bias (Stake & Rosu, 2012) is a potential issue in this study; researchers may be predisposed to collect confirming evidence that their designs are working and fail to see the evidence that they are not working. Due to confirmation bias and personal attachment to one's own designs, it is possible that I might perceive ADAPT to be effective while it is not. To counter this, I engaged in triangulation (Patton, 1990), engaging multiple methods and looking at several data sources, as well as frequent check-ins with Critical Friends from the Leadership for Educational Equity Program (LEEP) at UC Berkeley while interpreting data. I believe that I effectively negotiated advocacy bias in the study; relying on multiple data sources, I can point to evidence of what worked in the intervention and what did not work. And although I would like to report success, careful examination of the evidence as synthesized in the next chapter demonstrates that I actually have more failures than successes to report. Despite the lack of overall effectiveness of ADAPT, I have learned a great deal as a designer and researcher about design-based research, its utility in systemic reform, and the critical and complex role of professional learning for teachers in the adoption of new technology.

In addition to taking steps to avoid bias in this research, I took active measures to ensure rigor. Coghlan and Brannick (2014, p.14) define rigor as “how data are generated, gathered,

explored and evaluated, how events are questioned and interpreted through multiple action research cycles.” This definition of rigor, derived from action research, is well suited for design studies. Rigor addresses dimensions of quality such as how are the outcomes of the study are challenged, supported or disconfirmed (Coghlan and Brannick, 2014). To ensure rigor, I clearly documented my design process and product, and I reflected upon and questioned the ADAPT prototype during the cycles of iteration. When changes were made in the design, I referred to research to guide decisions and documented the changes in process notes. Throughout the research process, I reflectively examined how my background as a practitioner has shaped my interpretation of findings (Creswell, 2009).

Conclusion

The issue of adopting new technology and improving teacher practice is a problem of a human and social nature, and better understanding of this issue may be possible through a paradigm that can capture the complexity of human interactions in natural settings (Creswell, 2009). The intention of design-based research in education is to inquire more broadly into the nature of learning in a complex system and to refine generative or predictive theories of learning (Design Based Research Collective, 2003). It is not my intention in this study to design a specific program to facilitate the adoption of all technology or even a specific new educational technology; rather, I am developing and refining a model of a successful innovation to facilitate teacher learning. A design-based approach is most appropriate to address this challenge.

This design study is an attempt to create an intervention to facilitate teachers’ adoption of new educational technology, iteratively refine this intervention, and document the design process. In this chapter, I discussed my research design and methodological choices for this study. In response to my problem of practice, I have engaged in design research. This chapter explored design research methods, the intervention design, study participants, types of data, data collection and data analysis procedures, with special attention to issues that may affect the quality of the findings. In the next chapter I present my findings from data collection and analysis.

CHAPTER 4: FINDINGS

Introduction

This design based research study had three main purposes: the design of an intervention to facilitate teachers' adoption of new, mandated educational technology, the assessment and iterative refinement of this intervention, and investigation of the design process and reflection upon the tacit practices and assumptions of both the designer and the professionals under examination in this study. In this chapter, I present and analyze impact and process data relative to these three purposes. I consider evidence for assessing the effectiveness of the ADAPT intervention in its facilitation of teachers' adoption of the technology. I also reflect on the design process, including my chronicling of the refinement of ADAPT, and I consider the changes made to the intervention during the study and the validity of the ADAPT intervention. I note surprises and failures, and briefly consider implications for the future of ADAPT which I further elaborate in Chapter 5. Throughout the discussion, I situate and relate the significant findings to the instrumented activity model.

Organization of Data Analysis

I endeavor in this chapter to tell the story of ADAPT as both researcher and designer, with consideration for the effect and effectiveness of the intervention and the core design as a whole. I begin with a description of the pilot study and beta version of the ADAPT design. I then introduce ADAPT and the participants in the study, focusing on the impact data. Through analysis of the survey, interview, intervention participation data, and technology analytics, I consider the impact of ADAPT upon a small group of urban elementary teachers. I apply this impact data to consider issues of validity of the ADAPT intervention. I then present and analyze process data drawn from my memos, field notes, and reflections on the recorded ADAPT sessions. This data enabled me to reflect upon surprises and failures, and identify and address issues related to practices and assumptions of both the designer and the professionals under examination in this study. When appropriate, I include direct quotations from participants to support my findings, and I triangulate sources of evidence when possible. The instrumented activity model is referenced throughout this chapter to both abstract and anchor the findings.

Pilot Study

Before designing and analyzing the impact of the ADAPT intervention, I considered the impact of the original professional learning and an initial iteration of the new model. As described in chapter two, the central office of this school system originally provided one traditional professional development training for all teachers in the system. This one-shot, one-day workshop addressed all of the teachers, regardless of subject area or grade level they taught, in the same manner. The trainer was an employee of the company that sold the digital assessment system to the Diocese; consistent with business practices in the field of education, publishers, service providers and education technology companies often include free or discounted training with the purchase of their products. The central office made the decision to use this training as the introduction and sole training for the mandated technology reform initiative. During my interviews one month after the one-day workshop, the training was described by teachers as "*ineffective*" while the central office cited that many schools, including the urban schools, were

simply “*not on board*” with the new technology. The central office explained that the purpose of the one-day training was “*to give the teachers a taste of the new technology*” and considered it useful in that regard, although the Director of Educational Technology and other central office leaders admitted that the training was insufficient to facilitate adoption and that “*Principals will need to support this locally to make it work.*” Interestingly, when I attempted to triangulate data with principal interviews, I learned that the principal of the school had no idea that she was supposed to “make it work”; she had no professional development around how to lead the initiative or what to do to support teachers in the adoption of this technology. She did not have a sense of how, or if, she should also be using the new technology as a school leader, but was most concerned about supporting the teachers in using it.

An examination of the sign-in sheet for the September one-shot workshop revealed that the majority of teachers from the urban schools did not show up for this required training, instead working at their own sites that day. Two of the three teachers who participated in the ADAPT intervention attended this training; they both noted that it was “*not helpful*” and “*junk.*” When I probed further, Melanie critiqued the pedagogical methods of the day, stating, “*The trainer just told us to sit down and log on. That’s not how I learn. We learn by talking, and by watching him show us how to use it. He just spewed a bunch of jargon.*” Mara, the other teacher who attended the training, agreed, lamenting that, “*The funny thing is I actually really like this technology. But I did not like how it was introduced to us. Nothing was explained- it was like now you will just do this. We were treated like children.*”

Anne, the third teacher in our ADAPT group, did not attend the training. She explained that she skipped it because she knew she could just learn about it later from a colleague or on her own if it ended up being a new idea that “sticks” and is actually going to be implemented in schools. She also expressed skepticism regarding any new reform that was mandated from the central office, asserting that “*They just grab for the latest thing. There is such a drive for data right now, that is why they latched on to this. Too bad they don’t drive with some thought in their heads the way they want us to drive with data.*”

I participated as an observer in the one-day training in September. My field notes recorded that there were not enough seats and computers for the number of teachers who were mandated to attend the training, suggesting that the central office did not actually expect full compliance with the directive. The teachers who did attend seemed engaged. They listened to the trainer, who had a limited background in elementary education in another state, and watched the PowerPoint. Each teacher was given a spiral-bound hard copy of a book with directions for how to use the new technology. The trainer opened with a discussion of what it might mean to be a data-driven school. He emphasized the need to “strengthen the core curriculum” and suggested that using the new technology would facilitate this. He then gave teachers a dummy login and password and instructed them to take the test as a student. They then were given a dummy teacher login and password and were able to look at the student results. Teachers appeared tired and a confused by this point, but they asked many questions, including “*What about math?*” and “*How do we explain this assessment to our students’ parents?*” The teachers’ questions focused on relationships between the curriculum, the new technology, and the use of the assessment data in their classrooms and with students’ families as well as general questions regarding the purpose and expectations around the use of the new technology. The trainer chose to not answer any of those questions, stating that those are “*local decisions.*” He instead focused on logistical aspects of the digital assessment, including how to administer the assessment, how to print various reports, how to add students’ names in, and how to turn on the extended time feature. He

concluded by stating that using the new system could “*change your whole school... just the simple stuff we talked about, do it and you will become a data-driven school!*” The teachers, some puzzled and some frustrated, collected their books and left.

The impact data for this one-day session is scarce due to a lack of an evaluation form by teachers regarding the session, and the lack of clarity or specificity on the part of the school system as to what the goal for the session was. If the goal was truly to “*give a taste*” then the people who attended experienced a small taste. If the goal was to have all teachers attend the training, the goal was not met. A month after this training, roughly half of the teachers in the urban schools had not yet logged in to the new digital assessment system, ostensibly the first step in using it. Clearly an additional focused professional development session was needed.

Beta ADAPT

The very first iteration of ADAPT was designed for a whole faculty. Following the unsuccessful, generic, traditional professional development approach, I partnered with the Director of Educational Technology to create an intervention focused on a faculty level to support the adoption of the new digital assessment technology in the urban schools. We decided that we would do a 1-hour training session, reviewing the basics of how to use the digital assessment system and also show some of the reports that teachers in other schools found to be popular. This training occurred during a regularly scheduled faculty meeting time on a Wednesday in late October at St. Francis, an urban school site. The selected site at the time had 50% of teachers participating in using the new digital assessment system. The training was led by the Director of Educational Technology and an expert teacher from another school in the Diocese. The audience included all of the teachers in the urban school; therefore, teachers who taught grades K-8 and a variety of subjects were in the training. Notably, both the Director of Educational Technology and the expert teacher leading the session were not from another urban school; their experience in elementary schools occurred in affluent settings – they were referred to as being from “*schools in the hills*” as I heard one teacher from the urban school – “*a school in the flats*” describe. This comment generated nods of agreement from other teachers, leading me to consider that the next iteration should include not only an expert teacher, but an expert teacher from another urban school. Perhaps there was something about the educational context of the trainer, or the match between the trainer and teacher colleagues, that increased the efficacy of the training or the legitimacy of the perceived expertise. Perhaps there was some aspect of professional vision (Goodwin, 1994) that was specific to not just teachers, but teachers of urban schools in particular.

The training lasted approximately one hour. All of the teachers were seated, facing the front of the room, where the Director of Educational Technology and the expert teacher stood and explained various reports that were projected from their laptops to an overhead projector. Approximately 12 minutes were spent on looking at generic student data, and then approximately 23 minutes were spent looking at various reports that could be created and shared with parents. A little under 10 minutes were spent considering interventions for students who were deemed to be performing below grade level as determined by the new digital assessment. This final portion of the training seemed to excite the Director of Educational Technology the most, who smiled and quickly reviewed, with great enthusiasm, a variety of educational technology tools that were available for teachers to use at no additional cost to the school. He saw this as an opportunity to show the teachers the utility of tools such as Razzkids, Mathletics, ST Math, STAR reading, and

other online tools that were available to teachers. The teachers seemed overwhelmed at this point. One teacher stated, *“More technology to respond to the other technology? Can we focus on one thing?”* Another teacher agreed, stating, *“It must be nice to have so much time to look at all this stuff.”*

In terms of impact, this whole faculty session proved only moderately successful in spurring the use of the new technology. After the training, the number of teachers logging on increased marginally from 6 out of 12 to 7 out of 12. Feedback from the teachers affirmed that the teachers enjoyed seeing demonstrations of various reports, but this did not increase their actual generation or use of these reports in their own classrooms. They appreciated seeing the options that are available to support students in need of extra support, but they felt that the training covered too many things too quickly. A teacher stated that, *“we covered too much superficially, and nothing in depth that applied to me or my kids.”*

Thus, with consideration for the experience of the first two iterations combined with the principles gleaned from the literature about effective teacher professional learning, the ADAPT intervention was designed. ADAPT would focus on an even smaller group of teachers in an existing professional learning community, and would include multiple sessions to ensure prolonged contact, focus and accountability. Rather than passively watching an expert use the new digital assessment technology, the ADAPT model would facilitate occasions for joint work (Little, 2006) where teachers would actually use the system together to explore real data with their very own students. The expert teacher to lead the sessions would be a teacher from another urban school, or ideally a member of the faculty of the school in which the intervention was occurring. The ADAPT sessions would be embedded in the teachers’ usual work routines. This new model, and in particular the elements of modeling of expertise by peers in similar educational contexts, providing time for teacher reflection, and practice in small, pre-established groups, would be the next iteration of the intervention. The following sections of this chapter explore impact data, process data, and significant findings of this iteration of ADAPT.

ADAPT

The ADAPT intervention consisted of three 60-90-minute professional learning sessions with three teachers in a 3rd-5th grade level group. These teachers were all from one urban elementary school which served a high need population, including students whose families were below the poverty level (89% free and reduced lunch) and English learners (63%). Additionally, teachers reported that the school had a large population of students with identified learning differences and students who had experienced trauma. The school was identified as an urban school by the central office and was part of a regional group of schools that focused on underserved populations. This school, along with all of the schools in the school system, were mandated to adopt the new digital assessment technology. This school had been identified by the central office as having a low level of adoption of the technology. The school principal and all of the teachers in the study volunteered to participate in the ADAPT intervention despite the multiple initiatives that were being implemented in their school. The study participants included three teachers and the researcher. The teachers were all female and had between two and 23 years of experience. All of the teachers taught math and language arts to their classes. The table below illustrates the teacher demographics.

Table 6: ADAPT Teacher Demographics

Teacher Pseudonym	Gender	Years of Teaching	Self-assessed Tech Comfort	Grades Taught
Melanie	Female	2	High	5
Anne	Female	17	Medium	3,4,5
Mara	Female	21	High	3

It is interesting to note that all three of the teachers self-assessed at having at least a medium level of comfort and familiarity with technology. None were techno-phobes or afraid to use technology. This is a significant observation from my baseline data survey which counters the prevailing rationale or myth about why teachers do not adopt technology – they do not use it because they are afraid of it; they resist implementing new technology because they don't know how to use technology in general. My personal observations of the teachers during initial surveys, interviews, and our opening session supported the teachers' self-assessment as capable users of technology. While teachers reported that they felt comfortable using technology to assess student learning in general, the preliminary survey revealed that none felt that they had yet received any helpful professional learning regarding how to use the newly mandated digital assessment system. All of the teachers felt strongly that teacher professional learning was important - this supported the need for the ADAPT intervention. All of the teachers participated in the professional learning sessions and completed surveys and interviews as well.

Data Analysis: ADAPT Impact Data

To assess the impact of the ADAPT intervention, I collected pre and post-survey data, pre and post-interview data, pre and post-analytics on teacher use of the technology, and pre and post-student achievement scores. I also had teachers complete a performance task during the final session (teaching a new teacher how to use the technology). Finally, I observed the teachers' participation in ADAPT sessions and their professional learning community meetings to look for evidence of increased use of the new technology.

The following table summarizes the impact of ADAPT by data type:

Table 7: ADAPT Impact by Data Type

Data Type	Pre-ADAPT	Post-ADAPT	Impact
teacher surveys (likert scale ratings)	-low ratings for experiences of PD (1.5) -low ratings for knowledge of new mandated tech (2) -high ratings for importance of tech, assessment, and PD (4.5)	-high ratings for experiences of PD (4) - high ratings for knowledge of new mandated tech (4) -high ratings for importance of tech, assessment, and PD (4.5)	Positive – ADAPT increased teacher ratings on their experiences of PD (+2.5) and teacher ratings on their knowledge of how to use the new tech (+2)
teacher interviews	Interviews confirmed that teacher experiences with professional learning had been superficial and ineffective; teachers were willing to use technology but did not see purpose or value of the newly mandated tech	Interviews confirmed that teacher experiences of engaging in ADAPT contributed to their learning; in particular, teachers felt that learning from expert peers was powerful	Positive – ADAPT increased teachers' positive responses about professional learning and provided an experience that they felt was worthwhile
tech. use analytics	33% usage	100% usage	Positive – ADAPT worked in terms of getting teachers to use the new tech. However, this increase in usage was not sustained after the ADAPT sessions (the impact diminished to 66% usage, which is still a positive increase but less than noted here).
student scores	Average: Below Grade Level	Average: Below Grade Level	No Significant Impact- Teachers pointed out that while individual student growth occurred it was not enough to move the average of all student scores into grade level
observation: ADAPT sessions	Teacher PLC meetings were unfocused and frequently interrupted.	Teachers participated and fully engaged in all ADAPT sessions; expressed that their time was spent in a	Positive – Teacher engagement was high.

		meaningful and worthwhile manner.	
Performance tasks	None	Performance tasks demonstrated that teachers knew how use the tech and how to analyze the assessment data; however, performance tasks that required evidence of response to the assessment in classroom practice were not completed.	Positive – Teachers learned how to use the tech and analyze the assessment data Negative – Teachers did not transfer this knowledge to their classroom practice; they adopted a compliance orientation to the new tech and completed only the most basic use of it.

As illustrated in the table, teacher surveys indicate that ADAPT was effective in increasing teachers' positive experiences with professional development and knowledge of the new educational technology. Interview data supported this finding and affirmed the significance of teachers learning from expert peers. Technology use analytics demonstrate an increase from 33% to 100% of teacher usage of the new technology after participation in the ADAPT sessions, although this finding should be tempered by the idea that the usage rate declined after the intervention concluded. While there was no notable increase in student achievement scores such that average student classification would move from below average to average, teachers identified individual student growth on the digital assessment after the ADAPT sessions. Observations and field notes indicate that teacher participation and engagement during the ADAPT sessions was high, and teachers frequently expressed that the time was well spent. The performance tasks associated with the ADAP intervention reveal mixed results; on one hand, teachers learned how to use the technology and analyze the student data, showing success of the professional development; on the other hand, the performance tasks that were connected to actually responding to the data through changes in the classroom were not completed.

Impact Data Findings

The impact data suggests that ADAPT worked in terms of increasing teacher usage of the mandated educational technology. Analytics, teacher comments, and researcher observations all confirm that teachers used the new technology together. Teachers participated in the intervention sessions and engaged in data analysis and reflection with colleagues, expressing that they enjoyed the collaboration with peers and felt "honored to participate."

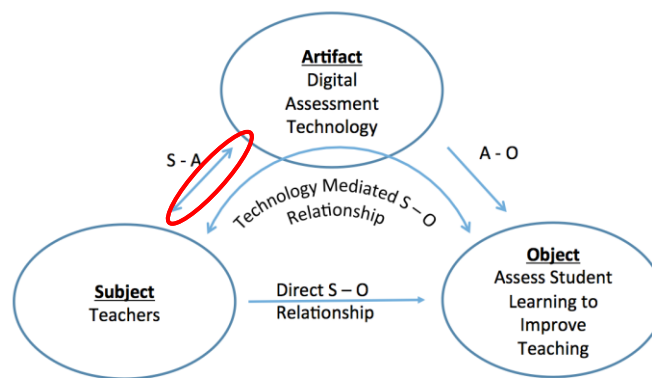
The impact data also suggests that ADAPT did not work in terms of changing teacher practice relative to formative assessment, which was the driving force behind the systemic reform initiative. The teachers adopted a compliance orientation toward the new educational technology; ADAPT moved them from not using it at all to using it in the most basic sense to "check off the box" that they did it. Teachers did not transfer their learning from the ADAPT sessions to their classroom practice; there was little to no follow-through on discussed interventions; little evidence of application of data formatively; no reported or observed change

in classroom practice. The use of the mandated technology decreased after ADAPT sessions ended, suggesting that the limited impact was not completely sustained.

Returning to the conceptual framework of instrumented activity for ADAPT, the findings here suggest that ADAPT supported the teachers in understanding the object and its connection to the artifact. ADAPT helped teachers to see the possibilities of the new technology and to understand how to use the new digital assessment technology. However, ADAPT did not support teachers enough in instrumentalizing the new technology. Rather than enhancing the relationship between the teachers and assessment, the digital assessment technology became another step to take, disconnected from the teachers' objectives. The technology-mediated relationship between the teachers and student assessment broke down between the subject and the artifact. As described by Ritalla and Hakkarainen (2012, p. 248), personal appropriation of even simple technology is initially challenging because it requires appropriating new social practices in gradually "adapting and changing one's cognitive-cultural operating system of activity. "The new educational technology that was mandated as part of this reform initiative was arguably complex rather than simple technology, and it was designed to enhance a relatively complex teacher practice of assessment. The appropriation of the new technology, amidst this complexity, is challenging.

Figure 6: Instrumented Activity Model for ADAPT, Breakdown #1

Instrumented Activity Model for ADAPT



An examination of the process data for this study further illuminates possible reasons for the failure of ADAPT to support teachers in the instrumentalization of the new technology.

Data Analysis: ADAPT Process Data

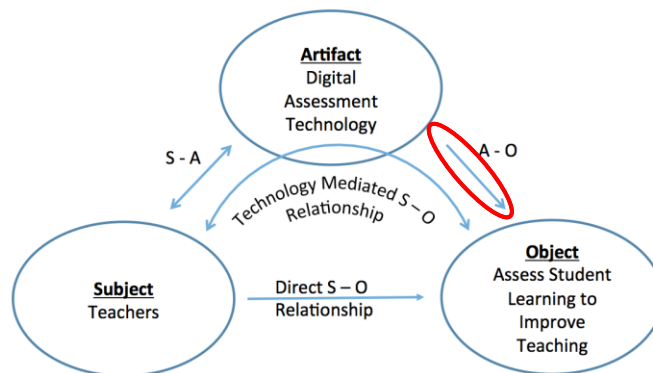
The process data for ADAPT included memos and field notes for each of the sessions, and audio recordings of the sequence of activities. I engaged in weekly check-in reflections between myself and a critical friend in LEEP to review and explore the data throughout the design study. This data provides clues as to why ADAPT did not facilitate the instrumentalization of the new technology for the teachers. Process data and the conceptual framework for instrumented activity in ADAPT will be referenced in the next section to explore this breakdown.

Process Data Findings

Why didn't ADAPT facilitate the instrumentalization of the new educational technology? Originally, I hypothesized that there was a mismatch between the training that teachers needed to adopt the new technology and the training that was provided to them by the school system. While this may have been accurate, reflection upon the process data and the instrumented activity framework for ADAPT suggest that there may also be a mismatch between the artifact and the object. That is to say, I assumed that the artifact and object were aligned and did not consider that teachers might have a different perception.

Figure 7: Instrumented Activity Model for ADAPT, Breakdown #2

Instrumented Activity Model for ADAPT



Perceived Mismatch Between Artifact and Object

Specifically, ADAPT focused on the relationship between the subject and the artifact, but did not focus on the relationship between the artifact and the object - this was a critical and incorrect assumption. ADAPT focused on the relationship between teacher and the technology, designing occasions for the teachers to apprentice with other expert teachers in the use of the technology. It did not explicitly focus on the relationship between the technological artifact itself and the object of student assessment. A focus on student assessment connected with the digital artifact may have revealed a bias that was elicited as process data: teachers did not believe that the mandated educational technology was the best tool for the objective. In fact, teachers were actively using another digital tool that they perceived to be much better. The emphasis in ADAPT on instrumented activity was countered by the teacher notion that the mandated technological artifact is not the instrument for the objective. Teachers believed in the importance of assessment and the power of technology to enhance their practice, but they did not believe that this specific technological artifact was a worthwhile tool for this specific objective of formative student assessment. There would be no instrumental genesis since teachers did not accept this technological artifact as a potential instrument for the activity. The teachers had selected an alternative tool, which they were writing grants to support, that they believed was more appropriate, effective and powerful for the purpose of monitoring student assessment. They were

willing to use what they perceived to be an inferior technological artifact to comply with the mandate, especially given the support of the ADAPT sessions. However, they would not accept this artifact as their instrument when they had something better. It was as if the central office was asking the teachers to learn to play a song on a plastic recorder while they secretly practiced their clarinets; the teachers would play exactly the notes required on the required recorder, and then use the rest of their energy honing their skills with their real instruments.

Data Visualization Clashes with Professional Vision

A second major finding from the process data which may explain why the new educational technology was not instrumentalized has to do with professional vision. The data visualization models embedded in the new technology clashed with the teachers' professional vision. Goodwin (1994, p. 612) asserted that graphic representations constitute embodied practice and can organize phenomena in ways that language alone can't; the creation and use of such representations is one of the distinctive forms of professional literacy that constitutes a profession. For educators, the data visualization of student assessment data in the new technology did not align with their professional vision. The parameters of the data visualization for the new digital technology were established by a system outside of the teachers to organize their perceptions. The teachers in this study did not enjoy this organization.

Through interviews and observing their interactions with the technology, it was evident that the landing pages of the technological artifact upset the teachers and did not "look right" to them. The initial models that represented the results of the student assessment data evoked negative reactions from all of the teachers in the study. It was as if the designers of the technology had assumed that most students would be on grade level. In this particular school for this particular set of students, the class average was below grade level in each class. The portal to the site displayed this in a prominent fashion with big red bars. The teachers did not want to "dig deeper" into a report that showed the majority of their students as failing or behind; the articulation of graphic representation was so unpleasant that they did not want to even use the technological artifact. This data visualization clashed with a deeply held belief for this set of urban teachers that all students can learn, and that growth matters more than achievement. The emphasis on labeling students "below grade level" and the highlighting of these students was particularly offensive to teachers; they stated a preference for highlighting learning progress rather than labeling students.



Data Visualization of Student Score, Teacher's Attention on Red

Teacher surveys revealed that while the teachers in this study strongly agreed with the idea that all children can learn, the teachers in this study did not strongly agree with the statement that all students can achieve the grade level standards of the curriculum. Thus, the emphasis that the technology data visualization placed on grade level standards – and the prioritization of this over the potential learning gains made by students – clashed with the beliefs and priorities of the teachers.

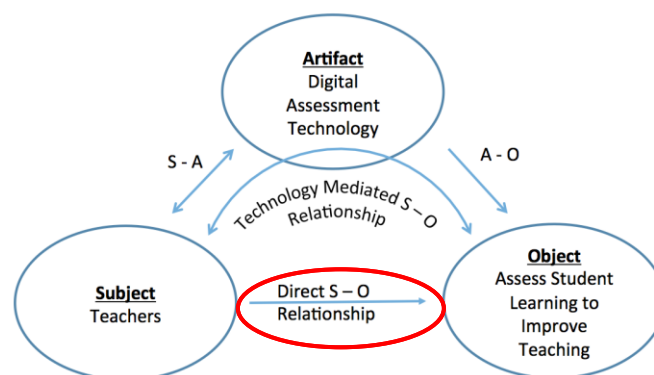
Teachers seemed to have a protective nature when it came to their students and achievement testing. Through interviews and observation of the ADAPT sessions, I learned that the teachers believe that most high stakes assessments are worthless in terms of measuring student learning and that for their population, they are a harmful experience. Perhaps due to the mandated nature of this technology, teachers coupled the assessment results with their experiences in the accountability regime and felt the need to shield students.

Teachers were not merely defensive of students. Teachers also seemed to be defending themselves as professionals with their rejection of this student assessment technology. It seemed that teacher identity was deeply yet implicitly connected to student performance; this connection was articulated by one teacher who criticized the assessment technology as “*one more way to tell us we’re failing*.” The increasing push to assess students had a demoralizing impact rather than motivating impact on teacher behavior with this group of teachers. Interestingly, teachers were able to analyze and respond to the same student data when it was presented in a different format by the expert teacher colleague. The expert colleague clicked past the landing pages to show growth scores and to look closely and error patterns with student performance. The teachers seemed willing, even eager, to understand and use this data. However, their preferred tool (an alternative technology that they had locally adopted) simply made it easier to see and respond to this type of student information.

Returning to the conceptual framework of instrumented activity, this finding suggests a disconnect between the subject (teachers) and the way they perceive the object (assessing students) which clashes with the artifact. Professional vision of the subjects was not adequately accounted for in the technology-mediated relationship with the artifact of the new digital assessment tool.

Figure 8: Instrumented Activity Model for ADAPT, Breakdown #3

Instrumented Activity Model for ADAPT



Resistance as a Resource: Urban School Teachers Are Smart

As mentioned earlier in this study, the teachers who participated in this research seemed neither afraid of technology nor resistant to change. They were, however, resistant to the adoption of the mandated digital assessment technology. They expressed this resistance initially through passively not using the new digital artifact. After participating in the ADAPT sessions, they used the artifact but only in a superficial and limited fashion while they were being observed in the study. During interviews and through observations of the ADAPT learning sessions, it became apparent that their resistance was due to the perceived lack of adequacy between the technological artifact itself and the needs of the students. The teachers had opinions and expertise that had not been considered prior to the implementation of this reform. Specifically, the teachers felt that the mandated artifact was not as powerful as it could be to promote learning for their particular students in this underserved community. The teachers felt that the artifact might work for more affluent student populations but was a mismatch for their community.

The teachers' resistance to the adoption of a mandated reform could be viewed as a resource that could be helpful in adopting or changing a reform initiative to meet the needs of students and teachers. Clearly, there are pools of expertise among these teachers and their colleagues. Like their students, urban school teachers are smart. Yet it was evident that the teachers in this particular urban school are viewed by other actors in their school system through a similar deficit lens as their students; they are perceived to be deficient and resistant due to a lack of skill rather than a conscious objection. Process data revealed that the teachers had the capacity to use and instrumentalize the mandated artifact, but were choosing to use a different digital tool that was more complex and a better fit for their students.

The teachers adopted a compliance stance and a pragmatic approach to the mandated technology; the superficial implementation of this required reform allowed them to focus their energies on addressing what they perceived to be students' critical needs with the best tools at their disposal. The teachers expressed that they had limited time and energy, and their students had profoundly deep learning needs. For this reason, they simply could not waste time with technological artifacts they perceived to be inferior. This resistance, once identified and explored, is both logical and helpful. It could be a resource for the system to support improved student learning rather than a hindrance to overcome.

Leadership Support Needed

A final finding from the analysis of the process data is the need for local school site leadership to actively support the implementation of the reform initiative. Since the mandate was issued from the central office, school site leaders do not need to just reiterate the requirement to adopt the new technology. School leaders need to make sense of the mandate and support the teachers through the change. Specifically, school leaders can do this by protecting collaboration time for teachers to learn from each other and buffering teachers from other distractions during this time. It was clear that the principal's commitment to providing a steady focus on the technology reform and providing teachers support to implement the reform contributed to the limited success that we had with ADAPT. The principal was also quite willing to step aside and empower expert teachers to take the lead with facilitating teacher learning, rather than micro-

managing the teacher meetings.

I noted that during every single ADAPT session, there was an interruption of our work by a student, parent, or the school administrative assistant. It seemed that the teacher meeting time was not perceived to be as critical as the urgent needs of other members of the school family. The school principal's support in protecting the teacher meeting time as "sacred" was helpful to the teachers' learning.

Digital Exodus for Urban Teachers

A significant failure of the ADAPT intervention, despite the fact that it was designed for use in the under-resourced environment of urban schools, is that it underscored the hardships and realities of teaching in urban environments. Even though the school calendar had professional learning community time scheduled twice monthly, the teachers appeared to be juggling myriad responsibilities and expressed frequently that they simply "*did not have time*" to really learn how to use the technology or collaborate with each other on anything. It appeared that the ADAPT intervention provided a consistent and protected space for collaboration, but this was atypical for the teachers. The teachers also expressed that they had very little support to handle everything on their plates, and that the school needed more technology support in general to keep the infrastructure conducive to actually using technology.

The teachers in this study, while very pleasant and cooperative, were visibly stressed during all of our sessions. They expressed being tired and having a really hard time keeping up with changing schedules and changing expectations within their school and within the school system. Much like their own students who experience trauma and are unable or not ready to learn, the teachers seemed dazed, exhausted and unfocused; despite their joking, pleasant manner, they were clearly overwhelmed. The expert teacher was gentle and helpful with her colleagues, even though she appeared equally exhausted. The teachers seemed to appreciate my acknowledgement of their fatigue and participated dutifully in the intervention. However, the intervention itself, in its next iteration, needs to address somehow the exhaustion of the teachers in these environments and respond to them in a way that facilitates understanding and learning. Perhaps initial sessions could be added to provide time and space to become ready to focus on the learning. The irony of school reform is that the teachers of underserved students are themselves overwhelmed and exhausted, and often tasked with implementing multiple, significant school improvement efforts. Attention needs to be paid in the future to supporting teachers' readiness for participation in professional learning, perhaps through increasing the amount of protected time that teachers have to reflect or increasing the frequency of support-oriented professional learning sessions while decreasing the expectation for the number of initiatives adopted at a time.

Despite the fact that ADAPT was designed to promote instrumental genesis, the teachers in this urban school seemed to experience a digital exodus. The teachers left the inferior technology behind as soon as they identified it as such. They were willing to wander in digital wilderness, but only with the right leadership and tools that aligned with the teachers' needs and the needs of their students. Anything that might not work for their students is not worthwhile for them.

Findings Regarding the Validity of ADAPT

Validity in design-based research is best assessed through an analysis of whether the design works. To determine this, I evaluated the final iteration of ADAPT in light of three variables that demonstrate effectiveness in design research, including climate variables, learning variables, and systemic variables (Collins & Joseph, 2004).

Table 8: External Validity Results for ADAPT

Design Effectiveness Variable	Operationalized for ADAPT	Result
Climate variable	Teacher engagement: <i>Evidence will include teacher participation in intervention, teacher interview on perceptions of participation in intervention, researcher observation of teacher engagement, principal interview on perceptions of teacher participation in intervention</i>	All teachers participated in the intervention. All teachers reported enjoying spending focused time in small groups, and appreciated having a teacher expert who understood their needs lead the sessions. Principal confirmed that teachers were “honored” to participate.
Learning variable	Teacher skills and dispositions: <i>Evidence will include teacher self-assessment, demonstration of performance task, researcher analysis of teacher conversation regarding formative assessment during intervention sessions, and observable increase of teacher use of technology</i>	While use of the digital assessment increased and all teachers administered the assessment to their students, there was limited application of the digital results to teaching practice. Teacher reports and researcher observation suggest that teachers found the data inconsequential, unhelpful, useless or inaccurate. Teachers were amenable to discussing student assessment data but preferred other technology tools. Teachers responded to ADAPT with a compliance orientation.
Systemic variable	Sustainability, scalability, ease of adoption and cost: <i>Evidence will include researcher analysis of cost, principal interview on perceptions of scalability, researcher analysis of change in teacher use of technology</i>	The costs associated with ADAPT are minimal since teacher professional learning occurs on site with expert peer colleagues. The amount of time for ADAPT is comparable to the 1-day training (8 hours) but the difficulties of maintaining a focus without the presence of the designer or outside support is questionable. Scalability is contingent upon local expertise, leadership commitment to the technology adoption, leadership protection of the professional learning time of the teachers, and a better fit between the objective and the instrument.

From this study, I conclude that ADAPT is a moderately valid intervention. Climate variables measured suggest effectiveness, and learning variables suggest mixed effectiveness. Systemic variables are complicated but promising. The validity of the ADAPT intervention could be increased by strengthening the design in the next iteration to elicit teacher perceptions early on related to the alignment among the components of instrumented activity (for example, the match between the technology and the needs of their specific students). Addressing this earlier in the study might strengthen the teacher learning and transfer of that learning to the classroom, thus strengthening the overall effectiveness of ADAPT.

Conclusion

Findings from a design-based research study of the ADAPT intervention include mixed results. The impact data suggests that ADAPT worked in terms of increasing teacher usage of the mandated educational technology. The impact data also suggests that ADAPT did not work in terms of changing teacher practice relative to formative assessment, which was the driving force behind the systemic reform initiative. The teachers adopted a compliance orientation toward the new educational technology and did not transfer their learning from the ADAPT sessions to their classroom practice. The use of the mandated technology decreased after ADAPT sessions ended, suggesting that the limited impact was not completely sustained.

The process data from this study provides clues as to why ADAPT was not more effective. While the teachers enjoyed learning from expert peers in their professional learning community, the emphasis in ADAPT on instrumented activity was countered by the teacher notion that the mandated technological artifact was not the best instrument for the objective. Teachers believed in the importance of assessment and the power of technology to enhance their practice, but they did not believe that this specific technology was a worthwhile tool for this specific objective of formative student assessment. There would be no instrumental genesis since teachers did not accept this artifact as a potential instrument for the activity.

Similarly, professional vision of the subjects was not adequately accounted for in the technology-mediated relationship with the new digital assessment artifact. Teacher resistance to the reform initiative was not adequately explored or addressed prior to the implementation of ADAPT. Increased leadership support for teacher learning, in particular the protection of collaborative professional learning time, and a deeper understanding of the complexity and challenges of teaching in underserved schools is necessary to support the efficacy of the next iteration of ADAPT.

CHAPTER 5: DISCUSSION

Introduction

In this chapter I discuss the findings of this study and assert that ADAPT has promise for meeting the design challenge of supporting teachers in the adoption of educational technology. I contend that instrumental genesis, a critical conceptual framework for ADAPT, both illuminates the missing components in the last iteration of ADAPT and also fails to account for the social and dynamic aspect of teaching. An expanded framework that includes this aspect is described below.

I begin with a summary of the study in which I highlight key elements of ADAPT and the most significant findings. Next, I consider whether ADAPT met the design challenge. I examine the ADAPT findings in light of the literature on technology in schools, teacher data use practices, and teacher professional learning. After reexamining my theory of action for ADAPT, I offer the expanded conceptual framework for instrumental genesis with technology in schools. I identify limitations of the study and implications for practice with specific recommendations for further research. I conclude with my final thoughts about this study.

Summary of the Study

This dissertation is a story about instrumental genesis, or the lack thereof, and digital exodus in technology-mediated systemic reform in urban elementary education. The purpose of this design study was to develop a support-oriented intervention for exploring new practices aimed at organizational change in K-12 schools, in particular, the case of teachers adopting mandated digital assessment technology and developing new data use practices. The intervention was job-embedded, locally situated, and specific to the needs of a small group of three urban elementary school teachers. Through structured professional learning sessions emphasizing peer modeling and reflection, the ADAPT model intended to create space for instrumental genesis and the potential adoption of the educational technology.

While ADAPT proved effective in increasing teacher use of the new technology, it failed in terms of changing teachers' practices regarding data use and assessment. The design failed to support teachers through instrumental genesis (specifically, the instrumentalization of the new technology) because of a perceived mismatch between the objective and the instrument. The intended systemic reform objective of the technology adoption did not align with the selection of the artifact itself for teachers. Findings from the iterative development and evaluation of ADAPT suggest a need to reframe teacher resistance to technology adoption as a resource in systemic reform, and a need to improve the alignment of data visualization models embedded in technology tools with teacher professional vision. Increased leadership support for teacher learning, in particular the protection of collaborative professional learning time, and a deeper understanding of the complexity and challenges of teaching in underserved schools is necessary to support the efficacy of the next iteration of ADAPT. The study suggests that there is potential for design research situated in systemic reform to inform learning theory and school improvement. Through assessment of the design impact and an investigation of the design process, the nuanced nature of technology adoption and teacher practice, and the possibility of shifting them, is elucidated.

Meeting the Design Challenge & Design Principles

The design challenge in this study was to create a support-oriented intervention for exploring new practices aimed at organizational change, in particular, the case of teachers adopting assessment technology and developing new data use practices. Specifically, this intervention was designed to replace and improve the traditional professional development associated with the implementation of a technology reform initiative and must work in the under-resourced environments of urban schools. The intervention was designed to improve teachers' use of the educational technology as well as increase their ability to implement the technology as a formative assessment to improve student learning.

The ADAPT intervention partially met the design challenge. The intervention was perceived by teachers to be supportive and increased their use of the new mandated digital assessment technology. However, the intervention did not affect teacher practice in the classroom or change their formative assessment practices. The teachers approached the technology with a compliance orientation rather than a learning orientation, as discussed in the last chapter. Future iterations of ADAPT, and the process of instrumental genesis in particular, will likely be more successful if teacher input is included in the selection of the tools they will be required to use.

Understanding the Findings within the Context of the Literature

The findings of this study comport with the findings from the research base of technology in schools, teacher data use practices, formative assessment and teacher professional learning.

As Venkatesh (2000) noted in his study of technology acceptance models in organizations, there are limits to the use of organizational mandates as a lever for increasing the use of technology. Specifically, Venkatesh highlighted that the technology needs to be perceived to be useful, both individually and collectively. While the central office considered the technology to be useful enough to mandate its adoption in all of the schools, this study found that a small group of urban teachers did not perceive the technology to be useful for their needs and their student population. It is critical that users individually and collectively find the technology useful and this was not adequately explored prior to the systemic reform that was the subject of this study. The lack of inclusion of the end users in the technology selection, the teachers in the urban schools, resulted in a limited adoption of the technology in this case.

The literature on technology use in schools also illustrated that teachers' attitudes matter for technology adoption and that teachers' technology use improved with professional learning. This finding is particularly salient to this study, since this study focuses on the adoption and use of new digital assessment tools, which were a top-down, mandated technology reform. Teachers adopted a compliance attitude to the mandate and increased their technology use after participating in the ADAPT intervention but did not change their classroom practice. Thus, professional learning increased technology adoption while teacher attitudes limited it.

According to Coburn (2009), it is not only the working knowledge and practices of educators that shape their decisions; context factors including organizational structure, content knowledge of key leaders, resource constraints, and leadership turnover influence decision making processes. These factors may influence, among other things, the use of tools in

organizations. Although this study emphasized improving the working knowledge and practices of educators, the context factors of teaching in a resource-constrained urban school were noted and did influence the adoption of the technology. In particular, the lack of support for focused teacher collaborative learning time hindered the adoption of the technology. Emphasis on teacher collaboration time might provide support to foster a “culture of data use” (Hamilton et al, 2009) that would enable a deeper adoption of the technology.

Finally, this study supports the literature on effective professional learning. The inclusion of peer modeling and the provision of time and space for structured collaboration and reflection were associated with positive teacher attitudes and increased technology use. With a tool that aligned with teacher professional vision, the ADAPT intervention may have been more effective.

Reexamining the Theory of Action

ADAPT postulated that if teachers participate in a supportive, reflective, structured, professional learning experience about data use with expert teacher colleagues, they will learn how to both analyze and act upon the student assessment data that emerges from the new educational technology. Essentially, the theory of action for ADAPT was that if teachers apprentice with expert teachers through actively using the new educational technology, they will be able to adopt, instrumentalize, and use it successfully on their own to improve teaching and learning. This theory of action, tested in the various iterations of ADAPT, only partially aligned with the realities of teaching and the use of new tools for this small group of urban elementary school teachers. While the theory of action was premised upon evidence from the literature and included the design of an effective learning experience, teacher motivation and teacher perceptions about the mandated educational technology were not adequately considered. The teachers’ voice had been omitted from the systemic reform and the tool selection process, and this could not be compensated for through effective adult learning.

Reflection on field memos facilitated a striking realization regarding the assumptions of the central office about how adult learning occurs. The central office believed that the teachers needed to be taught how to use the technology before being taught why to use the technology, or how it could be purposefully used in relationship to student learning. The director of educational technology stated in an interview that

“We are still in a really early phase in implementation of this initiative; moving forward, it will be umm about how we can use this to do transformative teaching. Right now, we are just trying to get the teachers to log in.”

This statement, supported by my observations of the early training sessions and interviews with teachers, revealed a bias toward a model of learning that suggests users of artifacts need to learn the most basic elements of their usage as a necessary precondition to adoption of the tool. The most basic elements – which users could easily discover on their own with limited to no guidance – were the focal point of trainings and were synonymous with adoption. The instrumentalization of the artifact as a tool - using it to enhance and extend the teacher practice of formative assessment – was left for an unstated time in the future. Teachers suggested that this is because neither the central office nor the designers of the technology itself know how to do this. The sophisticated, more meaningful adoption of the tool was left to teachers to figure out on their own. Thus, the expert teachers proved invaluable here; in addition to sharing professional vision with the novice teachers and creating a space in which teachers felt

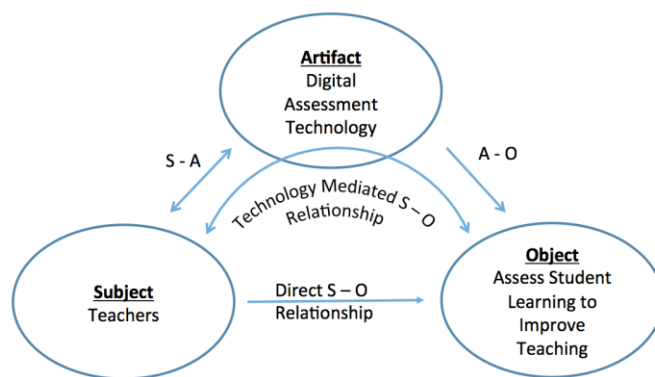
comfortable to learn, they were the only people with any expertise related to the use of the new assessment technology to actually connect with teaching and learning. The concept of teachers apprenticing with expert colleagues was well-received as a professional learning experience; however, it was not enough for instrumentalization to occur in light of the teachers' perceptions about the inadequacies of the technological artifact.

Expanding the Instrumental Genesis Framework

The framework for instrumented activity in ADAPT, modeled on Verillon and Rabardel's (1995) instrumental genesis framework, served as an illustration for how the technology would actually be adopted in schools. As depicted below, the subject in the model is the teacher and the object is the assessment of student learning, or the teacher practice of assessment. The teacher's relationship with assessment is amplified by the use of technology. Through this technology-mediated relationship, the technological artifact becomes an instrument. It is appropriated by the teacher and as she uses the, she enhances her assessment practice.

Figure 9: Instrumented Activity Model for ADAPT

Instrumented Activity Model for ADAPT

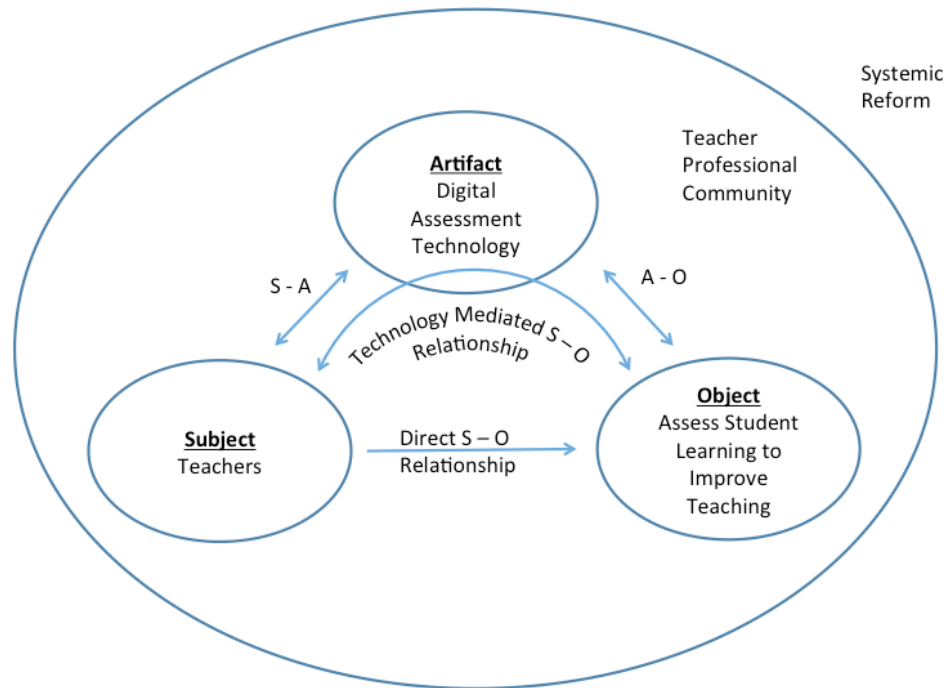


This study focused on the relationship between the subject and the object as well as the subject and the artifact; the study emphasized supporting teachers to use the technological artifact to improve their assessment. However, the study was negatively impacted by inattention to the relationship between the artifact and the object; that is, the relationship between the technology itself and its intended purpose was not considered. Due to teacher perceptions that this technological artifact was not a worthwhile instrument for this objective, the technology was not fully adopted and used in classroom practice.

While the model accounts for this inattention, it does not account for another limitation. The teachers operated in a small learning community and shared professional vision. They had similar and consistent beliefs regarding students and teacher practice. It was possible to shift some of their perceptions through the ADAPT intervention, but the social nature of their work as well as their instrumentalization of tools was not adequately accounted for in this model. The expanded framework below adds this critical missing component to the model, exemplifying the

application of the instrumental genesis framework to the adoption of technology in urban school systemic reform. The entire process of instrumental genesis is influenced by the teacher professional community, which is itself nested in the school system and externally influenced by and responding to the pressures of systemic reform.

Figure 10: Expanded Instrumented Activity Model for ADAPT



Study Limitations

Study limitations include the lack of sustainability of ADAPT and its effects. Post-intervention data collection regarding the mandated assessment window after the ADAPT intervention showed that not all teachers participated in the 3rd testing window. While 100% participated in the 2nd testing window which coincided with the ADAPT intervention, only 75% participated in the 3rd testing window after the ADAPT intervention of this study concluded. It is possible that the decrease in participation was due to the lack of support and accountability that ADAPT provided, or that the effects of the intervention were not sustainable. This hints at a potential bias in K-12 urban schools. Collaboration time among peers is protected only when a guest is present; teachers were typically more accountable to other tasks (attending SST or IEP meetings, handling parent concerns, or substituting for other classes) than to participating in their professional learning communities together.

As designer and researcher, I wonder if I took the place of the outside trainer in the traditional professional development model. While the expert teacher provided the modeling of use of the technology, I suspect that my presence signified some sort of importance or legitimacy of occasion. There was at least one instance during each of our three sessions where teachers were interrupted and asked to step away. Each time, the teachers stated that they could not leave

– *because I was there*. The teachers did not state that they could not leave due to this being their collaboration time or because they were in the middle of important learning; my presence would not be shorthand for this. It became clear that what I was told was an established routine – the gathering of teachers in grade level groups to focus on improving student learning – rarely occurred without interruption. The teachers seemed unfazed by and patient with the interruptions, but also seemed to be appreciative of being part of something that was important enough to make the other issues wait. When the principal of the school told me that the teachers were “*honored to be part of the ADAPT group*,” I remembered the relief on their faces when they were able to say, “*No, I can’t take care of that right now*.” The service orientation and problem-solving, crisis-managing demeanor of the teachers in the urban school perhaps precludes or at least inhibits their ability to engage in focused professional learning. It is critical then that the school leadership and school culture focus on protecting the learning space and time for teachers. This study, and the intervention itself, were limited by the teachers’ lack of protected collaborative learning time.

Further study limitations are that the final iteration of ADAPT, during which time most data was collected, included a small sample size of only three teachers in one school. This limits transferability of the findings to other settings.

Implications for Practice

ADAPT findings have significant implications for practice in the K-12 education sphere. Specifically, ADAPT demonstrated that it is possible to instantiate in professional learning what research reveals to be qualities of effective professional learning. Even in the resource-constrained environment of urban elementary schools, it is possible to connect the empirical research base with the reality of educational practice. It turns out that it is possible for professional learning to be significantly more engaging than it currently is!

For school leaders, the implications of this study are clear: in order for teacher professional learning to be effective, it needs to be led by expert teachers. Leaders need to provide clarity of purpose and protected collaboration time for teachers to engage in learning. Creating job-embedded professional development that facilitates reflection is possible but will not happen without intentional support.

It is also critical to include the voice of teachers in the educational decision-making process. Teachers’ expertise is a resource to be tapped, and their resistance is a resource to be explored to strengthen any reform initiative.

There are equity implications for practice here. It is critical that the teachers who serve the neediest students in the most resource-constrained schools are perceived as professionals with expertise whose voices matter. To be effective in their challenging work, these teachers need effective professional learning experiences that are job-embedded, locally situated, and specific to their needs.

Rather than technology acting as a mediator of reflective practice for teachers, as I had expected, the technology became the battleground between top-down efforts of systemic and teacher resistance to the mandated instrumental genesis of the flawed artifacts of an accountability regime. Both the central office leaders and the urban elementary school teachers believed that they were acting to promote equity and excellent for their students, yet they clashed on what tools to use to do this. Given the expense of technology and teacher professional development, it is worth grappling with this issue before mandating technology-oriented reform.

Final Thoughts & Conclusion

In *Teachers and Machines*, Cuban (1986) takes aim at reformers who fail to understand the complex relationship between constancy and change in schools and instead spur on the new technology cycle of exhilaration, scientific credibility, disappointment and teacher-bashing in schools. He wrote that the reformers “viewed teacher reluctance as an obstacle to overcome” (p. 6). Although not officially a reformer, I engaged in this behavior. I failed to see teacher expertise as a rich source of wisdom with rational, purposeful decision-making. Under the guise of support, I attempted to overcome the obstacle of reluctance. I am grateful that my eyes were opened to the role I play in the egregious dismissal of teacher perspective in the adoption of technology-related reform. I have a renewed commitment to shaping school leaders who listen to teachers and who view resistance as a resource—a clear, alarming signal that the tools may need calibration or that the system is not working. In the future, I will not investigate how to lessen teacher resistance to the adoption of imposed artifacts, but instead look at what tools these professionals choose to use and why, and how technology and professional learning can evolve to enable and augment effective practice rather than dictate and constrain it.

While the mandated adoption of selected technological artifacts may be a feature of a systemic reform initiative, I am not convinced that instrumental genesis can be mandated. The appropriation of technological artifacts by professionals is not something that is effectively dictated in a top-down fashion. Thus, the intentional selection of technological artifacts with those who will be expected to use them as tools will be critical for future systemic reform efforts. Perhaps a future iteration of ADAPT can encourage a learning rather than a compliance perspective to the adoption of such technology, and teachers can move from digital exodus to instrumental genesis again.

REFERENCES

- Abrahamson, D. (2015). Reinventing learning: A design-research odyssey. In S. Prediger, K. Gravemeijer, & J. Confrey (Eds.), *Design research with a focus on learning processes* [Special issue]. *ZDM Mathematics Education*, 47(6), 1013-1026.
- Abrahamson, D. (2013). Toward a taxonomy of design genres: Fostering mathematical insight via perception-based and action-based experiences. In J. P. Hourcade, E. A. Miller, & A. Egeland (Eds.), *Proceedings of the 12th Annual Interaction Design and Children Conference (IDC 2013)* (Vol. "Full Papers", pp. 218-227). New York: The New School & Sesame Workshop.
- Abrahamson, D., & Chase, K. (2015). Interfacing practices: Domain theory emerges via collaborative reflection. *Reflective Practice*, 16(3), 372-389.
- Alexander, P.A., & Murphy, P. K. (1998). The research base for APA's Learner-Centered Psychological Principles. In N. Lambert & B.L. McCombs (Eds.), *How students learn: Reforming schools through learner-centered education* (pp.33-60). Washington, DC: American Psychological Association.
- Allen, I. E., & Seaman, J. (2011). *Going the distance: Online education in the United States, 2011*. Sloan Consortium. PO Box 1238, Newburyport, MA 01950.
- Argyris, C., & Schön, D. A. (1978). *Organizational learning: A theory of action perspective* (Vol. 173). Reading, MA: Addison-Wesley.
- Argyris, C., & Schon, D. A. (1974). *Theory in practice: Increasing professional effectiveness*. San Francisco, CA: Jossey-Bass.
- Bambrick-Santoyo, P. (2010). *Driven by data: A practical guide to improve instruction*. San Francisco, CA: John Wiley & Sons.
- Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the Learning Sciences*, 13(1), 1-14.
- Beguin, P., & Rabardel, P. (2000). Designing for instrument-mediated activity. *Scandinavian Journal of Information Systems*, 12(1), 1.
- Bell, F. (2010). Connectivism: Its place in theory-informed research and innovation in technology-enabled learning. *The International Review of Research in Open and Distributed Learning*, 12(3), 98-118.
- Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability (formerly: Journal of Personnel Evaluation in Education)*, 21(1), 5-31.
- Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice*, 5(1), 7-74.
- Bloom, G. (2005). Chapter 1: What is coaching? In B. Bloom, G., Castagna, C., Moir, E., Warren (Eds.), *Blended coaching: Skills and strategies to support principal development* (pp. 3–12). Thousand Oaks, CA: Corwin Press.
- Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, 2(2), 141-178.
- Bryk, A. S., & Schneider, B. (2003). Trust in schools: A core resource for school reform. *Educational Leadership*, 60(6), 40-45.
- Buckenmeyer, J. A. (2010). Beyond computers in the classroom: Factors related to technology adoption to enhance teaching and learning. *Contemporary Issues in Education Research*, 3(4), 27.

- Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research*, 65(3), 245-281.
- Christensen, C. M., Horn, M. B., & Johnson, C. W. (2008). *Disrupting class: How disruptive innovation will change the way the world learns*. New York: McGraw-Hill.
- Cobb, P., Confrey, J., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher*, 32(1), 9-13.
- Coburn, C. E., & Turner, E. O. (2011). Research on data use: A framework and analysis. *Measurement: Interdisciplinary Research & Perspective*, 9(4), 173-206.
- Coburn, C. E., Touré, J., & Yamashita, M. (2009). Evidence, interpretation, and persuasion: Instructional decision making at the district central office. *Teachers College Record*, 111(4), 1115-1161.
- Coghlan, D., & Brannick, T. (2014). *Doing action research in your own organization*. London and Thousand Oaks: Sage Publications.
- Collins, A. (1992). Toward a design science of education. In E. Scanlon & T. O'Shea (Eds.), *New directions in educational technology* (pp. 15-22). New York, NY: Springer-Verlag.
- Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator*, 15(3), 6-11.
- Collins, A., Brown, J. S., & Newman, S. E. (1988). Cognitive apprenticeship. *Thinking: The Journal of Philosophy for Children*, 8(1), 2-10.
- Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *The Journal of the Learning Sciences*, 13(1), 15-42.
- Creswell, J. W. (2009). *Research design: Qualitative and mixed methods approaches*. London and Thousand Oaks: Sage Publications.
- Cuban, L. (1999). The technology puzzle. *Education Week*, 18(43), 68-69.
- Cuban, L. (1986). *Teachers and machines: The classroom use of technology since 1920*. New York: Teachers College Press.
- Cuban, L., & Pea, R. (1998). The pros and cons of technology in the classroom. Paper presented at the Funder's Learning Community Meeting Palo Alto, CA, February. Abstract retrieved from <http://media.ablaonline.org/documentos/74/742829da.pdf>
- Cuban, L., & Usdan, M. (2003). *Powerful reforms with shallow roots: Improving America's urban schools*. New York: Teachers College Press.
- Datnow, A., & Yonezawa, S. (2004). Observing school restructuring in multilingual, multicultural classrooms: Balancing ethnographic and evaluative approaches. In H.C. Waxman, R.G. Tharp & R.S. Hilberg (Eds.), *Observational research in US classrooms: New approaches for understanding cultural and linguistic diversity* (pp. 174-204). Cambridge, England: Cambridge University Press.
- Dede, C. (2010). Comparing frameworks for 21st century skills. In Bellanca & Brandt (Eds.), *21st century skills: Rethinking how students learn* (pp. 51-76). Bloomington: Solution Tree.
- Dede, C. (2004). Enabling distributed learning communities via emerging technologies- Part one. *THE Journal*, 32(2), 12.
- DiSessa, A. A., & Cobb, P. (2004). Ontological innovation and the role of theory in design experiments. *The Journal of the Learning Sciences*, 13(1), 77-103.

- Ericsson, K. A. (2006). The influence of experience and deliberate practice on the development of superior expert performance. In K. Ericsson, N. Charness, P.J. Feltovich, & R.R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 685-705). Cambridge, England: Cambridge University Press.
- Fishman, B., Marx, R. W., Blumenfeld, P., Krajcik, J., & Soloway, E. (2004). Creating a framework for research on systemic technology innovations. *The Journal of the Learning Sciences*, 13(1), 43-76.
- Freire, P. (1972). *Pedagogy of the oppressed*. New York: Herder and Herder.
- Frisby, C. L. (1998). Contextual factors influencing the classroom application of learner-centered principles. In Lambert, N. & McCombs, B. (Eds.), *How students learn: Reforming schools through learner-centered education* (pp. 61-79). Washington, DC: American Psychological Association.
- Fullan, M. (1993). *Change forces: Probing the depths of educational reform*. London: Falmer Press.
- Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, 38(4), 915-945.
- Gates Foundation. (2015). *Teachers Know Best: Making Data Work for Teachers and Students*. Retrieved from <https://s3.amazonaws.com/edtech-production/reports/Gates-TeachersKnowBest-MakingDataWork.pdf>
- Gibbs, G., & Simpson, C. (2004). Does your assessment support your students' learning. *Journal of Teaching and Learning in Higher Education*, 1(1), 1-30.
- Goodwin, C. (1994). Professional vision. *American Anthropologist*, 96(3), 606-633.
- Hakkarainen, K. (2009). A knowledge-practice perspective on technology-mediated learning. *International Journal of Computer-Supported Collaborative Learning*, 4(2), 213-231.
- Hamilton, L., Halverson, R., Jackson, S. S., Mandinach, E., Supovitz, J. A., Wayman, J. C., Pickens, C., Martin, E., & Steele, J. L. (2009). Using Student Achievement Data to Support Instructional Decision Making. United States Department of Education, retrieved from http://repository.upenn.edu/gse_pubs/279.
- Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. *Journal of Research on Technology in Education*, 41(4), 393-416.
- Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77(1), 81-112.
- Hess, F. M. (1999). *Spinning wheels: The politics of urban school reform*. Washington, D.C: Brookings Institution Press.
- Horn, I. S., & Little, J. W. (2010). Attending to problems of practice: Routines and resources for professional learning in teachers' workplace interactions. *American Educational Research Journal*, 47(1), 181-217.
- Innosight Institute. (2011). The rise of K-12 blended learning. San Francisco, CA: Horn, M. B., & Staker, H.
- Joan Ganz Cooney Center. (2016). *Opportunity for all: Technology and learning in lower income families*. New York, NY: Rideout, V. J., & Katz, V. S.
- Joan Ganz Cooney Center. (2015). *Connecting to learn: Promoting digital equity among America's Hispanic families*. New York, NY: Katz, V. S., & Levine, M. H.

- Journell, W. (2012). Walk, don't run—to online learning. *Phi Delta Kappan*, 7-9.
- Kennedy, M. M. (1984). How evidence alters understanding and decisions. *Educational Evaluation and Policy Analysis*, 6(3), 207-226.
- Kleiman, G. M. (2000). Myths and realities about technology in K-12 schools. *Leadership and the New Technologies*, 14(10), 1-8.
- Kluger, A. N., & DeNisi, A. (1996). The effects of feedback interventions on performance: a historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin*, 119(2), 254.
- Koper, R., Giesbers, B., Van Rosmalen, P., Sloep, P., Van Bruggen, J., Tattersall, C., & Brouns, F. (2005). A design model for lifelong learning networks. *Interactive Learning Environments*, 13(1-2), 71-92.
- Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago, IL: University of Chicago Press.
- Lachat, M. A., & Smith, S. (2005). Practices that support data use in urban high schools. *Journal of Education for Students Placed at Risk*, 10(3), 333-349.
- Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in US schools. *Educational Researcher*, 35(7), 3-12.
- Laurillard, D. (2013). *Teaching as a design science: Building pedagogical patterns for learning and technology*. New York: Routledge.
- Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry* (Vol. 75). Newbury Park, CA: Sage Publications.
- Little, J. W. (2012). Understanding data use practice among teachers: The contribution of micro-process studies. *American Journal of Education*, 118(2), 143-166.
- Little, J. W. (1993). Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis*, 15(2), 129-151.
- Lofland, J. (1995). ANALYTIC ETHNOGRAPHY Features, Failings, and Futures. *Journal of Contemporary Ethnography*, 24(1), 30-67.
- Mandinach, E. B., & Gummer, E. S. (2013). A systemic view of implementing data literacy in educator preparation. *Educational Researcher*, 42(1), 30-37.
- Marzano, R. J. (2003). *What works in schools: Translating research into action*. Alexandria, VA: ASCD Publications.
- Marzano, R. J., Waters, T., & McNulty, B. A. (2005). *School leadership that works: From research to results*. Alexandria, VA: ASCD Publications.
- McCandless, J. (2015). *US Institutions Spend Billions on IT*. Retrieved from <http://www.centerdigitaled.com/higher-ed/US-Education-Institutions-Spend-66-Billion-on-IT-in-2015.html>.
- Means, B. (2010). Technology and education change: Focus on student learning. *Journal of Research on Technology in Education*, 42(3), 285-307.
- Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). *Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies*. Washington, D.C: US Department of Education.
- Mintrop, H. (2004). *Schools on probation: How accountability works (and doesn't work)*. New York, NY: Teachers College Press.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017.

- National Education Association. (2006). Professional development and professional community in the learner-centered school. Washington, D.C: Little, J.
- Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, 31(2), 199-218.
- Noguera, P. A. (2001). Racial politics and the elusive quest for excellence and equity in education. *Education and Urban Society*, 34(1), 18-41.
- Oakes, J. (1997). Detracking: The social construction of ability. *Teacher's College Record* 98, 483-510.
- Organization for Economic Cooperation and Development & Program for International Student Assessment. (2012). *PISA 2012 Results in Focus*. Paris: OECD. Retrieved from <http://www.pisa.oecd.org/>.
- Papert, Seymour. (2004). *Keynote for 1:1 Education Conference*. Retrieved from <https://vimeo.com/9092144>.
- Patton, M. Q. (1990). *Qualitative evaluation and research methods*. London and Thousand Oaks: Sage Publications.
- Peterson, K. D. (2002). Positive or negative. *Journal of Staff Development*, 23(3), 10-15.
- Pintrich, P. R., & Zusho, A. (2002). The development of academic self-regulation: the role of cognitive and motivational factors. In A. Wigfield, & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 249-284). San Diego: Academic Press.
- Plomp, T., & Nieveen, N. (2007). An introduction to educational design research. In *Proceedings of the Seminar Conducted at the East China Normal University, Shanghai, November 23-26, 2007*. SLO: Netherlands Institute for Curriculum Development.
- Reeves, D. (2007). Leading to change-closing the implementation gap. *Educational Leadership*, 64(6), 85.
- Ritella, G., & Hakkarainen, K. (2012). Instrumental genesis in technology-mediated learning: From double stimulation to expansive knowledge practices. *International Journal of Computer-Supported Collaborative Learning*, 7(2), 239-258.
- Rogers, E. M. (1995). *Diffusion of innovations*. New York, NY: The Free Press.
- Ruby, J. (1980). Exposing yourself: reflexivity, anthropology, and film. *Semiotica*, 30(1-2), 153-180.
- Ryan, G. W., & Bernard, H. R. (2000). Data management and analysis methods. In N. Densin and Y. Lincoln (Eds.), *Handbook of qualitative research*. (pp. 769-802). Thousand Oaks, CA: Sage Publications.
- Sahin, I., & Thompson, A. (2007). Analysis of predictive factors that influence faculty members' technology adoption level. *Journal of Technology and Teacher Education*, 15(2), 167.
- Schön, D. A. (1983). *The reflective practitioner: How professionals think in action* (Vol. 5126). New York: Basic books.
- Seale, C. (1999). Quality in qualitative research. *Qualitative Inquiry*, 5(4), 465-478.
- Spillane, J. P. (2012). Data in practice: Conceptualizing the data-based decision-making phenomena. *American Journal of Education*, 118(2), 113-141.
- Spillane, J. P., & Miele, D. B. (2007). Evidence in practice: A framing of the terrain. *Yearbook of the National Society for the Study of Education*, 106(1), 46-73.
- Stake, R. E., & Rosu, L. (2012). Energizing and constraining advocacy. *Qualitative*

- Suchman, L. (1995). Making work visible. *Communications of the ACM*, 38(9), 56-64.
- Sun, P. C., Tsai, R. J., Finger, G., Chen, Y. Y., & Yeh, D. (2008). What drives successful e-learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers & Education*, 50(4), 1183-1202.
- Tallent-Runnels, M. K., Thomas, J. A., Lan, W. Y., Cooper, S., Ahern, T. C., Shaw, S. M., & Liu, X. (2006). Teaching courses online: A review of the research. *Review of Educational Research*, 76(1), 93-135.
- The Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 5-8.
- Trouche, L. (2005). Instrumental genesis, individual and social aspects. In D. Guin, K. Ruthven & L. Trouche (Eds.), *The didactical challenge of symbolic calculators* (pp. 197-230). New York: Springer.
- Trujillo, T. M. (2012). The politics of district instructional policy formation: Compromising equity and rigor. *Educational Policy*, 0895904812454000.
- U.S. Department of Education, Office of Educational Technology. (2016). *Future Ready Learning: National Education Technology Plan*. Retrieved from <http://tech.ed.gov/netp/>.
- Van den Akker, J. (1999). Principles and methods of development research. In V. den Akker, J., Branch, R.M., Gustafson, K., Nieveen, N., & Plomp, T. (Eds.), *Design approaches and tools in education and training* (pp. 1-14). Netherlands: Springer.
- Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research*, 11(4), 342-365.
- Verillon, P., & Rabardel, P. (1995). Cognition and artifacts: A contribution to the study of thought in relation to instrumented activity. *European Journal of Psychology of Education*, 10(1), 77-101.
- Wayman, J. C., Snodgrass Rangel, V. W., Jimerson, J. B., & Cho, V. (2010). Improving data use in NISD: Becoming a data-informed district. *Austin, TX: The University of Texas*.
- W. K. Kellogg Foundation. (2004). Logic model development guide. Battle Creek, Michigan: W. K. Kellogg Foundation.
- Weiss, C. H. (1998). Have we learned anything new about the use of evaluation? *American Journal of Evaluation*, 19(1), 21-33.
- Weiss, C. H. (1995). Nothing as practical as good theory: Exploring theory-based evaluation for comprehensive community initiatives for children and families. In J. Connell, A. Kubisch, L. Schorr, & C. Weiss (Eds.), *New approaches to evaluating community initiatives: Concepts, methods, and contexts*, (pp. 65-92). Queenstown, MD: Aspen Institute Publications.
- Weiss, C. H. (1988). Evaluation for decisions: Is anybody there? Does anybody care? *Evaluation Practice*, 9(1), 5-19.
- Wicks, M. (2010). A National Primer on K-12 Online Learning. Version 2. *International association for K-12 online learning*. Retrieved from http://www.inacol.org/wp-content/uploads/2015/02/iNCL_NationalPrimerv22010-web1.pdf.
- Wiggins, G. P. (1998). *Educative assessment: Designing assessments to inform and improve student performance* (Vol. 1). San Francisco, CA: Jossey-Bass.

- Yin, R. K. (2013). Validity and generalization in future case study evaluations. *Evaluation, 19*(3), 321-332.
- Young, V. M. (2006). Teachers' use of data: Loose coupling, agenda setting, and team norms. *American Journal of Education, 112*(4), 521-548.
- Zhao, Y., & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American Educational Research Journal, 40*(4), 807-840.

APPENDICES

APPENDIX A: Comparison of Structured Professional Learning Opportunities To Facilitate Adoption of Educational Technology

Traditional Professional Development (TPD) vs. Proposed Intervention (ADAPT)

Feature	TPD	ADAPT
Focus	how to use this new instrument in general	why you would use the instrument, what you can use it for, how to use it specifically to meet your needs
Purpose	purpose not explicit, mandated use, assumed or mysterious intentionality	purpose is explicit and discussed
Teacher “Buy-In”	Assumed through compliance with a mandate	Teacher beliefs will be engaged through testimonials; teachers will be motivated by working with real colleagues & real data; iterative design will empower and motivate
Duration	one shot, no follow-up <i>“Good luck... do it.”</i>	3 sessions with reflection <i>“Let’s figure it out together.”</i>
Leader of PD	OUTSIDER (individual) Industry trainer (provided by the company that sold the product)	INSIDERS (team) Expert teachers (collaborating with Ed Tech Director and Asst. Sup.)
Pedagogy & Process	teachers are passive recipients of direct instruction in a large group, transmissive activities include listening, participating in assessment as student, and looking at generic test data and report options	teachers are actively engaged in small groups, codesigners in the learning, constructing meaning activities include peer modeling by expert teachers, individual analysis, planning, reflecting, and discussing assessment with real student data
Design of PD	standardized, one size fits all, static; workshop model	rapid-prototyping, iterative development peer modeling / ad hoc PLC
Fiscal Impact	efficient, fixed cost of time for teachers (1 day) plus fee cost of presenter	potentially more expensive, ongoing (research suggests that costs could be the same if this type of PD supplants traditional PD)
Theory of Action	if students TAKE the test, teachers will use the data to improve instruction	if teachers engage in support-oriented prof. learning experiences with expert teacher colleagues regarding new ed. tech., teachers will analyze and use student assessment data to improve instruction
What’s New?	does not identify what is the same and what is different, e.g. the same educational objective and same practice (assessment) but it will be enhanced by leveraging new tech	Identifies what is the same – objective and assessment practice - and highlights what is new – the tech to enhance this process

APPENDIX B – ADAPT Intervention Survey for Teachers

Likert Scale: (1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree

- I use assessment to get a picture of what my students have learned.
- I use assessment to get a picture of what I need to change in my teaching.
- I am knowledgeable about formative assessment practices.
- I know how to analyze student assessment data.
- I could give you examples of how assessment drives instruction in my classroom.
- I could give you examples of how assessment drives instruction in my school.

- I have clear expectations from my principal about data use in our school.
- I have clear expectations from our Diocese about data use in our school.
- My principal gives me guidance about how to analyze and use assessment data.
- My teacher colleagues give me guidance about how to analyze and use assessment data.

- I feel comfortable using technology as a tool for instruction.
- I feel comfortable using technology as a tool for assessment of student learning.
- I stand out among our faculty as a user of technology.
- I am excited to learn about and use educational technology.
- I understand how to use the new STAR digital assessment system.
- I could teach a colleague how to use the new STAR digital assessment system.
- The professional development experiences I have had so far regarding the new STAR assessment system have been helpful and supportive.

- I believe that every student can learn.
- I believe that every student can achieve the grade level standards of our curriculum.
- I believe that looking at student assessment data will make me a better teacher.
- I believe that technology supports and enhances my work as a teacher.
- I believe that technology complicates my work as a teacher.
- I believe that teacher professional development is important.

- In the past year, I have experienced supportive, focused, helpful professional development as a teacher.
- My best professional learning experiences were learning from expert trainers from outside our Diocese.
- My best professional learning experiences were learning from other teachers like me.

- Most people have a good idea of what it is like to be a teacher today.
 - My principal understands my needs as a professional educator.
 - My Diocese / District leaders understand my needs as a professional educator.
 - Designers of educational technology understand my needs as a professional educator.
-
- I support the initiatives that we are adopting in our school right now.
 - I believe we are adopting too many initiatives in our school right now.
 - I have experienced personalized support to assist me in adopting the initiatives in our school.

APPENDIX C – ADAPT Intervention—Preliminary Interview Questions

Baseline Assessment for Individual Teachers who are participating in the ADAPT intervention

Semi-Structured Clinical Interview Protocol

Teachers have so many responsibilities... and so much work that happens in addition to what people think of when they think about classroom teaching. Think for a moment about assessment.

1) About how many hours per week do you spend on assessment?

2) Hours on summative assessment vs. formative assessment?

Which type of assessment do you think is more important, summative assessment or formative assessment? Why?

Which type of assessment does your principal think is more important?

Which type of assessment do parents think is more important?

3) Can you describe some examples of formative assessment practice in your teaching?

4) Your central office recently mandated the new STAR enterprise system for assessing student learning. So far, what are your thoughts on this mandate and on the new digital assessment system?

Follow-up question: Is it easy to use? Is it useful to you as a professional educator?

5) We often hear the phrase in education that teachers need to use data to drive instruction. What does this mean to you? What do you think of this idea? Do you agree or disagree? If you had to come up with an argument against this, what would it be?

6) Now I want to switch to talking about teacher learning on the job. If you could design the dream PD experience, what would it look like?

7) The STAR digital assessment system is one example of educational technology that is supposed to support teaching and learning. What are your hopes and fears with the adoption of educational technology? (With STAR or ed tech in general)

* standardized testing – is it summative or formative?

APPENDIX D - ADAPT Intervention—Teacher Think-Aloud Protocol

Tell me what you are thinking as you are looking at the student data on this screen.

What do you notice? What do you wonder?

How do you make sense of this data?

How could you use this data?

How does this assessment data connect with your experience of these students as a classroom teacher?

Is there anything about the way this data is presented that makes it hard to understand?
What might make it easier?

What do you plan to do with it? What are your next steps?

APPENDIX E – ADAPT Detailed Design Calendar Outline

Timeline	Design Activity
August 2014	Develop draft design elements drawing from research about technology integration, teacher learning, and instrumental genesis
September–December 2014	Conduct needs assessment for support in adopting education technology Pilot teacher professional learning workshop to support the adoption of the new, mandated education technology – Iteration #1 Create ADAPT design based on feedback from pilot Seek expert teachers within system to serve as models for peer learning to support the adoption of the education technology Include input from advisor, expert teachers, Ed Tech Director, and peers in LEEP to finalize the ADAPT model
March 2015	Present opportunity to 3-5th grade urban math teachers to solicit volunteers via email, flyer, and faculty meeting presentation Present opportunity to all principals to participate in baseline survey
April-May 2015	Baseline data collection • Survey teachers to elicit understanding of their current use of technology and current formative assessment beliefs and practices • Individual interview with each participating teacher to elicit understanding of their current use of technology and current formative assessment beliefs and practices • Survey principals to elicit understanding of the adoption of the ed tech reform in their school • Individual interview with each participating principal to elicit understanding of data use in their school and the implementation of the new digital assessment system • Collect data on student performance on the 1st experience with the digital assessment • Collect data on teacher response to student performance on the 1st experience with the digital assessment via short focus group
September 2015	After school A.D.A.P.T session 1 with teachers (2 hours) Agenda: 13. Welcome, introductions and objective for session 14. Presentation on ed. tech reform purpose and ADAPT model 15. Mini-presentation of research on formative assessment 16. Highlighting how the new education technology enhances the

	existing teacher practice of formative assessment 17. Data analysis demonstration - Model teachers “thinkaloud” looking at data and analyzing data 18. Response demonstration – Model teachers “thinkaloud” making decisions about what to do / how to connect data to classroom practice 19. Reflection demonstration- Participating teachers reflect individually, then collectively share reflections / ask questions 20. Time for participating teachers to experiment/ play with the educational technology 21. Identify 1 classroom level instructional response to the data and commit to it in writing 22. Peer feedback on commitment 23. Peer feedback on the design of the session 24. Reflection on process
October 2015	After school A.D.A.P.T session 2 with teachers (2 hours) Agenda: 12. Welcome and objective for session 13. Mini-presentation of research on the instrumented activity model 14. Highlighting how the new education technology requires data analysis and reflection to be useful / efficacious – highlight teacher role 15. Data analysis demonstration - Participating teachers “thinkaloud” looking at data and analyzing data 16. Response demonstration – Participating teachers “thinkaloud” making decisions about what to do / how to connect data to classroom practice 17. Reflection demonstration- Participating teachers reflect individually, then collectively share reflections / ask questions 18. Peer feedback from model teachers and participating teachers on the participating teacher demonstration 19. Revisit the 1 classroom level instructional response to the data commitment from the last session and share progress 20. Peer feedback on progress and suggestions for alternative instructional responses to the data 21. Participating teacher commitment to 1 new instructional response 22. Peer feedback on the design of the session / Reflection of process
October 2015	After school A.D.A.P.T session 3 with teachers (2 hours) Agenda: 12. Welcome and objective for session 13. Mini-presentation of research on teacher reflection and data use 14. Review NEW student data (2nd assessment) together 15. Data analysis demonstration - Participating teachers “thinkaloud”

	looking at data and analyzing data 16. Response demonstration – Participating teachers “thinkaloud” making decisions about what to do / how to connect data to classroom practice 17. Reflection demonstration- Participating teachers reflect individually, then collectively share reflections / ask questions 18. Peer feedback from all on the participating teacher demonstration 19. Revisit the 1 classroom level instructional response to the data commitment from the last session and share progress 20. Peer feedback on progress and suggestions for alternative instructional responses to the data 21. Preview performance task – “Data Guru Teacher Tips” create 2 minute video of 1 way to use the assessment data formatively to improve student learning 22. Peer feedback on the design of the session / Reflection of process Concurrent Data Collection 1. 15 minute individual debriefing interviews with participating teachers via skype 2. online focus group session with participating teacher feedback on the usability and usefulness of the new educational technology and the role, if any, that A.D.A.P.T played in it; what is going well with ADAPT, suggestions for improvement, potential for use with other new reforms
November 2015	Summative Data Collection 1. Post-intervention surveys for teachers on assessment practices 2. Post-intervention survey for teachers on the ADAPT model 3. Post-intervention survey for principals on the ADAPT model 4. Student assessment data