UNIVERSITY OF SOUTHERN MAINE

University of Southern Maine
USM Digital Commons

All Theses & Dissertations

Student Scholarship

5-2016

An Examination of Teacher Understandings of Technology Integration at the Classroom Level

Shawn M. Carlson PhD
University of Southern Maine, Muskie School of Public Service

Follow this and additional works at: https://digitalcommons.usm.maine.edu/etd

Part of the Curriculum and Instruction Commons, Educational Assessment, Evaluation, and Research Commons, Educational Leadership Commons, Educational Methods Commons, Educational Sociology Commons, Junior High, Intermediate, Middle School Education and Teaching Commons, Leadership Studies Commons, Organizational Communication Commons, Other Teacher Education and Professional Development Commons, and the Social and Philosophical Foundations of Education Commons

Recommended Citation
Carlson, Shawn M. PhD, "An Examination of Teacher Understandings of Technology Integration at the Classroom Level" (2016). *All Theses & Dissertations*. 293.
https://digitalcommons.usm.maine.edu/etd/293

This Open Access Dissertation is brought to you for free and open access by the Student Scholarship at USM Digital Commons. It has been accepted for inclusion in All Theses & Dissertations by an authorized administrator of USM Digital Commons. For more information, please contact jessica.c.hovey@maine.edu.

AN EXAMINATION OF TEACHER UNDERSTANDINGS OF TECHNOLOGY INTEGRATION AT THE CLASSROOM LEVEL

By

Shawn M. Carlson

B.S. University of Maine

M.S. University of California

M.S. University of Southern Maine

A DISSERTATION

Submitted in Partial Fulfillment of the

Requirements for the Degree

Doctor of Philosophy in

Public Policy

University of Southern Maine
May 2016

Advisory Committee:

Dr. Catherine Fallona, Professor of Educational Leadership, Advisor

Dr. David Silvernail, Professor Emeritus and Research Professor

Dr. Michael Muir, Policy Director, Maine Learning Technology Initiative

LIBRARY RIGHTS STATEMENT

In presenting this dissertation in partial fulfillment of the requirements for an advanced degree at the University of Southern Maine, I agree that the Library shall make it freely available for inspection. I further agree that permission for "fair use" copying on this thesis for scholarly purposes may be granted by the Librarian. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature:

Date: 30 MAY 2016

AN EXAMINATION OF TEACHER UNDERSTANDINGS OF TECHNOLOGY INTEGRATION AT THE CLASSROOM LEVEL

By

Shawn M. Carlson

BS/University of Maine

MS/University of California

MS/University of Southern Maine

Approved by:

Catherine Fallona, Chair

David Silvernail, Member

Michael Muir, Member

AN EXAMINATION OF TEACHER UNDERSTANDINGS OF TECHNOLOGY INTEGRATION AT THE CLASSROOM LEVEL

Shawn M. Carlson

Dissertation Advisor: Dr. Catherine Fallona

An Abstract of the Dissertation Presented
In Partial Fulfillment of the
Requirements for the Degree
Doctor of Philosophy in
Public Policy
May 2016

The purpose of this dissertation is to describe and understand how teachers describe the changes in their practices as a result of ten years participation in a one-to-one environment. This research study focuses on one successful middle school's adoption of laptops to support teaching and learning. A qualitative study using interviews of key participants was undertaken with teachers and administrators. The Technological, Pedagogical and Content Knowledge (TPACK) framework was used in conjunction with Rogers' Diffusion of Innovation framework to understand from the participants' perspective changes to their practice. The results indicate teachers underwent changes in their use of technology to support teaching and learning, showing increasing overlap between the domains of technological and pedagogical knowledge. The changes resulted in an increase in the transparency of the teaching and learning process for other teachers,

students, administrators, and parent. These changes were supported by four school-wide factors; the adoption of a common software suite, robust social networks, modeling by leadership and the professional development model used. The findings were discussed in relation to participants' position on the adoption spectrum of Rogers' Diffusion of Innovation theory.

Acknowledgements

I wish to thank my committee members, Dr. Michael Muir and Dr. David Silvernail for their thoughtful advice, comments, and support. I would especially like to acknowledge my indebtedness to my committee chair, Dr. Catherine Fallona for her insight, quiet strength and understanding. This dissertation would not have been completed without the love and support of my family, friends, and a kindred spirit.

List of Figures

Figure 1.1 Rogers' Adoption Spectrum for Innovations………….……………6

Figure 1.2 Technological Pedagogical and Content Knowledge Framework…..8

Figure 2.1 Distribution of Adopters in Rogers' Model…………….………….32

Table of Contents

Acknowledgements ... v

List of Figures ... vi

Chapter 1: Introduction ... 1

Background ... 3

Conceptual Framework and Propositions ... 7

Statement of the Problem ... 9

Purpose of the Study ... 11

Significance of the Study ... 11

Chapter 2: Literature Review ... 14

Introduction ... 14

Evaluating Large-Scale, One-to-One Technology Initiatives ... 16

Critiques of Large-Scale Technology Implementations ... 21

Evaluating Maine's MLTI Initiative ... 23

Limitations in the Evaluation of MLTI ... 27

Frameworks to Describe The Adoption Of Innovations ... 28

Technology Acceptance Model (TAM). ... 29

Concerns Based Adoption Model (CBAM). ... 30

Diffusion of Innovations (DoI). ... 30

The Diffusion of Innovations: A Social Process. ... 31

Factors Affecting the Rate of Adoption. ... 35

Evaluating Technology Integration Using TPACK ... 38

Summary 43

Chapter 3: Methodology 45

Methodological Overview 45

Site Selection 47

2013 MLTI Survey. 48

Deployment Configuration. 48

Size Requirements. 48

Location. 49

Nominations from Technology Leaders. 49

Participant Selection 50

Data Sources and Collection 52

Interviews. 52

Interview 1: Focused Life History. 53

Interview 2: The Details of the Experience. 54

Interview 3: Reflection on Meaning. 54

Administrator Interviews. 55

Data Analysis and Interpretation 55

Trustworthiness 60

Limitations 62

Researcher Role 64

Chapter 4: Teachers' Percetions of MLTI's Impact 65

On Their Practices 65

Early Adopters 66

Logan Ackerman. 66
Pedagogical Stance. 67
TPACK in the Classroom. 72
Evolution of TPACK. 83
Evan Reed. 87
Pedagogical Stance. 88
TPACK in the Classroom. 93
Evolution of TPACK. 95
Summary. 106
The Early Majority 107
Matt Doyle. 108
Pedagogical Stance. 108
TPACK in the Classroom. 114
Evolution of TPACK. 122
Lauren Maddox. 129
Pedagogical Stance. 129
TPACK in the Classroom. 138
Evolution of TPACK. 144
Summary. 149
Late Majority 150
Sharon Bishop. 150
Pedagogical Stance. 150
TPACK in the Classroom. 153

Evolution of TPACK. 162
Daniel Gallagher. 168
Pedagogical Stance. 168
TPACK in the classroom. 174
Evolution of TPACK. 185
Summary. 191
Chapter 5: School-Wide Factors that Influence 192
Teachers' Adoption of Technology 192
Modeling by Leadership 192
Continuous Learning 199
Summary 209
Chapter 6: Themes and Findings 211
Impact on Practice 211
Teaching with the tool, not about the tool. 212
Writing Digitally. 213
Information Literacy. 216
Blended learning environments and flipping the classroom. 219
Communication and Opening up the Classroom. 223
Student-centered practices. 224
Growing Importance of Videos. 227
Summary. 230
Evolving Understanding of TPACK 231
Summary. 244

Factors That Have Encouraged Teachers to Change and Adapt Their Practices 247

Common Software Suite. 248

Social Networks. 251

Modeling by Leadership........ 254

Continuous Learning. 257

Summary. 259

Conditions for Success 260

References 265

Appendix A: Initial Survey 277

Appendix B: Interview Questions 279

Appendix C: Informed Consent Form 290

Biography of the Author 293

Chapter 1: Introduction

The Maine Learning Technology Initiative (MLTI) was the first statewide one-to-one technology initiative in the United States (McCarthy and Breen, 2001). As such the MLTI program and its deployment have shaped other initiatives, as well as the debate about the relative merits of large-scale technology initiatives. After almost a dozen years, policymakers and educators need to be able to answer the question: does the investment of time, money, and human capital in large-scale deployments of computers or tablets improve teaching and learning to an extent that schools should adopt one-to-one computing? This study proposes to describe the reflection of teachers on MLTI's impact on their teaching and student learning.

The impacts of one-to-one technology initiatives have been investigated on a number of fronts: the impacts on student achievement (Silvernail and Buffington, 2009; Suhr, et al. 2010; Bebell & Kay, 2010; Li & Ma, 2010); , impacts on instructional approaches and pedagogy used by teachers (de Koster et al. (2011); Wong, et al (2008); Ertmer, et al. (2001); on professional development (Martin, et al, 2010); Mouza, 2011); and on economic development (Warschauer & Matuchniak, 2010; Kotteman & Boyer-Wright, 2009). Each of those areas has been the focus of several studies. That interest can be attributed to what Seymour Papert identified as the protean nature of digital technologies (Papert, 1980). As such, technology is used for so many different reasons to achieve so many different ends that no single study or set of research questions can illuminate the complete impact of one-to-one technology on teaching and learning in schools today.

Digital technologies can be used for many different purposes and in many different ways in educational settings. Further, the evolution of digital technologies creates an ongoing and challenging problem for educators immersed in a one-to-one environment (Hall, 2010). Straub (2009) has called the integration of technology in educational environments a Sisyphean task, never finished or achieved. Others have noted that technology use in school settings is an example of what Rittel and Webber (1973) called a wicked problem (Koehler & Mishra, 2008; Neiss, 2008). Viewed as a wicked problem, evaluating one-to-one technology outcomes is likely to be incomplete, contradictory, and unique to a given context (Rittel & Webber, 1973). Simon (1956) termed decision making in this type of environment as "satisficing," accepting an outcome that is satisfactory but perhaps not optimal.

The evaluation of any one-to-one technology initiative against any set of outcomes will inevitably come down to the solutions employed by individual teachers in solving the wicked problem of technology use and integration. Understanding why teachers have adopted, used, and embedded technology into their practice is necessary to interpreting all evaluations of technology in an educational setting. Koehler and Mishra (2008) describe the process as "bricolage"; the art of doing the best possible with what is at hand. Here, Connelly and Clandinin's (1988) view of the teacher as curriculum maker is central to understanding the experiences of teachers in one-to-one technology environments. Despite the best-laid plans of policymakers, technology enthusiasts, and administrators, technology adoption, integration, and implementation will be unique, contextualized and teacher dependent. Their voices and experiences must be included to fully understand the impacts of large-scale one-to-one technology adoptions. Importantly,

the voices and experiences of teachers in schools that have successfully implemented a one-to-one model may shape and inform the work of schools still struggling to embed technology in their classrooms and the implementation strategies employed for other large-scale ubiquitous computing programs.

Background

Within Maine, and across the country, researchers have used a number of methods to evaluate the effectiveness of large-scale technology initiatives. Maine's MLTI initiative has been documented by the Maine Policy Research Institute (MEPRI) and the Center for Education Policy, Applied Research, and Evaluation (CEPARE). Over the past eight years the adoption and use of laptops for instruction has been reported by 75 percent of teachers participating in the Maine Learning Technology Initiative. Silvernail (2011) found that the use of laptops for assessment was three times more likely by teachers identifying as constructivists as opposed to traditionalist in the Maine Laptop Learning Initiative. Other results from the ongoing studies have found that how students use their laptops in the writing process influenced the scaled scores obtained on the Maine Educational Assessment in writing (Silvernail and Gritter, 2005). While in mathematics, Silvernail and Buffington (2009) found that measurable changes in student outcomes from using technology-based instruction require both pedagogically sound practices and adherence to the practice over sustained periods.

Studies outside of Maine have measured implementation features (Drayton, Falk, Stroud, Hobbs, and Hammerman, 2010); student performance data in one-to-one implementations (Suhr, Hernandez, Grimes, and Warschauer, 2010); or both student performance and implementation strategies (Bebell and Kay, 2010). Although small

improvements in student outcomes have been correlated with technology deployments (Bebell and Kay, 2010, Suhr et. al., 2010), clear gains in student performance have been harder to document.

While the studies above have found some evidence that one-to-one technology initiatives can have positive impacts on student achievement, other commentators and policy evaluators have expressed concerns about the value of these initiatives to improve teaching and learning. Lei and Zhao (2008) noted that 39 percent of parents surveyed were concerned with the amount of time their students spent on laptops, and 40 percent of teachers believed that they were a distraction for their students. In a series of articles and commentaries, Cuban (2001) has argued that the results of large-scale implementations have not justified the costs to teacher time and school finances. The difficulty in mastering new technologies, and changing pedagogy to effectively integrate computers into classroom instruction and practice, are given as reasons not to invest widely in computers (Cuban, 2001). Cuban also maintains that the results of large-scale studies such as those described above are largely inconclusive in improving student achievement or changing teaching and learning (Cuban 2006).

Weston and Bain (2010) argue that "few large scale reform initiatives can demonstrate large scale effects on teaching, learning, and achievement" (p.8). The results for one-to-one initiatives are no surprise when compared with other significant reform efforts. Noting the contributions of others, Weston and Bain (2010) suggest that several factors may contribute to that outcome: poor implementation, the idiosyncratic nature of teaching, and the significant amount of teaching practice that is uninformed by research. Weston and Bain (2010) then go on to argue that for the promise of one-to-one initiatives

to be achieved, technological tools in schools must begin to be viewed as "cognitive tools" (p.10). In their view a cognitive tool extends the abilities of a user to achieve outcomes that are not possible without them.

Critics and advocates alike have been underwhelmed by the relatively modest improvements seen with large-scale one-to-one computer deployments as measured by student achievement in statewide accountability systems (Cuban, 2006; Silvernail, 2011). These outcomes may be a result of poor implementation (Shapley et al., 2010), confounding adverse effects such as distractions created by the device (Lei & Zhao, 2008), or the difficulties in changing school cultures as it pertains to instruction and assessment (Weston & Bain, 2010). Several researchers comment on the relationship between technology use and pedagogical stance (Silvernail, 2011; Beaudry, 2004; Drayton et al. 2010; Gauci, 2009). Implementation may be strongly affected by the stance of both the teacher, i.e. student-centered or teacher-centered and/or the use of technology as either a simple substitution for non-digital tools and techniques, or the adoption of technologies that provide redefinition and augmentation of current instructional practices.

Other factors may influence the success of large-scale computer deployments. Rogers (2003) describes the process that innovations undergo as they diffuse through cultures and social systems. Rogers (2003) describes the diffusion of innovation as a "special type of communication in which the messages are about a new idea" (p.75). More importantly he highlights the dependence of such communication on the channels present among members of a social system. In his model, the diffusion of innovation is "essentially an information seeking and processing activity" (p.100) to reduce uncertainty. The rate of adoption depends upon the relative advantage of the innovation,

compatibility with existing values, complexity of the innovation, observability and trial-ability of the innovation (p.105). Rogers (2003) further notes that the transfer of ideas "occurs most frequently between two individuals who are similar in.... beliefs, education, socioeconomic status, and the like" (p.117). What do those social networks look like in successful schools implementing one-to-one networks? In this model, the largest implementation gap is between Early Adopters and the Early Majority (Figure 1.1)

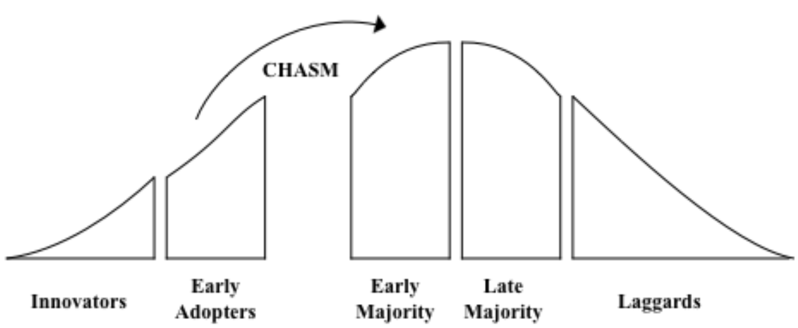

Figure 1.1 Rogers' Adoption Spectrum for Innovations

There is no standard definition of technology integration (Bebell, Russell & O'Dwyer, 2004). It has been described as how teachers use technology to carry out instruction (Bebell, et. al, 2004; Hennessy, Ruthven & Brindley, 2005). Others have defined technology integration in terms of how it supports thinking skills (Lim, Wong, Khine, Chai & Divaharan, (2003), as its use as a cognitive tool (Weston & Bain, 2010) or to support specific aspects of teaching and learning such as assessment (Gauci, Dantas,

Williams & Kemm, 2009). As such, to understand technology integration a framework can be used to view the many possible solutions to the wicked problem of technology integration.

One approach to understanding technology integration is to identify the domains of knowledge required to use technology effectively. Mishra and Koehler (2006) created the Technological Pedagogical Content Knowledge (TPCK) framework. Within that framework a teacher's content knowledge, pedagogical knowledge and technology knowledge all contribute to the effective integration of technology (Mishra & Koehler, 2006). Specifically, those domains include knowledge of the existence, components, and capabilities of various technologies, an understanding of how to use those technologies, and how those technologies can change pedagogy (Mishra & Koehler, 2006).

Conceptual Framework and Propositions

The development of the TPACK framework extended the initial work of Shulman (1987, 1986) to include the knowledge domain of technology. In Shulman's original conceptualization, content knowledge, including the knowledge of concepts, theories, ideas, frameworks, and practices in a discipline, was integrated with a teacher's pedagogical knowledge, knowledge about the practices, processes, and methods of teaching during the act of instruction. Shulman described that interaction as pedagogical-content knowledge: the knowledge of teaching that is specific to the content of a lesson. Mishra and Koehler (2006) added the domain of technological knowledge to describe how the three knowledge domains of content, pedagogy, and technology interact to produce effective teaching with technology. (See Figure 1.2 for Mishra and Koehler's (2006) conceptualization of this framework.)

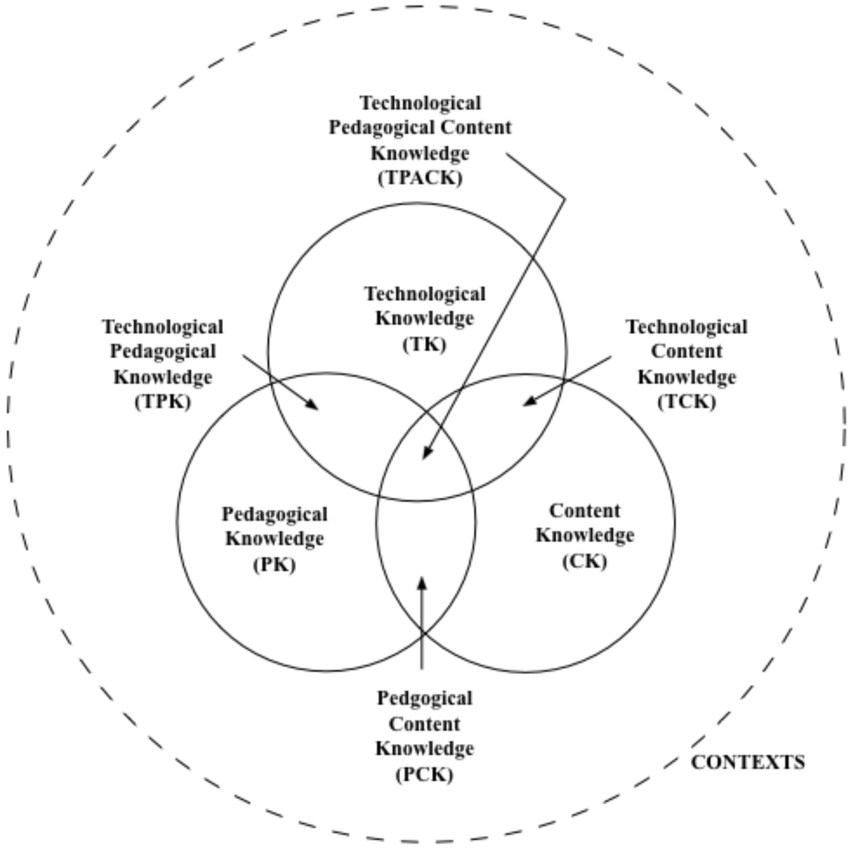

Figure 1.2 Technological Pedagogical and Content Knowledge Framework

TPACK was used to understand the implementation of technology in the classroom by teachers in a school which has participated in the MLTI deployment. Specifically, it was used to understand how effectively teachers integrated technology. The framework was chosen to untangle the myriad different uses of technology in the classroom settings of teachers throughout a school. Those three domains, and the possible interactions between and among them, allow the researcher to characterize and understand the protean, unique, and contextualized nature of technology integration. This study, then, focused on the interplay of pedagogy, content, and technology in teachers' practice as illustrated in their words, instructional materials, and enacted curriculum as described in their classrooms.

That interaction was expected to be mediated by the willingness and comfort of teachers to integrate technology. Rogers' Diffusion of Innovation (Rogers, 2003) describes the factors involved in adopting an innovation such as technology into the classroom. That adoption decision is made at different rates by individuals creating an adoption spectrum that categorizes adopters from innovators to laggards. This study describes the differences in technology integration from the perspectives of teachers at both ends of Rogers' adoption spectrum.

Statement of the Problem

Does the investment of time, money, and human capital in large-scale deployments of computers or tablets change teaching and learning to an extent that policy should encourage the adoption of ubiquitous computing? The current answer may be no. However, the questions asked and the answers obtained may not yet be sufficient.

Maine's Learning Technology Initiative is more than ten years old. As of January 2010, all of Maine's 226 middle schools, and 55 percent (66 schools) of its high schools were participating in (MLTI, 2013). That comprises 29,570 students in grades 7 and 8, 23,717 students in grades 9-12, 4468 teachers at grades 7 and 8, and 7401 teachers in grades 9-12 (MLTI, 2013). Using costs for the 2013 deployment, the state of Maine invested more than nine million dollars in fiscal year 2013-14 while local schools invested another six million dollars in technology deployments. That may be the largest discretionary spending done by schools participating in the MLTI. It is critical that the investment is maximized to influence teaching and learning. The work of Chen and Lui (2011) suggests that professional development and the development of large-scale networks of collaborating educators (something that enhances diffusion and is also more

likely with MLTI) is essential for maximizing returns on the investment in the MLTI program.

Maximizing that investment requires understanding how teachers in one-to-one schools have integrated technology into their classrooms and practice over the past ten years. Some schools and teachers have been more successful in achieving integration than others. The experiences of teachers successfully integrating technology into their practices can serve as models for those teachers struggling with the adoption of technology. Asking teachers to describe and interpret the evolution of their practices, over their participation in a one-to-one technology environment, provides context for understanding the influences of ubiquitous computing on teacher practice.

Most evaluations of the Maine Learning Technology Initiative have focused on describing student outcomes from technology use (Silvernail, 2011; Silvernail & Gritter, 2005; Silvernail & Buffington,2009) or identifying the tools, software, or types of activities used by teachers and students during the initiative (Silvernail, 2011). Those quantitative studies have given Maine policymakers a big-picture view of the implementation of a one-to-one model of technology deployment. School-level or classroom-level studies have been fewer. Beaudry (2004) undertook a qualitative case study of assessment practices using laptops in a Maine middle school. Earlier in the deployment of the MLTI, Garthwait and Weller (2005) undertook a qualitative investigation of two middle school teachers in the first year of the project. Fairman (2004) undertook an early qualitative evaluation of MLTI in its second year of existence. Using interview, survey and observational data, Fairman (2004) noted that teachers

reported a shift towards more student-centered and inquiry-based approaches in their practices.

Maine’s Learning Technology Initiative is moving into its second decade. As the first statewide one-to-one technology deployment, it has served as a model for other states, districts, and policymakers. Some teachers have developed deep understandings of the integration of technology into their practices. Some schools have seen those understandings and practices diffuse widely throughout their staffs. However, current research is silent on how successful teachers describe and understand the practices and how they have acquired these understandings.

Purpose of the Study

The purpose of this qualitative study was to describe and understand how teachers describe the changes in their practices as a result of ten years participation in a one-to-one environment. To that end, the following research questions were examined.

1. How do teachers in a school participating successfully in the Maine Learning Technology Initiative describe the impact on their practices?
2. In what ways, and how do, teachers describe their evolving understandings of technological pedagogical content knowledge in a successful school’s participation in a one-to-one technology environment?
3. What factors influence teachers’ decisions to change and adapt their practices as a result of their school’s participation in a one-to-one technology environment?

Significance of the Study

No evaluations of Maine’s Learning Technology initiative have sought to understand teachers’ use of technology as described by Koehler and Mishra’s TPCK

framework. The literature is also silent on how teachers describe the evolution and acquisition of their TPCK understandings. Koehler and Mishra (2006) describe three domains of knowledge --content, pedagogical, and technological-- required for the effective integration of technology into teacher's practice. The intersection of those domains has been described in other research outside of Maine (Manfra & Hammond, 2006; Polly, 2011; Harris & Hofer, 2011). Those qualitative studies have provided context specific examples of technology embedded in teacher practice. Early reports in the deployment of MLTI, from researchers such as Fairman (2004) and Garthwait and Weller (2005), identified some aspects of changes in teacher practice but were not coded using the TPCK framework. The framework can be used to analyze and understand both teacher descriptions of technology integration, as well as observations and analysis of teacher practice and artifacts.

Hall (2010) notes that "teachers and schools becoming high-quality users of technology is a process, not an event" (p.233). The process can be described as the diffusion of technology throughout an organization. Rogers (2003) describes the diffusion of innovations as a social process involving communication. Teachers considering the adoption of technology in their practices may use a host of possible channels for communication. Importantly, the adoption choices also depend upon the relative advantage of an innovation, compatibility with existing values, complexity of the innovation, observability and trial-ability of the innovation (Rogers, 2003). Maine middle school teachers have been using laptops for almost twelve years. Which of Rogers' factors have supported or inhibited the adoption of laptops in their classrooms? Which of those factors are more important for early adopters versus late adopters?

Understanding the adoption and diffusion of effective technology integration practices by teachers requires utilizing a framework to analyze teacher descriptions of their experiences. Rogers' Diffusion of Innovation is such a framework.

The process, as noted by Hall (2010), can also be viewed from the standpoint of implementation choices made by individual teachers over time. As teachers implement one-to-one computing in their classrooms, how do they adapt and change their practices to accommodate the innovation? Do teachers demonstrate increasing understandings of technological, pedagogical content knowledge? How do they move from task-related issues of technology use and deployment to substantive changes in pedagogy? Are teachers integrating the three domains of knowledge in the TPACK model to leverage technology in their classrooms?

Finally, no study of Maine's unique, long-standing MLTI deployment has focused on a successful school or schools. Quantitative studies have surveyed schools across the state for large-scale outcomes, or focused upon the application of technology to specific tools and programs. Qualitative studies have looked at schools very early in the deployment of the Maine Learning Technology Initiative. Furthermore, no attempt was made to study specifically successful teachers or schools.

Chapter 2: Literature Review

This chapter is organized into several sections. An initial overview of the Maine Learning Technology Initiative begins the chapter. The results obtained in evaluating one-to-one deployments in other states are reviewed next. In the third section, the critiques of large-scale one-to-one technology initiatives and the challenges identified by supporters are reviewed. In the next section, the review focuses on the research results obtained in studies of the Maine Learning Technology Initiative (MLTI), followed by a discussion of the limitations of those studies. In the final section, a review of the various frameworks to describe the adoption of innovations that integrate technology into teaching practice.

Introduction

Maine has taken the lead in deploying and implementing ubiquitous computing in schools since 1999. The Maine Learning Technology Initiative has made Maine the first state in the nation on several fronts: first to develop a plan to provide all teachers and students in grades 7-12 with a digital device: first to actually equip all of Maine's seventh- and eighth-graders and teachers with personal learning devices; and the first to provide a mechanism for every home of a seventh- and eighth-grader to obtain Internet access (Maine Department of Education, 2014). MLTI is the first statewide one-to-one technology initiative in the United States (McCarthy & Breen, 2001).

In 1999, the Task Force on the Maine Learning Technology Endowment was established by the legislature with Public Law 1999, Chapter 731, Part FFF, Sec. FFF-2.

The task force recommended five guiding principles: equity, integration with Maine's Learning Results, sustainability and avoiding obsolescence, teacher preparation and professional development, and economic development (Maine Department of Education, 2001). After the issuance of the task force's report in 2002, the Maine Learning Technology Initiative (MLTI) was established in Title 20-A, Chapter 801: Maine Learning Technology Fund §19101-§19110.

Although begun with a one-time state budgetary surplus (Maine Department of Education, 2001), the MLTI has been supported (re-authorized) by the Maine State legislature on three additional occasions over the past 15 years. In that time the program has supported the deployment of digital learning devices to all seventh- and eighth-grade students, teachers, and administrators, and has added the ability for school systems to purchase participation for high-school teachers and students. The State of Maine reports the following levels of one-to-one participation as of 2010 (Maine Department of Education, 2014):

- Middle Schools: 226 (100%)
- High Schools: 67 (55%)
- Students 7-8: 29,570
- Students 9-12: 23,717
- Teachers 7-8: 4,468
- Teachers 9-12: 7,401

Former Governor Angus King's vision of providing Maine students and schools with an advantage relative to other states has been achieved in terms of providing access to personal learning devices. The impact of the MLTI on providing an educational advantage is described below.

Evaluating Large-Scale, One-to-One Technology Initiatives

Drayton, Falk, Stroud, Hobbs, and Hammerman (2010) undertook a three-year study of three schools that had been implementing a one-to-one computing environment for at least five years. Their mixed-methods study reports on both qualitative and quantitative data from the third year of the study. They collected teacher reports, student questionnaires, school and district documents, and observations and interviews from science teachers who selected one course for the study. Quantitative data was limited to summary statistics, while qualitative data was analyzed with a grounded-coding approach.

Drayton et al. (2010) reported on teacher and student use of various computer programs, applications, and forms of technology such as interactive whiteboards. Those summary statistics reported on the tools used instead of the cognitive activities involved or the integration into teaching and learning. The results also indicate a minimum level of integration as measured within TPACK. The authors noted that science teachers in the three systems provided additional content for their instruction from primarily three sources; the web (33 percent of the classrooms); software (11 percent of classrooms); and teacher-created websites (11 percent of classrooms). However, they noted that overwhelmingly the content was mediated by the teachers, through PowerPoints interactive whiteboards, and rarely was obtained by students directly on their laptops. More pedagogically sound examples were reported on the use of animations, visualizations, and virtual labs by teachers, especially by biology and chemistry teachers. There coding indicated that illustrating molecular processes was reported as important for qualitative understanding. Although many teachers could describe the benefits of using

virtualization for laboratories and complex phenomena, only 11 percent reported using such tools in the third year of the study, suggesting that pedagogical and content knowledge were not fully integrated. Teachers also reported relatively low uses of spreadsheet programs or probe-ware for data collection (13 percent and 16 percent respectively) and data analysis (15 percent and 11 percent). In teacher interviews, the authors note that most teachers described the benefits of using those tools for “doing” science but rarely reported the use by students during actual instruction. Rarely did teachers report the use of online or actual data sources in their instruction, and no teachers reported the use of technology to connect or collaborate with the wider scientific community or other students. In all three schools, most technology use by students was focused upon accessing information or visualizations, and was rarely used in assessment, either formative or summative (p.46).

A three-year pilot program across western Massachusetts’s middle schools was reported upon by Bebell and Kay (2010). The Berkshire Wireless Initiative (BWLI) targeted the following student outcomes: improving student achievement, engagement, behavior, collaboration, and information literacy (Bebel & Kay, 2010). The project also targeted teacher outcomes including “fundamental changes in teaching strategies and curriculum delivery” (p.8). A pre- and post-comparison was made between students’ Massachusetts Comprehensive Assessment System (MCAS) scores at treatment schools participating in the BWLI program, and two nonparticipating surrounding schools. Qualitative data from teacher and student surveys, student demographic and school data, and observations were used to further differentiate the quantitative MCAS scores for various factor analysis.

Pilot students in the BWLI study were found to typically use their laptops on a slightly more than daily basis, with use in mathematics and science classes less frequent than in ELA and social studies. Over the three years of the study most uses reported by teachers showed increases, with the use of computers for communication, lesson planning and making handouts for students most common (120.9 days in the school year, 85.6 and 69.6 days respectively). Of surveyed items, teachers reported the smallest uses, in days over a school year, for preparing IEPs, Internet based lessons, and using a computer for modeling relationships or functions (15.8, 19.9, and 20.8 days respectively). Student-reported uses, in days in the school year, were largest for accessing information on the internet (85 days), accessing a teacher's website (53 days) and taking notes in class (36 days). Instructional or learning tasks reported least used were working with spreadsheets and databases (9 days), analyzing data (14 days), and creating graphs or tables (14 days).

Shapley, Sheehan, Maloney, and Caranikas-Walker (2010) proposed a different model to evaluate the relationship between technology deployment in a one-to-one environment and student achievement. They measured implementation fidelity of technology immersion as a predictor of student achievement in the Technology Immersion Pilot created by the Texas Legislature in 2003. They investigated the extent to which 21 treatment schools implemented the Technology Immersion model, and assessed each school's implementation strength, a composite variable derived from measurement of individual components of the technology immersion framework, against the state of Texas's criterion referenced assessment, the Texas Assessment of Knowledge and Skills (TAKS). Twenty-one middle schools were chosen. Seventy five percent of those enrolled fewer than 600 students. More than 600 teachers were involved in the study.

Data were collected on three cohorts of students, those participating for three, two, and one year in the project (Shapley et al., 2010). The data comprised five measures of support for technology implementation, four classroom or teacher indicators, and three student-access and use indicators, and were collected using surveys and questionnaires of teachers, administrators, and students. The indicators were evaluated with a four-point score and standardized into z-scores for each of the three areas, and for an overall implementation aggregated score. The scores were used to create linear models to investigate associations between these implementation measures and student achievement data on the TAKS.

Mean scores in the fourth year were reported for seven of the indicators. No schools were ranked as fully implemented for leadership support. Substantial implementation was measured at 52 percent of the schools for leadership support. Teacher "buy in" as measured by the scores was highest of all seven values with a mean value of 3.19 on the four-point scale. Student access and use was ranked lowest with a mean score of 2.07, or only partially implemented. Classroom immersion, a composite measure of technology integration into teaching and learning, had the next lowest average implementation index of 2.67 with 76 percent of schools ranked as having partially implemented (2.0 on the 4 point scale) technology into classrooms. Professional development was also ranked low, with 61 percent of schools ranked as minimal to partial implementation of professional development components.

Shapley et al. (2010) found statistically significant correlations between several of these components of Technology Immersion. Classroom immersion scores were correlated with administrative leadership, teachers' support for technology innovation,

and quality of professional development. Student access and use, uniformly low across most schools, was statistically correlated with measures of community support and technical support for immersion. Several factors were statistically significant predictors of student scores in reading. Immersion support and classroom immersion were significant predictors for some cohorts reading scores, while student use of laptops outside of school was the strongest predictor of student reading scores for all cohorts. There was no relationship found between student laptop-use measured in days of school and reading scores. The results were similar for TAKS mathematics scores. Immersion support was significant for some cohorts, while student access and use at home was a strong positive predictor of TAKS mathematics scores.

Full implementation of the Technology Immersion model was not achieved, with only six schools reaching substantial implementation on the composite index. Shapley et al. (2010) concluded that teachers, “on average used technology increasingly to support their own teaching but there was little change in the frequency of students’ technology use in classes” (p.47). School levels of immersion support and teachers’ reported levels of classroom immersion (integration) were inconsistent predictors of student TAKS reading and mathematics scores.

As noted above, evaluating technology integration’s impact on student learning outcomes is difficult. The outcomes vary in their demonstration of significant change in student outcomes due to technology. The protean and varied nature of technology use to support teaching and learning makes many measures of wide-scale student learning difficult to assess or document. That has led to questions about the relative value of large scale technology initiatives in schools. Assessing the impact of large scale one-to-one

technology initiatives on teaching and learning requires describing the changes in teacher practice as a result of the presence of ubiquitous technology in their classrooms.

Critiques of Large-Scale Technology Implementations

While the studies above have found some evidence that one-to-one technology initiatives can have positive impacts on teacher practice, other commentators and policy evaluators have expressed concerns about the value of those initiatives to improve teaching and learning. Lei and Zhao (2008) collected data on the perceptions of parents, students, and teachers in the first year of a one-to-one implementation in a middle school. Teachers reported the most satisfaction with the laptops, reporting that laptops had significantly improved their communication with parents and teachers, while all reported that the laptops had helped both them and their students. Students reported that laptops had helped them with homework and computer skills. Parents expressed less comfort over all, with 39 percent being concerned with the amount of time their children spent on laptops. Forty percent of teachers believed that it had become harder for their students to concentrate in class due to distractions available on the laptops (Lei & Zhao, 2008).

Over a series of articles and commentaries, Larry Cuban has argued that the results of large-scale implementations have not justified the costs to teacher time and school finances. The difficulty in mastering new technologies and changing pedagogy to effectively integrate computers into classroom instruction and practice is pointed to as reasons not to invest widely in computers (Cuban, 2001). Cuban also maintains that the results of large-scale studies such as those described below are largely inconclusive in improving student achievement or changing teaching and learning (Cuban 2006).

Weston and Bain (2010) argue that "few large scale reform initiatives can demonstrate large scale effects on teaching, learning, and achievement" (p.8). The results for one-to-one initiatives are no surprise when compared with other significant reform efforts. Noting the contributions of others, Weston and Bain (2010) suggest that several factors may contribute to that outcome including poor implementation, the idiosyncratic nature of teaching, and the significant amount of teaching practice that is uninformed by research. However, both authors also maintain that technology initiatives may yet hold the promise to significantly change the paradigms of teaching and learning in many traditional schools.

Weston and Bain (2010) then go on to argue that for the promise of one-to-one initiatives to be achieved, technological tools in schools must begin to be viewed as "cognitive tools" (p.10). In their view a cognitive tool extends the abilities of a user to achieve outcomes not possible without them. As they note, many technology initiatives have focused upon replacements of non-digital tools, resources, and methods with a digital version. Such substitutions do not change the outcome dramatically or substantively for teachers or learners. They note that type of technology integration "merely automates the practices of the prevailing paradigm (a) non differentiated large group instruction, (b) access to information in classrooms, (c) non-engagement of parents, and (d) summative assessment of performance" (p.10). Embedding technology in practices that are supported by research may be required before significant improvements in teaching and learning can be measured.

Evaluating Maine's MLTI Initiative

The deployment of laptops to all seventh and eighth grade students coincided with several other components of the technology plan developed by the Task Force. One of those components established the goal of ongoing evaluation of the one-to-one initiative. In 2002, the Maine Department of Education hired the Maine Policy Research Institute (MEPRI) to undertake that ongoing evaluation (Silvernail, 2011). In 2011, Silvernail described the results of an eight-year program to document the changes in teaching and learning resulting from the Maine Learning Technology Initiative.

That mixed-method study involved surveys, site visits and observations. The report documented the uses of laptops by Maine's middle school teachers and students, factors that affected use levels, perceived benefits by teachers and students, achievement effects of the MLTI program, and costs associated with the program (Silvernail, 2011). According to Silvernail, (2011) the adoption and use of laptops has increased over time with 75 percent of teachers reporting the use of laptops to provide instruction in 2010 verses only 42 percent of teachers reporting using laptops to provide instruction in 2005. In the same study, 53 percent of teachers reported, in 2010, using laptops to provide formative assessment, while 60 percent of teachers reported using laptops for summative assessments. Interestingly, teachers who identified themselves as a constructivist in teaching philosophy were almost three times (45 percent versus 16 percent) more likely to use laptops for assessment as teachers who identified their teaching philosophy as traditionalist. Constructivist teachers were also almost twice as likely (57 percent to 32 percent) to use their laptops to provide classroom instruction (Silvernail, 2011).

Silvernail and Gritter (2005) reported no "appreciable change in overall performance on the eighth Grade Maine Education Assessment" over the three years of the MLTI's existence. They also undertook a comparison of MEA writing scores for the years 2000, before the MLTI initiative, and 2005, three years into the initiative. Scaled scores were 3.44 points higher in 2005, representing an effect size of 0.32 (significant at the $p<.001$ level) (Silvernail & Gritter, 2005). Although the study could not demonstrate causality, it found that how students used their laptops in the writing process influenced the scaled scores obtained (Silvernail & Gritter, 2005). Those who used their laptops in all phases of the writing process (drafts, edits and final copies) statistically out performed students who did not use their laptops at all, or used them for only a portion of the writing process (Silvernail & Gritter, 2005).

In comparison, Suhr, Hernandez, Grimes, and Warschauer (2010), undertook a quasi-experimental design to analyze the effects of a one-to-one laptop program on fourth and fifth grade ELA scores in California. Student achievement was evaluated using the California Standards Test (CST), a criterion-referenced test of mastery of the California state standards. Suhr et al. (2010) found only a small statistically significant effect size of 0.04 for the use of laptops over two years on the writing subtest. Although the study used teacher surveys, observational, and student demographic data to ensure that differences between the control and experimental groups were minimal, the researchers did not explicitly collect data on how laptops were used to support the writing process.

The importance of measuring student achievement under conditions where technology use is tied directly to research-based practice was illustrated in mathematics by Silvernail and Buffington (2009). The researchers undertook a randomized-control

trial study of the impact of professional development in mathematics on student achievement. Experimental groups received two years of professional development to improve both pedagogical content knowledge and training in the integration of specific technological tools to facilitate both instruction and student understanding. Pre- and post-test scores of student achievement indicated that students who received instruction from teachers in the experimental group outscored the control group at a statistically significant level. Further analysis revealed that the significance was found only in subtest areas in which teachers in the experimental group showed “implementation fidelity” (Silvernail & Buffington, 2009, p.12). Subtest differences for experimental and control groups were only significant where teachers had the largest reported use of the introduced pedagogy. The results support the contention that measurable changes in student outcomes from using technology-based instruction require both pedagogically sound practices and adherence to the practice over sustained periods.

Early in the implementation of the MLTI program, Beaudry (2004) undertook a qualitative investigation of the use of laptops for classroom assessment. The study was short term, and best described as a case study, but in the observation of three teachers, Beaudry concluded that the presence of laptop computers did not improve a teacher’s ability to implement effective assessment strategies, such as linking instruction and feedback to clearly articulated learning targets. Rather, evidence was presented that in fact, the presence of web-based resources may have confounded the assessment practices and expectations for both summative and formative assessments.

Other evidence suggests that appropriately designed units and assessment products can measurably improve student learning. Berry and Wintle (2009) undertook

an action-research study on middle-school science classrooms. Experimental and control classes received the same instruction but were asked to complete different summative assessments. In the experimental group, students were asked to use technology to produce an animated podcast of the relationship between the Earth's angle of tilt and the seasons. The control group produced a paper and hand-drawn set of diagrams for their summative assessment. Pre-, post- and month-long retention assessments were taken to evaluate the effect of the treatment, the assessment product. Students required to complete the technology-rich assessment improved from 42 percent to 91 percent success on pre- and post- tests. Those students completing the traditional assessment improved from 52 percent to 81 percent on the same two tests. Treatment students had a post-assessment effect size of 0.61. More impressively, the experimental group had an 87 percent success rate on a retention assessment administered one month after the completion of the original unit. The retention for the control group was 63 percent, yielding an effect size of 1.42 for the treatment group.

In an early case study of two teachers participating in the MLTI project, Garthwait and Weller (2005) reported on the interplay of teacher beliefs, technical knowledge, time constraints, and policy. Using interviews, observations, and document analysis over the course of a year, they observed that "access to one-to-one computing did not automatically shift instructional styles from teacher-centered to student-centered" (p.373). They also observed differences in the technical knowledge that each teacher brought to the integration of technology into the classrooms. In the case of the teacher struggling with technical issues, her perception of the long-term value of one-to-one computing was cautious. Garthwait and Weller (2005) also reported a difference in

integration levels between the two teacher participants. They attributed the more advanced integration level to the teacher's technical knowledge and pedagogical stance. The teacher struggling with the integration of technology into her practice was described as having an "incrementalist view of laptops' place in her classroom: their purpose was to perform traditional work better and more efficiently, not to change the nature of educational roles" (p.375). Grathwait and Weller also noted that time constraints were significant issues for both teachers in integrating technology, while policy decisions concerning which students were able to bring their laptops home also played a role in the willingness and perceived success of integrating technology into these teachers' practice.

Limitations in the Evaluation of MLTI

The quantitative and descriptive studies of the MLTI deployment have provided insight into the types of tools being used by Maine teachers (Silvernail, 2011); student achievement results in writing (Silvernail and Gritter, 2005) and mathematics (Silvernail and Buffington, 2009). Beaudry (2004) undertook a short-term qualitative review of assessment practices of three teachers, while Grathwait and Weller (2005) performed a qualitative case study of two teachers in the first years of the MLTI deployment.

Those studies provide glimpses into the impact of one-to-one computing on teaching and learning. The qualitative studies were of limited scope, two teachers in Grathwait and Weller (2009) or duration (Beaudry, 2004). In addition, the qualitative observations of student and teacher uses were undertaken in the early deployment of computers to Maine's middle-school teachers. Although Grathwait and Weller (2009) found a difference in integration levels between their two teachers, the deployment period

had been only over two years. Much has changed and been learned over the 12-year deployment of MTLI in the state of Maine.

No qualitative evaluation of the impact of MLTI on teacher practices has been undertaken across all middle-school grades and content areas. It is not clear if deployment and implementation differ across content areas. Over the last dozen years several frameworks have been developed to understand teacher use of technology in the classroom. In Maine, no studies have applied those frameworks to the MLTI project. Finally, no studies have focused specifically on successful schools and teachers to attempt to understand what does this success look like and how did teachers reach it.

Frameworks to Describe The Adoption Of Innovations

Successful integration of technology into teacher practice requires more than just identifying research-based practices for the use of technology as described in the following sections. It also requires an understanding of the complexities of changing teacher practice. Those changes require teachers to adopt new approaches and in some cases new beliefs. Several models have been used to describe the adoption of technology in educational settings. Those include the Concerns-Based Adoption Model, (CBAM), (Hall, 2010), the Technology Acceptance Model, (TAM), (Davis, 1989), and Diffusion of Innovation, (DoI), (Rogers, 2003). The CBAM and TAM models were developed to specifically address the adoption of innovations in educational settings, while the DoI model has been used to describe the adoption of innovations, including technology, across multiple fields. Both the CBAM and TAM models address the adoption process from the perspective of the adopter or user (Straub, 2009). The Diffusion of Innovation

model combines both the adoption process for the individual user and diffusion process as it applies to the organization (Sahin & Thompson, 2006).

The choice of a framework to describe large-scale one-to-one implementations of technology is critical to understand the outcomes of such a change. As concluded by Straub (2009), “technology adoption is a complex, inherently social, developmental process, individuals construct unique (but malleable) perceptions of technology that influence the adoption process and successfully facilitating a technology adoption needs to address cognitive, emotional, and contextual concerns” (p.626). Each of the following frameworks describes the adoption of innovations from different perspectives.

Technology Acceptance Model (TAM).

The Technology Acceptance Model is tailored to information technology adoptions. It focuses upon the end users of technology, and why they accept or reject a new technology. The model uses two variables of user behavior: perceived usefulness and perceived ease of use to describe the adoption decisions of users (Davis, 1989). Perceived usefulness is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance,” while perceived ease of use is defined as “the degree to which a person believes that using a particular system would be free of effort” (Davis, 1989, p.320).

The TAM model has been used in quantitative studies of technology adoption (Baker-Eveleth et al., 2007; Ndubisi, 2006) because Davis’s variables have been quantified with Likert scales and tested for reliability and validity (Davis, 1989). Critiques of the TAM model note that perceived ease of use ignores self-efficacy judgments, as well as other individual differences that adopters weigh when making an

adoption decision (Straub, 2009). Further, the TAM model treats adoption as a dichotomous choice of use/non-use, and is silent on the ongoing process involved in long-term initiatives of technology integration (Hall, 2010).

Concerns Based Adoption Model (CBAM).

The concerns-based adoption model combines three components: stages of concern (SoC), levels of use (LoU), and the innovation configuration (IC). The CBAM is designed to allow a facilitator of change to understand the concerns of adopters, but not necessarily the adoption across an organization (Straub, 2009). One important component of the CBAM is the focus on adoption as a process, and not as a dichotomous choice between use/non-use (Hall, 2010). The CBAM also addresses implementation fidelity with the IC component, which is described by the innovator or developer in terms of high fidelity, and then delineates the various ways and configurations that an innovation may be used (Hall, 2010).

Researchers have used innovation configurations to describe the fidelity of various educational initiatives (George, et al., 2000; Donovan, 2005; Donovan et al., 2007). Donovan (2005) found three distinct configurations of laptop use in a single school implementing a one-to-one environment. Identified limitations of the CBAM are that the end user of the innovation is the teacher, and the model is blind to the impacts on students. Additionally the model focuses on teacher concerns while ignoring the possible positive perceptions of adopters for the innovation (Straub, 2009).

Diffusion of Innovations (DoI).

The Diffusion of Innovation framework addresses both the adoption process of individuals and the diffusion of adoption across organizations over time (Rogers, 2003).

There are four main elements in the theory; the innovation, communication channels, time, and social systems. Many of the elements of Rogers' theory echo components of both CBAM and TAM. The adoption of an innovation is dependent upon the relative advantage of the innovation, its compatibility with existing values, the complexity of the innovation, and its observability and trial-ability (Rogers, 2003). Although the adoption of an innovation is still described as a use/non-use decision, the process of making an innovation decision is identified as a time-dependent element (Straub, 2009). Importantly, the diffusion process focuses on the social nature of information sharing and is framed in terms of the social system undertaking the adoption. The primary criticism of DoI is that it is descriptive and not prescriptive (Straub, 2009), however it does allow a researcher to describe why adoption has occurred in a given setting.

The Diffusion of Innovations: A Social Process.

In investigating the adoption and penetration of home computers into a neighborhood, Goolsbee and Klenow (2002), computer adoption was found to give rise to an S-shaped adoption curve plotted over time. As more neighbors, friends, and family adopt computers around a non-adopter, a rapid rise follows the initial adoption by the relatively few early adopters. Finally, as adoption reaches most potential users, the adoption curve's rate of increase slows to zero. That type of diffusion of an innovation has been documented in many other areas and industries (Rogers, 2003).

Rogers' Diffusion of Innovation theory describes the process that innovations undergo as they diffuse through cultures and social systems (Rogers, 2003).

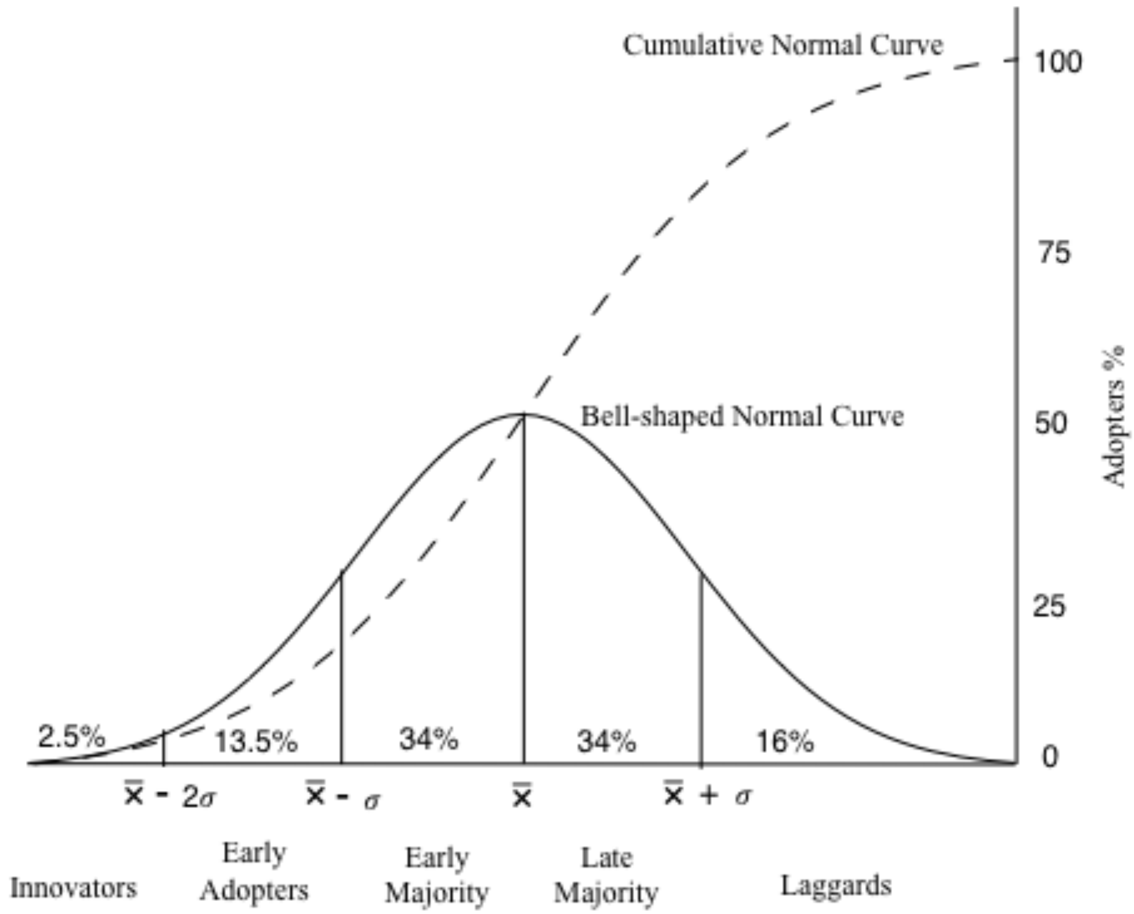

Figure 2.1 Distribution of Adopters in Rogers' Model

Adopters can be visualized along a spectrum according to their willingness to innovate (Figure 2.1) and were categorized by Rogers as innovators, early adopters, early majority, late majority, and laggards. Rogers (2003) describes the diffusion of innovation as a "special type of communication in which the messages are about a new idea" (p.75). More importantly, he highlights the dependence of that communication on the channels present among members of a social system. In the model, the diffusion of innovation is "essentially an information seeking and processing activity" (p.100) to reduce uncertainty.

Bala and Goyal (1998) state that social learning is what facilitates technology diffusion. They also point to the lack of perfect information when trying to make an adoption decision. The nature of the social network surrounding a potential adopter determines the likelihood of adoption (Bala & Goyal, 1998). Social learning is restricted when individual ability masks the relative advantage of an innovation. Munshi (2004) found that information flow was diminished when the performance of a new technology is sensitive to unobserved individual characteristics reducing the learning that can occur from observing a neighbors experience. Technology can be uniquely opaque to neighbors because it is protean (usable in many ways) and unstable (rapidly changing) (Koehler & Mishra, 2008).

Liu and San (2006) also found that social factors determine the spread of technology innovations when there are significant network externalities present. They investigated both economic and social factors in modeling the rate of internet adoption in several countries. They found that education was a significant social factor in Internet penetration, and that Internet penetration also followed an S-shaped diffusion curve (Liu & San, 2006).

Others have applied Rogers model to technology innovations in schools and universities. Sahin and Thompson (2006) found that collegial interaction and support were motivating factors in faculty technology use, and concluded that technology adoption strategies should take advantage of "collegial communication" to improve levels of instructional technology integration. Using Rogers's terms, Geoghegan (1994) argued that the largest gap in acceptance of instructional technology is between the early adopters and the early majority. Applying a market model described by Moore (1991),

Geoghegan notes that there is often a chasm between the innovators and early adopters and the next group beginning with the early majority (Figure 1.1).

Geoghegan (1994) suggested professional development aimed at reducing the uncertainty associated with innovation, and capitalizing on existing social networks within staff, to bridge that gap. Frank, Zhao, and Borman (2004) found that "the effects of perceived social pressure and access to expertise through help and talk were at least as important" (p.148) as the traditional constraints of time, access to the technology, and institutional professional development in the adoption of new technological innovations. In initiating a laptop program at Minnesota State University, Hall and Elliott (2003) focused much of their efforts on the early majority, addressing the needs of the early majority that are distinct from the early adopters. As described by Goeghegan (1994), early majorities tend to be more evolutionary, pragmatic, process-oriented and risk-averse when compared to early adopters who tend to be more revolutionary, visionary, project-oriented, and risk takers.

Rogers (2003) notes that the transfer of ideas "occurs most frequently between two individuals who are similar in.... beliefs, education, socioeconomic status, and the like" (p.117). Like other researchers using other methods Goos (2009) identified the importance of informal interactions with teaching colleagues as important in the integration of technology within their classrooms. Frank, et.al (2004) describe that transfer as social capital in the form of informal expertise and social pressure to conform. They note that unlike in traditional manufacturing settings where an innovation can be mandated from the top, educational institutions contain actors with a significant amount of autonomy in deciding whether to implement many innovations (Frank, et. al., 2004).

They contend that the diffusion of an innovation is depended upon a teacher's access and response to social capital (Frank, et. al., 2004). Such access echoes Rogers' contention that teachers are more likely to seek and offer help to those colleagues to whom they are close (Frank, 2001). In a case study of a primary school in Hong Kong implementing a one-to-one model technology initiative, Li (2010) found that social trust, access to expertise and social pressure were decisive factors in the development and implementation of the initiative.

Factors Affecting the Rate of Adoption.

Rogers describes the adoption decision as an individual process, distinct from the diffusion process, which describes group processes (Rogers, 2003). The rate of adoption depends upon the relative advantage of an innovation, compatibility with existing values, complexity of the innovation, observability and trial-ability of the innovation (Rogers, 2003). Minishi-Majanja and Kiplang (2005) found all five factors present in an analysis of the adoption of internet communication technologies in library and information science education. Kebritchi (2010) used a case study design to identify factors affecting teachers' adoption of educational games. The results, using Rogers' theory of diffusion, found compatibility, relative advantage, complexity and trial-ability played important roles in game adoption in the K-12 classroom (Kebritchi, 2010). Lee, et.al. (2011) found that compatibility, complexity, relative advantage and trial ability were significant factors in the attitudes of employees about the perceived usefulness of e-learning systems. Observability had no significant effect on employee attitudes of perceived usefulness (Lee, et.al, 2011). That is inconsistent with other studies (Huang, 2004; Yang, 2007 as reported by Lee, et.al. 2011). The lack of observability of a new technological innovation

in Indian agriculture contributed to a reduced rate of adoption, and was attributed to the heterogeneity of neighboring farmers (Munshi, 2004).

Compatibility with existing values should be conducive to successful adoption (Frank et. al, 2004). Levin and Wadmany (2006) found teachers' expertise and positive attitudes about technology were important in sustaining and institutionalizing technology integration. Sahin and Thompson (2006) found that computer adoption and use was significantly correlated with attitude toward computer use, computer access, support for computer use, and adopter categories (early adopters). Many researchers have identified barriers to effective technology integration. One such barrier is a teacher's beliefs or perceptions about technology. Quazi and Talukder (2010) used correlation and regression analysis to investigate the technology acceptance of employees based upon their demographics. Training was identified as the most important predictor of employee perceptions of technological innovations, which was the strongest predictor of technology acceptance and use (Quazi & Talukder, 2010). They conclude that an employee's adoption of an innovation is driven by favorable perception of that technology.

Those beliefs can be defined in many different ways. Ertmer, Addison, Lane, Ross, and Woods (1999), investigated the intersection of teacher beliefs, technology and curriculum, while others have defined teacher beliefs in terms of the impacts of use on students (O'Dwyer, Russell, & Bebell, 2004). Others have noted that a teacher's pedagogical stance –teacher-centered or student-centered—can impact the integration of technology in the classroom (Silvernail, 2011; Beaudry, 2004; Drayton et al. 2010; Gauci, 2009).

Other researchers have investigated other factors influencing the adoption of innovations in schools, and the factors that have contributed to unsuccessful adoptions. Research on both points contributes to maximizing the potential returns on investments in the MLTI program over the next cycle of deployment. Haelermans (2010) investigated which determinants of innovations matter most as shown in the data from Dutch secondary schools over a four-year period. Descriptive analysis and simple regression were used to identify the determinants of innovation. Importantly, she found that school size (positive correlation), competition (positive correlation), and teaching practice (positive for student centered) were all determinants of the likelihood for innovation with a school. The small school effect is an important variable to consider in evaluating the outcomes from the MLTI program and for considering future directions. Most Maine schools would be considered to be small by the classifications used in the study. The ability of Maine middle and high schools to maximize the return on the investments in the MLTI program may be compromised without thoughtful policy implementation.

The same Dutch innovation data used by Haelermans (2010) was also used by Konings, Brand-Gruwel, and van Merrienboer (2007) to investigate educator perceptions of an innovation and its use in their classrooms. Several perceptions were found, by regression analysis, to be related to the resistance to innovations: willingness to learn, lack of awareness of teaching behavior, incomplete reflection on practice, and dominant conceptions of teaching and learning (Konings, et al., 2007). Others have found similar factors affecting technology initiatives. Weston and Baine (2010) argue that “few large scale reform initiatives can demonstrate large scale effects on teaching, learning, and achievement” (p.8). The results for one-to-one technology initiatives are no surprise

when compared with other significant reform efforts. Noting the contributions of others, Weston and Bain (2010) suggest that several factors may contribute to that outcome: poor implementation, the idiosyncratic nature of teaching, and the significant amount of teaching practice that is uninformed by research. The successful deployment of the MLTI in the state of Maine may require much more focus on teacher practice if the economic benefits from positive social externalities are going to be fully realized.

Evaluating Technology Integration Using TPACK

Lee Shulman (1986, 1987) identified a framework for describing the domains of knowledge required for effective teaching. In Shulman's framework, three domains were identified: content knowledge, pedagogical knowledge, and pedagogical content knowledge. These are defined by Shulman (1986) as:

> *Content knowledge*: the amount and organization of knowledge, in the minds of teachers, about their disciplines. "Content knowledge requires going beyond knowledge of factor concepts in a domain. It requires understanding the structures of the subject matter" (p.9).
>
> *Pedagogical Knowledge*: the knowledge teachers use across all subject areas for general instructional planning and decision making. Shulman (1986) identified other typical categories of pedagogical knowledge as evaluation methods, recognition of the developmental differences in youth, cultural awareness, classroom management and understanding of educational policies and procedures.
>
> *Pedagogical Content Knowledge*: the dimension of subject matter knowledge for teaching specific to a given domain. It may refer to the most useful

representations of knowledge within a discipline, or the most appropriate analogies, illustrations, or developmental steps in acquiring a discipline's knowledge. Such knowledge also includes the understanding of how students' conceptions and misconceptions influence the development of their understandings.

Those domains represent a framework for describing the knowledge that teachers must master in becoming effective educators. No single domain is sufficient for effective instruction, and the intersection of these domains is unique to a discipline. Shulman proposed the framework to describe the development and evaluation of teacher pre-service programs.

Mishra and Koehler's (2006) TPACK framework extended the initial work of Shulman (1987, 1986) to include the knowledge domain of technology. In Shulman's original conceptualization, content knowledge- including the knowledge of concepts, theories, ideas, frameworks, and practices in a discipline were integrated with a teacher's pedagogical knowledge- knowledge about the practices, processes, and methods of teaching during the act of instruction. Mishra and Koehler (2006) added the domain of technology knowledge to describe how the three knowledge domains of content, pedagogy, and technology interact to produce effective teaching with technology. See Figure 1.2 for Mishra and Koehler (2006) conceptualization of the framework.

The framework adds a new domain, technological knowledge, and three new intersections to Shulman's original model. Those intersections as defined by Koehler and Mishra (2008) are described as:

> *Technological Knowledge*: the knowledge required to be fluent with information technology.
>
> *Technological Content Knowledge*: the knowledge of technologies and systems that influence the development or practices of content knowledge. Technology can either constrain or afford the representation of knowledge in a discipline.
>
> *Technological Pedagogical Knowledge*: the understandings of how teaching and learning change when particular technologies are used in the classroom. It is an appreciation for the affordances and constraints of a particular technology on teaching and learning.
>
> *Technological Pedagogical Content Knowledge*: an understanding of the interplay of all three domains in effectively integrating technology.

Koehler and Mishra (2008) view the intersection of all three domains (TPACK) as a dynamic transactional relationship, where the change in one domain must be compensated and adjusted for by changes in the other two. Effective technology integration requires not only knowledge of all three domains, but also an understanding of the interrelationships between each domain. One manner of understanding the impact of technology on teacher practice is to describe teacher practices using the framework.

Schmidt and Gurbo (2008) note that for teachers to use technology effectively, they need to develop knowledge that enables them to translate technological possibilities into solutions to pedagogical problems. Such problems and solutions are deeply

contextualized and may only be observed and described at the local level. They may not lend themselves to quantification, or even generalization. The present study attempts to recognize the unique solutions found by teachers by focusing on the descriptions and experiences of teachers in a single middle school in Maine.

Hughes and Scharber (2008) used qualitative methods to compare the developing TPACK of two in-service teachers. They found teachers' informal learning focused on content-rich technology applications, which were described as influencing teacher choices and integration in their classrooms. In those teachers'English classes, the development of TPACK required opportunities to simultaneously strengthen their English content, pedagogical and technological knowledge.

Polly (2011) investigated the impact of technology-rich professional development programs on teacher learning. Importantly for this study, Polly, utilized TPACK coding to analyze research interviews of 16 school personnel. In the analysis of the data, Polly reported that teacher learning could be described by various aspects of the TPACK coding scheme. Polly also noted that there were no reports of teacher learning that were related only to technological knowledge or pedagogical knowledge without being connected to at least one other domain: pedagogical content knowledge, technological pedagogical knowledge or TPACK. Teachers did report learning content knowledge in isolation from the other domains.

Pamuk (2012) conducted an interpretative qualitative study of pre-service teachers using multiple data sources: interviews, observations, and teaching documents using TPACK as a theoretical lens to understand teachers' integration of technology into their teaching. Pamuk found that the pre-service teachers in the study were less able to

describe or identify their pedagogical knowledge, but were much surer of their content and technological knowledge. Pamuk found that the lack of pedagogical knowledge prevented effective integration of technology as captured by TPK or TPACK. As described by Pamuk, instructional uses of technology added no new dimensions to their teaching. For instance, Pamuk describes the use of digital whiteboards as simple substitutions for blackboards missing affordances provided by the technology to alter the pedagogical possibilities. Pamuk concludes that despite strengths in two domains of the framework (content and technological) the absence of pedagogical knowledge significantly constrained the effective integration of technology into pre-service teachers' instruction.

Using a qualitative case study of two teachers, Manfra and Hammond (2006) found teachers' pedagogical aims defined their use of technology in teaching social studies content. They conclude that technology provided a platform to carryout pre-existing pedagogical aims by using TPACK as a conceptual framework during coding and data analysis. Using the same software packages (a resource providing access to primary source documents), Manfra and Hammond, found that the two teachers in the study enacted their pedagogical stances as revealed in the integration of the software. One teacher described as a "manager" used the software as a means to facilitate instruction, while the other described as a "facilitator" utilized the software to co-construct the curriculum with students. That outcome suggests that the intersection of the three domains of TPACK is influenced by teacher pedagogical aims. Manfra and Hammond conclude that if those "aims do not originate from a constructivist framework, there is little technology or content will do to make instruction more student-centered" (p.239).

Those studies suggest that teachers' instructional choices in technology integration can be viewed through the TPACK lens. The integration of technology is a complex, unique, and contextualized set of decisions that may be strongly influenced by deeply held teacher beliefs about teaching and learning. Technology integration may not easily translate into students' learning improvements as captured by large-scale assessments as described in the beginning of this chapter. However, technology integration can impact research-based teaching strategies when implemented by practicing teachers. Evaluation of the impact of the Maine Learning Technology Initiative may require the identification of those context-specific intersections of pedagogy, content knowledge, and technological knowledge.

Summary

Maine has been a national leader in the deployment of one-to-one computer technology. The MLTI program has been in existence for more than ten years, affecting every middle school in the state, and more than one-half of the state's high schools. A long-term evaluation of some outcomes of that initiative has been undertaken by the Maine Education Policy Research Institute. MEPRI's work has included collecting survey data, undertaking site visits, and observation. The research has captured the large-scale changes in teacher uses of technology, and documented some changes in student outcomes.

The protean nature of technology use by teachers and students limits the ability of large-scale quantitative studies to capture and isolate the impacts of one-to-one technology initiatives on teaching and learning. The potentially multifaceted use of technology has limited the ability of many researchers to document large-scale changes in

teaching and learning, and has contributed to questions of the value of ubiquitous technology in K-12 settings.

Further complicating the evaluation of technology integration is the interaction between teachers' pedagogical beliefs and their technical understandings. Koehler and Mishra's TPACK framework provides a lens through which a researcher can untangle the potential uses of technology in the classroom by teachers and students. Effective technology integration requires the dynamic interaction of domains of knowledge about content, pedagogy, and technology. Those interactions are best evaluated by reflecting on teacher choices, and descriptions of their pedagogy.

Finally, changes in practice also involve the dynamic interaction between teachers in a larger social system, such as a school. Few large-scale educational initiatives can be evaluated without considering the diffusion of change from one educator to the next. The Diffusion of Innovation framework describes that social process, and provides another lens to understand the adoption and infiltration of technology into a teacher's practice. The sophistication of integration and the relative pace of adoption are likely to be different for educators at either end of the adoption spectrum.

Chapter 3: Methodology

The purpose of this qualitative study was to describe and understand how teachers describe the changes in their practices as a result of ten years participation in a one-to-one environment. In the first section of this chapter, the principal methodology used in the study is described. Next a rationale for and description of the study location and principal participants is reviewed. The third section addresses the types of and methods used to collect data for the study. In the fourth section the principal methods of analysis are described. Issues of credibility, transferability, dependability, and confirmability are described and the methods to ensure each are reviewed in the fifth section. The final section identifies the delimitations of the study.

Methodological Overview

A qualitative approach was taken in this study. Specifically, a case study of one middle school that has participated in the MLTI over the past ten years was chosen. As described by Merriam (2009), "a case study is an in-depth description and analysis of a bounded system" (p.40).

The nature of technology integration into teacher practice is a complex multifaceted phenomenon. Yin (2008) as reported by Merriam (2009) notes that case study design is "particularly suited to situations in which it is impossible to separate the phenomenon's variables from their context" (p.43). In this study, the unit of analysis is the individual teacher. The nature of technology integration into teacher practice is a complex multifaceted phenomenon, likely to be different for teachers from different disciplines and with different pedagogical stances. Therefore, teachers were chosen from both ends of Rogers' adoption spectrum, and from different disciplines.

Case studies have been used in many investigations of technology integration (Ainley, et. al, 2002; de Koster, et al., 2012; Harris, 2002): pedagogical beliefs and technology use (Ertmer, et al., 2001; Garthwait & Weller, 2005); the investigation of factors supporting or inhibiting technology integration (Hsu & Sharma, 2008; Granger, et al., 2002; Staples, et al., 2005): and the adoption and diffusion of new technological innovations (West, et. al., 2007; Wong, et al, 2008). Specifically, Manfra & Hammond (2006) investigated, using a case-study methodology, the interaction of teachers' pedagogical, technological and content knowledge on their instructional choices and designs. Using interviews, focus groups of students, and documentary evidence, Manfra and Hammond (2006) found that pedagogical beliefs drove curricular decisions of how to integrate technology in two history teachers' practices.

Interviews have been used in many investigations of technology integration (Ainley, et. al, 2002; de Koster, et al., 2012; Harris, 2002); pedagogical beliefs and technology use (Ertmer, et al., 2001; Garthwait & Weller, 2005); the investigation of factors supporting or inhibiting technology integration (Hsu & Sharma, 2008; Granger, et al., 2002; Staples, et al., 2005); and the adoption and diffusion of new technological innovations (West, et. al., 2007; Wong, et al, 2008). Specifically, Manfra & Hammond (2006) investigated, using, in part, interviews, the interaction of teachers' pedagogical, technological and content knowledge on their instructional choices and designs. Using interviews, focus groups of students, and documentary evidence, Manfra and Hammond (2006) found that pedagogical beliefs drove curricular decisions of how to integrate technology in two history teachers' practices. In the current study, teachers were asked to

describe their pedagogical beliefs to facilitate understanding their decisions about how to integrate technology.

As described by Stake (2005), this study is an example of an "instrumental case study." The middle school chosen is secondary to the goal of providing insight into the effects of the MLTI program on how teachers describe changes in their practices. By focusing on individual teachers, through the use of thick description, and being heuristic, that design choice may resonate with a reader's own experiences, and suggest new interpretations and understandings (Merriam, 2009).

The researcher in this study approaches the interpretation of the data from a phenomenological perspective, or "how people describe things and experience them through their senses" (Merriam, 2009). That form of interpretive research assumes that reality is socially constructed (Creswell, 2007) and understandings are negotiated socially through the interaction with others. As such, both the participants' and the researcher's interpretations and descriptions cannot be separated from their backgrounds, histories, and prior knowledge and understandings. Those factors will be further discussed in the section on trustworthiness.

Site Selection

The middle school used in this study was purposefully chosen to provide information-rich cases (Patton, 1990). In this study design, sample selection occurred at two levels: the choice of the site and the choice of participants from the site (Merriam, 2009). Both choices required criteria for selection when using purposeful sampling (Merriam, 2009). The site formed the context (Yin, 2014) of the study and was used to bound the study. The criteria used for site selection were: results from the 2013 MLTI

survey conducted by MEPRI; nominations from technology leaders across the state; a minimum number of teachers and students; and location within the state of Maine. The attributes for each criterion are described below.

2013 MLTI Survey.

Schools considered for inclusion had to meet the following criteria: higher than average reported student uses for the factor; higher than average reported teacher beliefs about teaching with technology; and higher than average reported teacher uses of technology as reported.

The criteria were used to identify those schools that have made the most progress in integrating technology during the 10 years of the MLTI project as measured by the only longitudinal source of data available in the state of Maine on the outcomes of the MLTI project. Each factor captures information about teachers' integration of technology into their classrooms, and provides an opportunity to find teachers who will demonstrate a range of effective TPACK application and diffusion of practices.

Deployment Configuration.

The middle school was chosen from those schools in Maine that have maintained the same device, Apple laptops, for the entire deployment. Over the last redeployment, schools were given the opportunity to shift from the traditional Apple laptop to personal computers or Apple tablets (iPads). Those schools that made the shift in 2013 have had to address issues different from those encountered during the initial deployment ten years ago. To eliminate the confounding challenges to shifting platforms after eight years with Apple laptops, the study focused on schools that have not changed platforms.

Size Requirements.

The middle school chosen had to meet two size requirements: it had to have at least 20 teachers and 200 students; and it had to have at least two teachers in each major content area.

Haelermans (2010) found that school size was positively correlated with the likelihood for innovation adoption in a school. Rogers (2003) notes the importance of robust social networks for the effective diffusion of innovations within a network. Having a medium to large middle school increased the likelihood that a range of practices have evolved over the ten-year deployment of the MLTI program, and that those practices have had an opportunity to diffuse among multiple teachers. Schools of that size are also likely to have multiple teachers in each content area, which supports the potential for finding a range of integration practices.

Location.

To facilitate the multiple visitations needed for data collection, the middle school had to be located within 50 miles of the researcher. That distance allowed for multiple visits over the course of one year.

Nominations from Technology Leaders.

The final selection criterion was used to validate the relative success of potential schools in implementing a one-to-one program. A list of schools meeting the above criteria was shared with three state-wide leaders of technology. They were asked to rank the schools from most innovative to least innovative in their integration of technology.

Many aspects of schools can influence the successful implementation of one-to-one computing that may not be captured in the criteria listed above. Leadership and professional development opportunities are two examples. Screening the potential sites

with the perspectives of statewide technology leaders helped ensure that the site chosen was most likely to provide a range of integration approaches and applications. The school chosen was based on the highest average ranking from those statewide leaders.

The site chosen was located in southern Maine. The school had a population of 493 students and 75 staff members. The school was among the top five schools as rated by the MEPRI study and nominations from technology leaders. The site has also been recognized eight times by a national technology company for its integration of technology.

Participant Selection

School leaders, principals, technology coordinators, and directors were interviewed initially after site selection. The interview focused on the nature of technology integration supported by their personal visions, the school's vision, and professional development opportunities provided by the school. In addition, the interviews focused on the nature of the change process that has occurred within the middle school. Finally, the initial interview was used to confirm the selection of teachers for interviewing. A second post-study interview was conducted with the technology director after the teacher interviews were completed. That interview was used to revisit the themes and outcomes identified in the teacher interviews, and to follow up on any questions raised from the teacher interviews about the process undertaken at the middle school.

Participants were chosen purposively based upon the results of the initial survey of teachers in the middle school. This study employed a survey instrument designed to assess a teacher's presence on Rogers' adoption spectrum. The survey contained items

developed by Sahin and Thompson (2006) for classifying the faculty according to Rogers' (2003) adopter categories, and their attitudes towards the attributes of innovations. The initial survey was used as described below for the selection of teachers as participants.

The choice of individual teachers to be interviewed was purposive and designed to find teachers across Rogers' (2003) adoption spectrum. Three criteria were used to select participants; the length of time that they participated in the MLTI deployment; their adopter status according to Rogers' framework; and their subject or content area. The initial survey was given to all seventh and eighth grade teachers (See Appendix A) to collect basic demographic data, teaching areas, willingness to participate in the individual interviews, and identification along Rogers' (2003) adoption spectrum.

Staff were classified along the adoption spectrum based upon their responses to the survey instrument's items on Rogers' adoption categories and characteristics (see Figure 2 for the sampling procedure). Those assessments were confirmed with administrators (principal and technology coordinator) within the building before a selection was made. Four teachers were chosen in each group (early and late adopters). Two teachers were chosen from the same content areas of English, mathematics, science, and social studies. All else being equal, participants were chosen from those with the longest experience participating in the MLTI deployment. Length of service ensured that the participants had had adequate opportunities to implement technology integration into their practices, and were more likely to be reflective about their integration practices.

Eight teachers and three administrators were chosen for the study. Four teachers were chosen from the seventh-grade team: two teachers of math, science, social studies,

and English Language Arts (ELA). Four teachers were chosen from the eighth grade: two teachers of math, science, social studies, and ELA. (Teachers at the study site each teach two content areas, and are teamed with another teacher teaching the other two content areas.) The teams share the same cohort of students. The seventh and eighth grades each have three teams. No attempt was made to be sure that teachers chosen came from the same team, or that all teams at each grade level were represented. The administrators chosen were the technology director, principal, and assistant principal.

In all cases, the methods, questions, and approaches used in the study were submitted to and approved by the University of Southern Maine's Institutional Review Board. Participants were provided with a study description, a letter describing the steps taken to ensure confidentiality, any risks associated with the study and to obtain informed consent. (Those documents are provided in Appendices A and B.)

Data Sources and Collection

The primary sources of data used to investigate the research questions in this study were individual interviews of building leaders and teachers, and document analysis. The data were collected between October and April of the 2014-2015 school year. The structure and rationale for the interviews is described below.

Interviews.

All three research questions were investigated using in-depth interviews of building leaders and eight key participants. A series of semi-structured interviews in the manner described by Seidman (2013) was undertaken. Interviews for each participant occurred over a four-week period to minimize the potential of losing a connection between each interview, but provide enough time to review and consider the participants'

responses as recommended by Seidman (2013). Each interview was kept to less than ninety minutes, with most taking from 60 to 75 minutes. Three individual interviews were conducted with all participants focusing on the following major themes:

- their teaching philosophies and beliefs about student learning.
- their history of technology integration over the implementation of the MLTI project.
- the impact(s) of the one-to-one implementation on their practice.
- the factors that supported and inhibited their technology integration in their classrooms.
- description(s) of how their understanding of technology integration has changed
- description(s) of one artifact that captures their best integration of technology in their practices.

Interviewing was chosen as the primary research tool because it focuses on the experiences of participants, and the meaning they ascribe to those experiences (Seidman, 2013). The approach advanced by Seidman is phenomenological in nature, focusing on understanding the experiences of the participant. The purpose of this research was to describe the impact of the MLTI program on teachers' practice from their perspective. The strength of that approach lies in the contextualization of the experience from the point of view of the participant (Seidman, 2013). Using Seidman's three interview series, the study will organize the interviews to address the following (See Appendix C for the question used.)

Interview 1: Focused Life History.

Participants were asked about their experiences over the lifetime of the MLTI deployment, their initial difficulties, successes, obstacles and supports. They were also asked to share their uses of technology before the implementation of MLTI. Participants were encouraged to share their perspectives on how their use of technology has changed during the deployment. Participants were also asked to describe their current and past pedagogy and practice to assess their pedagogical and content knowledge.

Interview 2: The Details of the Experience.

Participants were asked to describe their current use and integration of technology in their classrooms. They were asked to share and describe an example (artifact) of technology integration in their classrooms that they found successful. The use of an exemplar of technology integration served to focus the interview on the salient points each teacher found in the product. The identification of a teacher's TPACK understanding was illuminated by the examination and description in the teacher's own words of each teaching artifact. A focus on obtaining the details of their integration facilitated answering the third research question: in what ways have teachers' TPACK changed or matured?

Interview 3: Reflection on Meaning.

Participants were encouraged to reflect on the meaning of technology integration in their practices as educators. Participants were asked to describe why they have implemented and used technology in their classrooms in the manner they had identified in previous interviews. An introduction to the TPACK framework was shared with the participants to facilitate their insight and reflection on their practices, with the hope that

the framework would provide them with another opportunity to recognize its impact on their practice.

Administrator Interviews.

All three building level administrators were interviewed once using the questions found in Appendix B. Administrators were interviewed to understand their roles in establishing the school's vision and goals around technology integration, the type of professional development provided to staff to support technology integration, and the types of technology use they undertake in their jobs.

Data Analysis and Interpretation

Data were analyzed continuously. Each participant's interviews were analyzed separately, and then themes were developed and reviewed for similarities across each participant's interviews. Finally, as Seidman (2013) recommends where a participant's interviews supported the development, profiles, as described below were developed to help in coming to know the participants' stories. After all interviews and analysis, six of the original eight teacher participants were chosen for the development of profiles. Those six participants provided unique experiences that contributed to an understanding of the research questions. Two of the participants provided minimal unique insight to the use of technology by teachers at the chosen site. The goal of data analysis as described by Merriam (2009) was to make sense out of the data by "consolidating, reducing, and interpreting what people have said and what the researcher has seen and read" (p.176). Interviews were recorded and transcribed verbatim for each participant. An open coding system was used.

An emergent design was employed to identify codes and categories. Although Seidman (2013) encourages a limited amount of analysis within the three-part interview model described above, the benefits noted by Merriam (2009) and Creswell (2007) for analyzing data simultaneously with data collection were employed. Data analysis during collection provided for a focus in future data collection that maximized the possibility that the collected data will be "parsimonious and illuminating" (Merriam, 2009, p.171).

Passages from the transcripts were coded for tentative categories. After the completion of coding and categorizing, the passages were collected into multi-participant categories organized by category. Initial codes and categories were reviewed against emerging codes and categories in an iterative process to obtain final categories that "have a life of their own apart from the data from which they came" (Merriam, 209, p.181). The construction of those categories had the following characteristics: they were responsive to the research questions posed above, exhaustive, mutually exclusive and conceptually congruent as described by Merriam (2009).

Those categories were analyzed and reviewed for significant observations and winnowed and consolidated looking for insights about a participant's experiences and understanding of technology integration. As Seidman (2013) suggests, that was a dialectical process between the participant's words and the researcher's own responses based on intuition and prior knowledge. Selecting the passages as significant was a function of repetition. Did the same ideas and thoughts show up multiple times, of commonality? Did several participants share the same insight, of connection to the literature base, or because they were unique, strikingly expressed or contradictory to the bulk of most of the participants other experiences? The researcher then sought

connections between those selected passages, and presented more general themes that emerged from the participants' experiences.

That dialogue between the participants' own words and the researcher's understandings were focused through the lens of TPACK as a framework for developing insight into why teachers integrate technology. The choice to adopt or not may be made for many reasons--content specific, pedagogical, or technical. The TPACK framework allowed the researcher to probe participants' responses for an understanding of what factors contributed to a teacher's choices of technology to integrate.

The framework may be most useful in understanding why some teachers have undertaken little adoption or change in their practice as a result of participation in the MLTI program. When exposed to a possible practice involving technology do they fail to adopt because they do not understand the pedagogical value, the application to their content area, or do they struggle with the technology itself? If it is not any of these, that too may be of value in developing an understanding of why technology integration is another example of the difficulty of changing practice, similar to other initiatives in education.

Several authors speak to the importance of articulating how categories are determined and constructed. Seidman (2013) notes that despite the best efforts of qualitative researchers to be responsive to the words of their participants, the process of categorizing cannot be divorced from the predispositions of the researcher. Seidman (2013) notes three predispositions in the analysis of data: a focus on passages that connect with other passages or the theoretical literature; passages that are told in a striking manner; or passages that are contradictory. Guba and Lincoln (1981) suggest

four guidelines for developing categories; the frequency with which something arises in the data, the audience who will evaluate the research has expectations of what is credible or not in describing a category, the uniqueness of the category, and categories that suggest new areas of inquiry. These guidelines were utilized in the construction of categories in this study. The issue of researcher bias and predisposition in the construction of categories is discussed in the section on “Trustworthiness.”

A second analysis was undertaken in an attempt to craft a “profile” as described by Seidman (2013). Seidman (2013) notes that not all interviews will support the development of a profile as a method of sharing interview data. As recommended by Seidman (2013), those interviews that are compelling enough to be shared as a narrative that has a beginning, middle, and end, lend themselves to presentation as a profile. Those stories allowed the researcher to provide a fuller context and understanding of the participants’ intentions and meanings that is different from the analysis undertaken above in searching for thematic connections between and across a participant’s interviews. As described by Seidman (2013), a profile in the words of a participant is the research product most consistent with the process of interviewing. That narrative, or story, is both the participant’s and the researcher’s. It is in the words of the participant, but it is crafted by the researcher winnowing and selecting the words of the participant to share what has been learned by the researcher during the interviews.

To construct those profiles, the researcher took the passages coded and identified as significant for a participant, and combined them into a single transcript. That transcript was then reduced and analyzed for those passages that are the most interesting and compelling. The passages were then combined into a single narrative, in the participant’s

words. Any words added by the researcher to facilitate transitions or clarity were clearly marked and bracketed.

An initial description of the study site, participants and setting was developed to contextualize the data collected during the study. That information included the demographics of the middle school, the teaching staff, students, and community. Descriptions of the participants' backgrounds, experience, and ages were also included in the study. Those descriptions were coded and used as described below to organize and sort the data collected throughout the study. A range of participants, early and late adopters, was interviewed across several disciplines. To facilitate later analysis and interpretation, the data were used to organize the passages selected in the development of categories and themes, as well as in the crafting of profiles. A participant's adopter status, content area, and demographics were used in looking for categories and themes. In addition, common categories and themes across all or most participants were also sought during the analysis.

After transcription of the interviews, and research notes, a computer-assisted qualitative data analysis software (CAQDAS) package was used for open and axial coding and the development of categories. Demographic data collected in the initial survey, as well as notes and memos, were combined with the coded transcripts in the CAQDAS to assist in identifying and testing both initial and final categories for understandings of the possible differences between early and late adopters, or those with differing understandings of TPACK.

Once the thematic and profile analysis were complete, the researcher undertook interpretation of the experiences of the participants. In that final step, the researcher

shares what has been learned from the participants' interviews. An attempt is made to describe where the participants' experiences are reflected within the larger literature, and what those experiences mean to the researcher based upon his own experiences, preconceived notions, and understanding of the larger literature.

Trustworthiness

Issues of validity and reliability must be carefully addressed in the qualitative paradigm (Creswell, 2007). In general, validity issues are more significant in qualitative research than are issues of reliability (Merriam, 2009). The nature of human interaction and behavior makes the repeatability of a study unlikely. Lincoln and Guba (1985) address those issues using the evaluative criteria of trustworthiness. Here the question for a reader and researcher is whether the results are consistent with data collected. They maintain that the researcher must meet four criteria:

- *Credibility*: demonstrating confidence in the truth of the findings.
- *Transferability*: demonstrating that the findings have applicability in other contexts.
- *Dependability*: demonstrating that the findings are consistent and could be repeated.
- C*onfirmability*: demonstrating that the findings are shaped by the respondents and not researcher bias, motivation, or interest.

In this study the following procedures were undertaken to strengthen and assure the trustworthiness of the categories and findings.

- *Triangulation*. In this study triangulation was assured by the number of interviews undertaken. Multiple participants were interviewed multiple times over time. Those multiple perspectives validate categories that emerge across the participants.

- *Member checks*. Merriam (2009) defines member checks or respondent validation as the solicitation of feedback on emerging findings from participants. In this study, the emerging and categories and themes were taken back to participants for confirmation and accuracy. The emerging categories were shared as they were identified at the end of the second and third interviews with participants.

- *Rich, thick descriptions*. Merriam (2009) defines rich, thick descriptions as a “description of the setting and participants of the study, as well as a detailed description of the findings with adequate evidence presented in the form of quotes” (p.227). Lincoln and Guba (1985) note that transferability is enhanced by rich, thick description. The use of quotes, detailed descriptions of setting, and multiple perspectives bring a realism and transferability to the analysis and interpretation of the study.

- *Researcher narrative*. As defined by Merriam (2009), reflexivity is the identification of a researcher’s bias, dispositions and assumptions regarding the research to be undertaken. A self-reflection on the researcher’s experiences, beliefs, and interests in this study is provided to allow the reader to understand the stance of the researcher and the potential bias brought to the study. That reflection will also identify any predispositions in selecting categories that the researcher found in his analysis.

- *Discrepant information*. The study reports significant information not supporting the major themes and findings of the study. The discussion of each theme notes any non-confirmatory information found in the study.

Other strategies were used to provide trustworthiness. The descriptions of the setting, participants, and the manner of their selection, are detailed and transparent to provide the reader with enough information to decide on issues of credibility and transferability to individual settings and experiences. How closely the findings align with reality is served by the data that are presented, which in turn is supported by the concept of rich and thick descriptions. But as Merriam (2009) notes, reality is holistic, multidimensional and ever changing, thus no final determination of validity can be made. It remains the reader's job to evaluate the validity of the findings.

Limitations

The study focused on a single middle school in Maine. That choice was to facilitate the understanding of the MLTI deployment from the perspective of individual teachers. Several studies of Maine's MLTI deployment have focused on statewide implementation features (Silvernail, 2011; Silvernail and Gritter, 2005; Silvernail and Buffington (2009)). Fewer studies have captured the impact on teachers' pedagogical practice in their own words (Garthwait & Weller, 2005) and none over the second half of MLTI's lifespan. Choosing to focus on cases from one school allowed the researcher to capture in detail teachers' perspectives and understandings.

The study also focused only upon a middle school that has deployed Apple laptops throughout its involvement in the MLTI project. Several schools have shifted from the initial configuration of Apple laptops to tablets or PCs over the last deployment. Such a shift brings with it a number of challenges that may alter the use of technology in teachers' practices. This study sought to understand the impact of the long-term effect of

MLTI on teachers' practice. For that reason, middle schools that have shifted platforms during the 2013 deployment were excluded from the study.

The study sought to understand the changes in teachers' practice in their own words. There are in any school a wide variety of adopters of technology, and this study describes the changes in practice for both early and late adopters. No attempt was made to delineate among all of Rogers' adoption categories because of the difficulty of classifying adopters across multiple uses of technology in the MLTI project. In many ways, the MLTI project is tens of innovations rolled into one deployment, some of which are adopted early and some late by an individual educator. The "protean" (Papert, 1980) nature of technology use makes fine-grained distinctions between adopter categories less valuable.

Not all researchers support the use of CAQDAS packages for the construction of categories and the development of themes. Creswell (2007) notes that a computer can distance a researcher from the data. Seidman (2013) mentions the possibility of the "coding trap," or over coding the text because of the ease with which it may be done, at the expense of thoughtful reflection on the importance of a bit of text. He also notes that in his experience there is a qualitative difference between reading on the screen and reading from paper, and the response that a researcher has to words in the two mediums (Seidman, 2013).

The study focused on just one school and only eight middle school teachers. Those delimitations impact the transferability and generalizability of the results. Obtaining in-depth descriptions and narratives from individual participants occurs at the expense of generalizability. Generalizability is further hampered by the focus on the

middle-school level. Pedagogical choices, teaching philosophy, and curricular focuses may be very different for middle-school teachers relative to those at other levels of education. Finally, by focusing on a school that has used laptops throughout its deployment, there may be less transferability to schools using other device configurations such as tablets.

Researcher Role

The researcher in this study has overseen several one-to-one technology deployments in Maine schools for more than10 years. As an administrator at the district level, the researcher has supported with time, school resources, and professional development the integration of technology across grades K-12. The researcher was also a teacher for over ten years in a school that integrated technology in both cart models and one-to-one models. The researcher has also provided direct instruction and professional development around technology integration to teachers and administrators. The researcher believes that technology can provide opportunities to fundamentally change both how teachers teach and students learn.

Chapter 4: Teachers' Percetions of MLTI's Impact On Their Practices

This chapter analyzes the results of teacher interviews around two research questions in this study. They are:

1. How do teachers in a successful school participating in the Maine Learning Technology Initiative describe the impact on their practices?
2. In what ways, and how, do teachers describe their evolving understandings of technological pedagogical-content understandings in a successful school's participation in a one-to-one technology environment?

Six participants were profiled from the 11 participants in the study. Those participants represent teachers from across the adoption spectrum at Walden Middle School. Logan Ackerman and Evan Reed could be described as Early Adopters by the characteristics identified by Rogers' in Diffusion of Innovation (Rogers, 2003). Matt Doyle and Lauren Maddox are members of the Early Majority, while Sharon Bishop and Daniel Gallagher Late Majority (Rogers, 2003). No participant could be described as a Laggard or Innovator. (Teachers not chosen to be profiled were also members of the early and late majority.)

In this chapter participants' words were consolidated and developed into profiles as described by Seidman (2013). The profiles are structured into three sections. The first section, pedagogical stance, provides examples of the core beliefs and philosophy each of the teachers holds about teaching and learning. Many researchers have noted the importance of a teacher's pedagogical stance on his or her adoption and use of technology (Silvernail, 2011; Beaudry, 2004; Drayton et al. 2010; Gauci, 2009). The

second section, TPACK in the classroom, looks at each teacher's actual integration of technology with examples from their practices. The final section provides examples of the changes in practice identified by the participants as they became more facile with technology integration.

The profiles are representative of the range of practices and integration illustrated by the participants in the study. The profiles are intended to illustrate pedagogical and content knowledge, and in what ways the teachers describe that knowledge. They provide a fuller picture of the intersection of the three domains of knowledge than snapshots, quotes, and descriptions from all participants.

Early Adopters

Rogers (2003) identifies respect as a description for Early Adopters. Those members of a social network have a high degree of opinion leadership and are looked to by potential adopters for advice and information about an innovation (Rogers, 2003). They decrease uncertainty for later adopters because of their successful adoption and willingness to share. Capable of dealing with uncertainty and willing to accept setbacks, these members of a social network bring significant knowledge to the problem being addressed. Two participants illustrated this level of technology integration in a school setting.

Logan Ackerman.

Logan Ackerman is a mid-career teacher who has been at Walden Middle School for seven years of his 14-year career. He is a graduate of Hobart College with a major in psychology and a minor in biochemistry. He has a master's degree from the Extended

Teacher Education Program at the University of Southern Maine. A Milliken Teacher Scholar, Logan teaches seventh-grade math and science.

Pedagogical Stance.

Logan's passion for teaching with technology is motivated by his desire for creativity. He speaks often about technology's ability to allow teachers and students to be creative.

> "But I do believe that with that [laptop], is a creative side of me that would come with using technology. And I think the neat thing about it is that you can shape your classroom that way. I think, as any teacher we want to be creative. Actually it was a poet that came here to an ELA class once and he said, by nature, humans want to be able to create things and, and leave their mark. Whether it's a painter making a painting, whether it's a sculptor, whether it's a builder, you know. And I guess that would be my mark as a teacher to say, hey, no one's done this before, let's try this kind of thing. And, then where is it going to take me? How am I going to leave my mark? After teaching so many years, how am I going to have a kid come back and say oh, that was so awesome Mr. Ackerman, what we did here? … I mean, the creative piece of maybe I can take this technology and be the first person to use it."

He sees creativity as an important motivator for students also. "They're [students] always going to be excited by technology. To give them that excitement and choice and allow them to take that to a creative side is huge."

His use of technology in the classroom is strongly influenced by his belief that student engagement is required for learning.

> “The driving piece is saying, what's going to engage these kids? … What's going to hold their interests, what's going to make them remember? Because I think that's, in the end, it's one of our jobs. It's moving from that short-term memory to that long-term memory and interest is obviously a big part of that.”

He ties his beliefs about creativity, differentiation, and engagement together when discussing his use of technology in the classroom.

> “But also, for educators I think it gives us a realm of creativity. It gives us another way to teach students, where I might increase engagement. It might give us another way to possibly reach some of those lower students and give extensions to the upper students and it evens the playing field sometimes too.”

Logan also views technology as supportive of his constructivist beliefs about learning.

> “That’s one of my philosophies that middle school should not be just something that they sit and get. I would hope they [his students] would say that they do the science. It’s not done for them or to them. I make connections to the community. I collaborate and bring people into the classroom, in almost every single unit we have someone from the community who’s coming in from outside. It makes the science real. It makes the math real.”

Logan also takes his students out into the real world to undertake projects. His students have recently completed a project on invasive species in the coastal region near the school.

The use of technology also provides coherence and equal access to curriculum and instruction. Logan shares a blog with fellow seventh-grade math and science teachers that each uses to deliver content, and provide access to instructional materials. “We want common experiences and consistency. Those are two big things that we want for all students.” That common experience and access is driven by the collaboration and sharing of resources and a web presence across classrooms with other teachers.

> “Jay Harrington and I, and before that, Mark McDonough and I, create project pages. And we used shared sites. So, when we talk about consistency over seventh grade, all the kids are getting the same content, they're doing the same projects, they're getting graded the same way. … Both Chris [another seventh-grade teacher] and I are using the same page, are able to populate it the same way and the kids are able to access it. And when they access it, they can access rubrics, product descriptors, links, and student exemplars. And I think we even have, RSS feeds there too for certain things.”

Other pedagogical considerations for Logan are differentiation and providing multiple access points to learning.

> “Actually technology helps us with this [differentiation]. If some kids are able to test out of a lesson, then there's also an extension given to them. And they will be able to take that on and learn further from it. It's not just like, do 20 more of these problems. I hope there's that choice that is allowed too. Definitely giving kids choice because they're going to have more of an investment in the actual education. I always try to do a couple different things that are going to hit on the different-level learners, the different modes of intelligences. And, and try to sort

> of mix it up a little bit. We try to keep them moving. So, you know, they could draw a card and change seats. We might do, you know, another day we might do more of a cafe style thing where they're going to have sheets of paper. They might have to answer a question on it, then rotate, look at someone else's answer, agree, disagree, add if they need to."

Over the course of his three interviews, Logan referenced a project that is done in biology on cell mitosis. At one point he notes the importance of involving movement it in developing student understanding of the process.

> "There is also that kinesthetic piece. And I don't think you can take that away. That's the one thing that I find is lacking when using technology. So, taking mitosis again, which is a microscopic thing that happens, and being able to actually move those things around the page and show the different stages. I guess the big misconception is that they're frozen in time. They're not frozen in time, you know, it's actually a sequence from one to the other. What changes from this one to this one, and that's what I really want them to get out of it by moving those things."

Later he described the evolution of this project over time, illustrating his growing TPACK understanding.

> "…newest things we're using right now are they're going to take a Google Doc and they're going to look at mitosis in cells. They're going to have a laminate in front of them and they're going to use pipe cleaners too and this is where I still like the hands-on, kinesthetic [Laughter] piece. … So they'll do a hands-on piece of actually you know taking the pipe cleaners and making the chromosomes.

They'll take a picture of it with their computer and drag that picture to the Google Doc so that they have a stage for each one of them. Then slowly they'll move the chromosomes apart as it replicates and makes the two cells and so they'll move through the different stages. They capture a picture at different points and add to the Google Doc.

What we're actually asking them to do this year is to go and find a real picture, so whether it's an onion root or it's a round worm you know going through the similar steps, but to take a picture of that and drag that into the document. Then they have to take a digital photo, so now they're making a comparison of three different ways of representing mitosis. … And so they have three of those things so they have their photo they just made, they have the actual photo a scientist took, and they have a digital photo created by a computer-generated photo made by someone online. And they're able to look at that and make comparisons of each. What are the similarities, what are the differences here? What is it still showing in each one of these photos? It actually gets at that understanding that it doesn't look just one way. …So they're getting at what those different things are as they go through the different steps of that, and finding out the similarities and differences. And they're populating this Google Doc. And then they can immediately share it with their partner. In ELA they might be sharing it for many purposes. We're actually sharing it as lab groups, where they can continue to do their work on it. And if one kid changes it, you know the other student gets to see the changes that that kid made and can comment on it."

His original assignment involving the use of pipe cleaners and movement to convey a process that occurs over time has been updated to include technology to capture multiple representations (three different views) of the process and to ask students to reflect on their similarities and differences while collaborating digitally with one another.

TPACK in the Classroom.

The intersection of the pedagogical and technological domains in Logan's practice affects teacher, student, and parent understandings. Logan speaks of opening his classroom up, and transparency. He points to the needs of parents to be active partners in student learning;

> "So, you know, if they miss something in class, they're expected to check the blog and the notes are going to be there. It might be a movie to help them out. It's going to be there. And, I would say that parents overwhelmingly have been open to that, too. I mean they really want to see what their kids are learning, to have those conversations with their kids. We hear it, they definitely, you know, show it in different kinds of surveys and forms that I put out there to parents."

He uses his blog for many aspects of his teaching, but his appreciation of the technological-pedagogical implications for parents is important to him.

> "I would say probably one of the major things that I'm seeing with the technology piece is through my day-to-day blog and my teacher page. We've really jumped into using technology, as a way to see into our classrooms, and I think that's one of the most important things. One of the things that parents noted was to be able to communicate with us, find out what the homework is, and find out how to help them study. And we found that we can do all of that on our day-

to-day blog whether it's taking pictures, posting notes, review guides, or extension videos. Posting even like PDFs of readings, that they can look into so it's all there, and it's all possible because of the technology, because the kids have these [computers] one-to-one, because they're able to take it home. [Laughter] With paper and pencil, I mean, really you wouldn't be able to."

He gives thought to how the use of a blog enables a more effective method to communicate with parents.

"So you always talk about technology-wise, you want to always take the least number of clicks to get to what you need to do. So, once they go to my page, they click once on math or science, and it opens up the blog, you know, some of them have even bookmarked it. Or, like I said, they've subscribed to it, so they receive an e-mail update every time I update it. They get sent an email so they can see exactly what the most current piece is. That's the neat thing. I could send these things home. I could send out a weekly update of what's going on, but it's not the same, you know. It's not the same, the technology has changed it."

Just making the assignments and tutorials available was not sufficient in his classroom. He took advantage of several best practices, reducing the number of clicks to find relevant information, and providing parents an opportunity to have updates pushed to them via RSS feeds. Parents who subscribe to the blog do not have to even visit his web page to see what is new. They are informed directly. Students also take advantage of that push notification. Parents who are interested in supporting their students can find detailed information on the major products in his classroom.

> "And when they access it, they can access rubrics, product descriptors, links, and student exemplars. So parents know what those big projects are ahead of time, they have timelines. They have their own calendars to them. We even put countdown days on it sometimes."

When discussing his own lesson planning and preparation, he notes several instances where his technological knowledge and pedagogical knowledge intersect. Teams and departments are provided common planning time several times a week. One of the outcomes from that practice is an awareness of where technology fits into teaching and student learning. "When we sit down for a unit, that's one of the things, that we sort of look at. It's not an expectation in the sense that you have to do that. But there's always that piece of how might you integrate." He takes advantage of the ease of storage and retrieval when planning from year to year.

> "And I can look at past blogs, you know, from year to year, and it's not that I have to create them new. I look at the links, see if they're updated and then you can repost, you know, kind of notes and stuff like that. So it's an easy way to do it once you get started and once you know how to retrieve."

At other times, Logan takes advantage of the technological tools available to facilitate his instruction and connection to students.

> "If I'm out, often some of the assignments will be virtual to them. It might be a Google form asking them to answer these questions and I can check up on them. And they always are blown away, if I have a sick kid at home, by me you know, popping over and chatting with them as I see them online, you know, on

some document [Laughter] or something like that. They're like checking in by Big Brother." If students are out there is the same connectedness.

"But I would say overall the student's use definitely includes more than homework on it. And as I said before I think, you know, 99 percent of our kids have access to the Internet. So it's almost an expectation that they will check the homework calendar, they'll check the blog."

The school day is lengthened by the use of these tools, and what might be a lost day due to teacher or student absences can be recaptured in part.

Technology supports Logan's assessment practices in several ways that illustrate the intersection of pedagogical and technological domains. Both summative and formative uses are found throughout his comments.

"Formatively, it could be an entry slip or it could be an exit slip. Just today I gave an exit slip that was a Google form the kids had to do before they leave. I'll check those out tonight. I might pull like three or four of them to begin the class tomorrow and just say, okay, here are four responses. What can we say about these kinds of things? Are there things that are similar here, things that are different? Does everyone have the same idea here? I think that provides ability for kids to see other people's comments and also respond to other people's comments."

Logan also uses several polling software products to check student understanding in the moment. One such application, Kahoot is used to ask quick questions, which are collated and displayed instantly to the class. Logan describes this as "dip-sticking" to check on where the students are relative to the day's content. The anonymous nature of

the responses, and the ability to see other responses reported graphically allows for instant feedback to Logan, while ensuring that all student understandings are represented.

> "I also give some entry slips sometimes. Mostly, I find those more helpful in math. The way that Matt and I will use those is as a form of assessment at the beginning of class. What they will do is allow us to differentiate in class that day. So it might be ten questions. If you get them all right or one wrong, you're going to be a one. If you got, you know, this next set you might be two. Next set, you know, if you got five or more wrong you're number three. So, ones you're going to go onto this sort of extension piece or maybe more of a challenge problem. Twos, you're going to go over here. I'll check in with you quick, but for a minute you're going to need to do some of these problems, not all of them. And then threes, we're really working together here. To get where we need to be. I find that works best in math. The best thing that I've seen is that differentiation that we can really do in math."

The technology is used to quickly determine groupings at the beginning of a class period. Again, the technology facilitates the differentiation that is the hallmark of best practices. Another use of formative assessment more fully illustrates the intersection of all three domains (technological, pedagogical, and content knowledge).

> "We've have also used a series of probes to uncover misconceptions. I've used a couple different probes. There's one sort of science probe that we were using a digital model of that's out of the National Science Teachers' Association that really sort of looked at questioning of students. So it was more of a formative assessment and the way we sort of looked at those is we're creating documents

> that kids are taking and then, we really get a good sense of the temperature by their response. And we're using Google forms in a way to be able to quickly record, look at answers, see that the best answer looks like and then be able to just peruse the Google form and see where the students are and where they fall. Do they need a little extra work? Are they ready to move on? And that sort of comes back to our practice."

The probes he described are scientifically developed to uncover well-documented student misconceptions around science topics. Summative uses of assessment are also present in Logan's practice.

> "We usually try to link at least one project per unit so kids have an ability to show their learning. A lot of that stuff is technology driven. Could be PowerPoint or Keynote. And so they might do a presentation from that. They could do a freeze time movie. We've done those for the cell cycle; some kids have done some sort of board game type stuff. The projects are very vast. And again, that allows for choice, which is kind of nice. So we've done those assessments online. So we might give an article on reintroduction of wolves to Yellowstone for example and have a video and have a written article and what they might have to do is compare and contrast. What are the two differences that you see in these two things? What were the views of the writer and the view of the person who made this video? And you know can you supply specific examples for me to support your findings?"

Typical projects or demonstrations of learning using technology are found, but also fairly sophisticated examples of teaching about point of view. Students today are

often seeking information from a variety of media: print, video, podcasts or webpages. Asking students to analyze the point of view of authors using various mediums prepares them for the world as it is today.

Finally, Logan and his colleagues are using video to support student learning, illustrating another aspect of the intersection between the technological and pedagogical domains. Those videos are created by students and teachers. The use of student-created videos supports the development of understanding and the uncovering of misconceptions. Logan describes how asking students to record their solving of math problems on an iPad achieves both outcomes.

> "And the tablet was nice for math as well when it was recording them because they had to talk through the problem as they did it as well. And so more and more, in math, you're having to talk through the problem describing their solution. So being able to listen to yourself, and saying I didn't explain that very well, you know. You'll get the upper-end kids, who won't explain it well, or they'll be like, did I just mess up a vocab word there. They'll catch themselves on those kinds of things. In math we've actually uncovered many misconceptions that way too. So, they're going through the problem and you sort of listen to it and they listen to themselves, and they're like wait a second that's not right. And so then they fix it and they film it again and then you can fix that misconception."

Video is used for other purposes too. Logan will record videos explaining some concept or solution process, and post the video to his blog. In other cases, he has posted links to video available online from sources such as Kahn Academy.

"One of the other neat things that we found that we've been using is us creating video for the kids who are not as quick to pick up stuff. The slower processors in our classroom, who aren't going to get it the first time, can watch it at their own speed, and that's a really neat thing that we saw when we started creating videos with our iPads. Kids can stop it, rewind it, hear it again and do those different pieces. And I think it does scaffold. I mean it scaffolds the process. And they can watch it as many times as they want to as well. So some of those learners that need to get it three times previously in your classroom would get it once. Then you have to sort of go find them because they're middle school kids they don't want to speak up. You have to notice that they haven't started their homework because they don't know what's going on. You have to give it to them again. With a video online they could have watched it two or three times. We've also supplied stuff on the blog when we can't create those videos. We've used Khan Academy or we've used some other ones and say, hey, check out some of these other places. They might do it a different way, see if you get that, you know, because math isn't just done one way."

Logan also mentions how these types of quick videos help many students who often return home to realize that they didn't understand the day's lesson as thoroughly as they thought.

Video is used in other ways that illustrate the intersection of all three domains of knowledge. Student use of video to trace the movement of blood through the heart, for example, allows students to illustrate their understandings of this dynamic process.

> “We also have kids create videos. We use it actually a lot during our body systems unit. How do these different structures do certain functions, and what do they do. So we'll take a picture and then the kids will actually trace it, they'll film themselves, as they do it, so we've used EduCreation, we’ve used Explain Everything. You are taping yourself and animating the actual page itself.”

The use of video to “flip” his classroom is another example of the intersection of all three domains in Logan’s practice. In a flipped classroom, the instruction is delivered as homework, while the practice and application occur the next day in the classroom with the teacher.

> “Matt and I have done some flipped classroom stuff and we actually brought that around to science too. So, science got into it as well, when Mark McDonough was here with us. And so what we've done in the past for a couple of those flipped things is that we'll structure a lesson and give them something that they would preview the night before. And we'd put that up on the blogs and the video would be put up onto the blog. And that sort of gives them a heads up of what's coming. And then sometimes we'll do a quick formative piece right when they get into class. Did they actually get this or not? If they did, boom. You're right onto the application of the concepts. If not, then right onto some problem that we can be in the room helping you out with. Today in education math is taught a little bit different than some parents understand. The way we teach math is a little bit different. And parents honestly say, at every single meeting, we can't always help our kids. So why not have that homework piece be more applied in the classroom. And the instruction piece is watching at home. And with the one-

> to-one, it is a possibility. And with blogs it's a possibility. And with filming you know, some of the stuff we can do, it's a possibility now."

Recording the instruction and posting it to his blog, allows Logan to facilitate the practice of concepts, preventing frustration or the development of misconceptions or procedural mistakes. Using quick check ins, also delivered by technology, at the beginning of class is one way Logan insures that students are watching the instruction at home. Again, an awareness of parent needs is illustrated in his approach.

Other applications in Logan's class illustrate the opportunity to use technology to accomplish goals that reflect good pedagogy, and align with Logan's philosophy. Not all those uses translate across disciplines, and in several areas of Logan's science-practices his integration of technology has allowed Logan to accomplish goals not possible in the past. In one example students are using modeling software to understand the impact of changes in an ecosystem.

> "Each kid can do their own simulation. So, instead of me doing the science for them and giving the answers, they're doing the science, they're making the changes, they're seeing the tweaks and, and they're actually seeing the difference in the population. So, it's a really cool program in the sense they're doing the science, they're extrapolating the data, they're seeing what the impact is and the change in the population versus me giving it to them. And that's the way I want to teach it, you know, that's the way I want the science to happen. And then from that we can ask the question in the state of Maine if you're a game fisherman, would it be advantageous to you to actually introduce a pike? Or would that be a detriment to a lake."

One aspect of pedagogy in a technology-rich classroom is to understand when it does not support the student-learning outcomes desired. That aspect of TPACK is illustrated in the following description.

> "But not everything lends itself to digital applications. Some of the fraction work I still think it's best to be done right in front of them. Or even geometry stuff with shapes that they can manipulate. They can manipulate shapes on the screen; they can take good photos of it. That might be an okay thing. But when you're coming back to the basics of fractions, they do have, now, drag and drop stuff so you can see the different cubes and stuff. But some of that stuff, I just think there's a different tactile sense of doing it in front of you with block-shaped sets and stuff like that, versus dragging and dropping on a computer.
>
> There are definite things that I feel are better on a whiteboard or a paper and pen you know, or done on graph paper. We actually will not let them use a graphing program until they can set up their own coordinate [LAUGHTER] grid. And plot their points on a coordinate grid, and be able to do it correctly. Because we still want them to be able to go back to that paper/pencil piece, use a ruler. Once they do that, then we'll let them use computer graphing programs and it kind of does it for you and it's that ease of speed that's saving time, you know, after they can show it and do it this way."

That awareness of when to use technology and when it may actually be less effective is an important development in the integration of technology in a one-to-one environment.

Finally, in a technology-rich classroom it is important to reflect on the impacts when technology is used.

> “I think when you push it out to the kids; it's always a trial piece. How is this going to work, or not? You have to look at it. Does it work? You know, you put the sticky on it at the end of the unit saying this worked or, you know, we have to change this for next year and then come back to that when you do your planning the next year.”

There is a constant evolution and revision process built into Logan’s work.

Evolution of TPACK.

Logan’s use of technology has evolved over his years at Walden Middle School. He describes early in his integration of technology a reluctance to allow students the freedom to use their laptops in ways that he had not intended.

> “I'll give you an example of one of our first units is shapes and designs. Well, at first, I sort of was, like, oh no, these kids have to take notes strictly by hand. And I would walk around and I'd say, why is your computer open, why is your computer open? A couple of these students they were on Google Draw, and they were keeping up with the rest of the class doing their notes, you know? And they were like; it's much easier to do these two-dimensional shapes on here, Mr. Ackerman. It's like wow, of course it is, you know?”

He notes that today, he is more spontaneous with the integration of the technology in his classroom. The use of technology as a tool frames the laptops in a manner closer to how the whiteboard or projector are used in classrooms.

> “It's not that way now. I mean it's one of those things that flow effortlessly. It's the ability to have that option if you want to use it, you know, and to incorporate that into your classroom. So I think it's more aligned to your

> practices these days than it was when you first started out. I think it first started out people had the idea that it had to be forced into the curriculum, versus, just to be used as a tool.

He is willing to take cues from his students at the same time. That spontaneity was facilitated by recognition that he had to release some control over the flow of the lessons in his class. “It is one of those things that I think you have to trust too, you have to have trust in the kids.”

In other ways the integration of technology has evolved to include students both creating content and being the experts.

> “The way that I'm using technology now is totally, totally different. Like now, if you ask me what my successes were I would be looking more at how the kids are creating some of this stuff. They are actually creating you know, some of these models. So it's not just going to this website. It's them creating the actual content. We're doing the hour of code this week and the kids are coding their own Scratch games. Some kids are making Pac-Man, you know? Some kids are doing apps that they're actually selling. They are doing this right now in our district, selling them to Apple you know, to take a look at and say, oh this is good, let's go for this, you know? So it's kind of crazy to think that you've come that far in like the course of like 11, 12, 13 years or so.”

That willingness to support kids in their own learning requires not needing to be the “sage on the stage.” Logan notes that he has become comfortable not being the expert.

> "We have to know how to openly monitor kids' work, and then either facilitate or say you might try this. You might go to this. It's okay to say I don't know everything. And I think we learned that early on in MLTI too, that kids are going to be further along than us in a lot of these things. I mean, if you ask me if I were one of the better programmers, I'd say definitely no. [LAUGHTER] In the robotics course, there are certain kids who can do that kind of stuff well."

Logan notes that the modeling program used for population simulations has allowed him to teach in ways not possible only a few years ago. "Now, if you asked me a couple of years ago or ten years ago how I would have done that, I would not have been able to do that without [Laughter] the program." In one example Logan had used online simulations to complete physics labs virtually, in part because the actual tools available to middle-school students were too crude to allow for reliable results. As technology has evolved and become cheaper, he can now use technology-enhanced probes to reliably make the measurements in class.

> "The stuff we have now in the eighth grade, it's fantastic. I mean, they're down, with the laser gate systems, they're down to hundredths of a second and it happens every time, so you get that reassurance of the physics behind the concepts."

In the course of only a few years, Logan moved from using technology (virtual simulations) to illustrate what was not possible in the classroom to actually replacing that technology with probes that allowed the laboratory work to be done in the classroom, not presented as a simulation. Throughout that evolution, the focus remained on providing

students with opportunities to "do" science and develop understandings based on observation.

The adoption of the suite of Google Apps for Education has spurned many in Walden Middle School to explore new ways to integrate technology. It has influenced Logan's practice and the ways he and students communicate and collaborate. Logan has slowly been moving his resources into the cloud.

> "We use Google Docs trying to move fully into the cloud. I still have binders. But the binders that I have are a non-digital step to where we're moving. Jay and I have been doing some great work in actually creating daily calendars. And all our stuff will be linked into it, even a copy of the papers that we're handing out to the kids. They have been added in there so I don't even have to create it the next year. The kids can then go to the blog, they will click on it, they'll make a copy of it, and they'll be ready to go."

As he notes, the use of Google Apps and digital locations for content allows, "kids to access things 24/7." The suite also allows students to more readily collaborate with one another, "whether it's a Google presentation, or if it's a science lab they do together, on Google Docs, or in Sharon's class where they're editing each other's work, it is an amazing piece to access Google Apps in this way." He views the teaching of the use of those resources and approaches as supporting students' executive functioning. "We're teaching them how to organize, it's the executive functioning stuff they still don't know how to do very well. Google Apps helps them."

Logan provided an example of how his evolution is driven by the fast pace of change that is occurring in online tools. As noted above, he is using polling software to

obtain feedback, and provide jumping off points for his lessons. The software he is currently using wasn't the first example he used:

> "I'll tell you there have been some great things that have come in for formative assessment that we started using. And I think we started with Socrative, which was a polling program. And then Get It came out which I think was from New Zealand. And now our favorite actually is a program called Kahoot. So Socrative is one of the ones that we actually have started to drop. We're like, this is pretty good, but this, Kahoots, is better now. You know? And here's the reason why. So we've moved on, you know, as technology moved on. So I'm not afraid to drop stuff as we move forward."

He expects that evolution, and the cycle of adoption and discarding, to continue. However, he has a direction he would like to move towards.

> "I'd still like to go to an almost virtual classroom, you know, where they could access that kind of stuff and really get the material more and more out there. I'd still like the parents to be able to access that, we still get questions around, you know, my, my son or daughter is struggling in this, can I help them in some way?"

Logan has moved further in that direction than any other participant.

Evan Reed.

Evan Reed is a veteran teacher of 18 years. He earned an undergraduate degree in biology and environment, and was environmental consultant before earning a master's degree in education. He has spent his entire educational career at Walden Middle School as an eighth grade science and social studies teacher.

Pedagogical Stance.

He speaks often of the amount of planning time he and his team spend working collaboratively.

> "Right now there are three teams of two in the 8th grade. The three teams will sit down at least once a week typically. More often than not we'll do more than one day a week that we'll use for planning. We look at lessons, upcoming units, and we'll make changes based on each other's ideas. During the week we have four meetings of about 45-50 minutes. One or two will be full 8th grade team meetings, one or two will be content for all science teachers in the middle school or social studies and the other(s) will be between my colleague, teaching mathematics and English. One afternoon a week is ours personally."
>
> "We develop these assessments together and will score them together whenever we build a new one. We'll sit down and look at them, talk about them. We'll say, 'you know this was really good and this was a new idea presented by this kid.'"

Norfolk doesn't have a curriculum coordinator; so content area teachers develop their curriculum together collaboratively.

> "And setting up a process for you know, a timeline for curriculum review. So every so many years a subject would go through this curriculum review, and a committee be formed, from different representatives throughout the district. They sit down together, look at the curriculum, and look at standards and what other schools are doing.

So that happens regularly. Two years ago for science we did that and it happened last year for social studies. Math, I think, is coming up next year. As part of the new science curriculum, it's a physics curriculum that was purchased; we got some great lab equipment. Really state of the art stuff, that's been outstanding. So we definitely changed things but we're still using a lot of stuff to supplement. And we're rewriting everything that they've given us, just to make it more kid friendly."

The teachers' work also extends into their "response to intervention," (RTI) and differentiation.

"We consult with our learning center. So, in my science class I have students with specific plans. And I have a learning center teacher that's with me in both of my classes. And so she does some prep work for them. So she looks at what we have coming up. She'll come to our meetings sometimes. … For this new unit, we just talked about how we were going to modify the assessments for a group of kids. We went through two or three drafts of how the modifications were going to work. To make it so that they are still working hard and being challenged, but it is not overwhelming for them."

That intervention is enacted in his classroom in both formal and informal ways.

"We have an intervention time at the end of the day. And so those kids, who you have for your home room, are allowed to go see other teachers if they've got questions or if it's something that I can help them with they'll stay with me. … There are other teachers in the building providing Gifted and Talented stuff or extension opportunities for them.

Within my classroom, I know there are definitely kids that do not have plans [IEPs or 504 plans] that struggle or are having a tough time. I check in with them often, sometimes they just need to be redirected or give them, you know, a confidence boost. In a lab sometimes they need to be redirected. Or if its, you know, a conversation that a group is having and I can see that that a particular group is struggling or someone is not participating, I'll join the group."

He strives to make everyone responsible for the group's learning.

"And I try to help facilitate, get everybody participating. After a while students undertake some of this. Generally, in Norfolk, one of the things that still amaze me is how nice the kids are to each other. And how much they support each other. So the kids know who is, you know, not as strong a student. And, they, more often than not…offer to help. Some of the kids are still learning how to do this, but there are a few in the class and I try to spread those kids out. So if I know a particular kid is very quiet and struggles I'll put a really solid kid next to them who's very friendly and outgoing and is willing to work with him."

Much of this collaboration with other teachers is also about equity. Common assessments, RTI, and even how they collaborate on their classroom webpages are an attempt to give all students an equal opportunity to achieve. Here Evan describes the rationale for his grade level's work together on webpages.

"This year, the discussion is that on your webpage you must have access to all of the documents and that it's common across a discipline or grade level. So, whatever the assignments are, there's access. It doesn't have to look the same, but

the idea is that a student should be able to find what they're looking for on your webpage and not have to go somewhere else for it."

In discussing his web page he notes: "It's also about communication, it's there to communicate with parents and communicate with students."

Finally, collaboration occurs informally between Evan and his colleagues. Some of that is facilitated by technology and some of it is about technology.

"Well, a lot of it is collaboration with, you know, my colleagues. If we, whenever we run across something, we'll send it, send an email to each other or share a link. I might bookmark something in Diigo and share it with a shared folder through Diigo as well. It's a way to share links or we'll send the information back and forth that way. I might come across an idea and say, you know, I need to do a little bit more with pulleys, or they need an extension here. And because I had a thought, I might find some websites and immediately, I'll bookmark those to a shared folder. We'll usually discuss, later, these ideas, sometimes that happens face to face, sometimes that happens over email. And so we will have those conversations and then that will become part of our curriculum for the next round. So, those types of things happen throughout the year."

When Evan describes what he wants students to experience and how he hopes to teach them, he often talks about engagement, and teaching the whole student.

"Learning is all about conversations and having those personal interactions and engagement. There's always that tension, you know, with content. You have to get to the content, and you have a certain amount of content that you have to get to. It's always a struggle no matter which way you look at it. I see any

stuff that they're doing on the computer as learning and I see that as part of their educational process. I don't see, just because I have a set curriculum that I have to address, I don't see that as the end all be all too.

The students' education within my classroom is eighth grade. Every day they come in the door they're learning something. And if they're engaged and they're working hard, and they're focused, they're learning. And, you know, today may not be the day that they're going to learn about Newton's laws or whatever it is, but they're learning something. And if they're, if I can get them engaged in the process, and engaged in the vehicle [lesson plan] to Newton's laws or whatever it is we're studying they're much more likely to take that concept and apply it. If I just throw them right into the study and say here's the material, this is how you do it, I think you lose a lot of that engagement. I definitely gauge it based on what my students are doing and the feeling within the classroom. So, trying to make something engaging or make it interesting is the challenge. Because if you do that, the student is much more likely to have it stick."

Evan described an introduction to a unit on Rube Goldberg devices. He shows them professionally crafted devices that accomplish myriad tasks. One famous one, he uses, appeared as a Honda car advertisement several years ago.

"You know, the kids are super engaged with it and really enjoy seeing it. And I can feel their energy level just increasing, and so it's, you know, more of a hook, the more they see, the more they get hooked on it."

In thinking about MLTI and using technology in the classroom, Evan returned to the idea of engagement.

"I find it exciting. Exciting within the classroom when kids are using new tools. And I find it exciting when kids are creating. And I do look forward to finding those projects where kids really get the most out of a program and really nail the content; really demonstrate their understanding of it. Every now and then, you get some really powerful projects where kids just really nailed it. So, I am constantly looking for those, and I do think it's a great way to see whether kids understand. It gives me an opportunity to see their work, and see what they're creating, and see how well they do understand the content. So I would say, I find it much more interesting and engaging than paper and pencil and I think they do too."

Engagement is a touchstone for many of Evan's beliefs and comes up again and again.

TPACK in the Classroom.

Evan Reed works closely with the others profiled, and has used many of the tools they describe. He also shared some others, and how they have changed student work. He described an online timeline tool used in his social studies class. It also locates the information on the globe using a Google Maps plugin.

"I found it fascinating. The timeline was created for you. We did a project with the Vietnam War. It was neat to put in a date and a location, and have the map zoom in there. They had to find a picture that corresponded with it. Some added music. It behaved like a video playing but you were able to jump from North Vietnam to South Vietnam to see what's happening in each. And it just flowed so neatly. It showed you where everything was in relation to everything else. Kids didn't have to worry about constructing the timeline and making sure

the time increments are the same. Because it does that for you. … It allowed them to use pictures, videos, voice and music on the timeline with the maps."

Evan has used timelines done by hand for many years, and had digitized them, before this tool, by requiring that the timeline contain links and information embedded in the final product. However, the tool was different, allowing many types of media to be used, and presented in a visual and compelling manner that allowed user interaction in viewing. His choice of tool echoes the choice Matt made around the tool for graphing (technological content). The importance of using the tool is not to focus on constructing a scale for the timeline that works, but instead in conveying information to a viewer. Evan notes that he had minimized the use of timelines in his class because of the time required, but now finds he has added more assignments into his units because of the new tool.

Evan considers all three domains when making choices about his implementation of a tool in his classroom.

> "As I move through a unit, go into a unit, one of the things that I'll do is I'll look forward at the list of, you know, activities that we have and I'll start to think about the products or the technological programs that are available. And I'll say oh, this would be a good one to use for this particular assignment. Some of them are really small, and I think, probably biggest changes that I've made, now that I think about it, is using these programs for much smaller either homework assignments, or smaller you know, pieces of classes as opposed to big projects.
>
> When I first started using technology it was much more of a big deal, it was a project. And now I tend to do a lot small assignments, I want you to put something together about whatever, [such as] the concept of atoms. I want you to

> do that in ThingLink, and that's your homework tonight. …But I do have a list on my computer of several projects using those programs that I just talked about, where they might fit in, in future units. So I might introduce them on a smaller earlier assignment.
>
> I mean, in order to choose a program you definitely have to apply what you know. And you definitely have to understand your content well enough to find a way to make it fit with the technology that also allows students the opportunity to express what they want. So, part of that is creating that assignment, giving students the right guidelines, so that they can understand how to use the technology to present what they would need to."

Although Evan is unfamiliar with the TPACK model, he describes the intersection of all three domains. His use of smaller assignments to master tools for later projects also shows an awareness of how his curriculum can spiral over time to accomplish familiarity with technological tools, instead of treating them as one-time activities.

Evolution of TPACK.

Evan described the evolution of a typical middle-school science project, a Rube Goldberg machine. The technological twist is that he asks students to film the machine in action and then to identify in the video the various simple machines being used, their mechanical advantage, and a description of the overall design. In the past, the students would bring a completed machine into class, and hope it worked as planned. He noted the pedagogical advantages for improving student learning in a description of a video produced in one of his classes.

"So, producing a movie was a requirement at the end. …They knew what they wanted to do. They sat down and pulled out their materials. They went right at it. They spent probably two or three hours on it at home. And then they worked on the video in class. I had other groups that did the project in class and then worked on the video at home. Which is another, you know, great benefit that I've found with the technology. They were able to work on it in two different places. They were able to share information, share scripts, write things via Google Docs and pass files back and forth."

Evan next described why the choice of a video improves the outcomes for the project.

"I've definitely had some groups that can't get this part going or that section of the machine. I tell them, all right, I want you to videotape this part and I want you to video tape this part and if you can't get the whole machine to work in one run, you can fit that in and then put the video together."

Students are able to show the completed actions using video in a manner that would not work in the classroom. Many times the machines take hours to get to run smoothly. Students can take that time at home, and then piece a completed set of actions together. Evan noted another pedagogical reason why video is effective for this project.

"The other thing that I like about adding the video aspect to this is they have to explain what's going on. And so the, the hands on piece is great, but then having them verbalize and explain, they take a lot of ownership of their project and what's happening and being able to explain. And being able to communicate how things work is a really important piece of learning.

I feel like being able to create a video takes it to the next level because then they have to explain it. And there are a lot of students who are very hands on, but they're not as verbal. And it also gives them the opportunity to say it several times. So, because it's a video, they rehearse and they practice, and they say it over and over. So, as opposed to, if I was just having a conversation with them, they say it once, and they may not get it quite right, but I'd understand what they were saying. This way they would have to do it over and over and practice and practice until it was a finished product for them to be able to submit. So, there's a lot of additional learning then that happens outside the classroom beyond just making machine and explaining it to me."

He also made reference to slowing down the learning.

Evan's evolution has taken one final step with Rube Goldberg project over the past year. He shows students examples from previous classes. He has now expanded his critique and feedback on the project to include what makes for an effective video. What makes one video better at communicating the information than another? Here he explains using two different projects involving video.

"For example, you saw the video of the rap today. After the rap, I went over and I had a conversation with the boys who did the rap, and I said, you know, I really like the part where you pulled out the money for the gilded age, I can see the connection to the time period. You know, extremes between the rich and the poor. But some of the rolling around on the floor, and the sliding on the banister, you know, I was trying to figure out how that connected. And they started chuckling. They understood where I was going with it, and what the

purpose was. I said, you know, if you're trying to communicate an idea and make connections, there are things you could have done to make that more clear to the audience. So it was a conversation that I had with them afterward that if I had had that conversation with them beforehand that may have given them a better product.

So today we look at examples and we will evaluate some. We do Tours of Maine [another video project] early on in the year when we do our Maine unit and that's our culminating project. Students have to take us on a tour of Maine and teach us what they've learned about Maine. They have three essential learnings that they need to focus their project on. I usually show two or three videos beforehand. And we look at those videos and I tell them what I liked about the videos and what this person could have done differently in the video. And I'm always very clear that these are examples, they're not exemplars. I try to show them where they missed the essential learning or where the video didn't support their assignment."

Evan summarized the experience, noting that technology and teaching are intertwined now.

"And the teaching, it's all so intertwined, it can't be separated today. It's a totally different feel. And it's actually; it's probably more like an exponential progression. It's just, you know, the more you use it the more familiar it becomes and the more you have on the computer, the more you use it for instruction. You're always adding more to it. So, the more you do it the more it becomes part of your class. Everyday there's something else that I've used as part of the

curriculum. There's something that we do every single day. And now we're constantly changing it and some things get outdated. You add new things so you can change the program but there's more and more involvement throughout the lesson. It might not just be a piece of the day, it's the whole day."

A shift also occurred in how spontaneous teachers were willing to be in their use of technology. Evan noted:

"Because it was so new everything, everything was very deliberate. Anytime you pulled out the laptops or wanted to use them everything that we did almost needed to be scripted. And you needed to write in your plans, you know, we will use our laptops at this point in the lesson or we pull the laptops out. We will, you know, have the kids go to this website and it was just very structured relative to the lesson."

He later described this deliberateness or intentionality as similar to how he uses a laboratory experience in his science teaching. "Using the laptops felt like doing a lab early on. It was something added on to the curriculum, you know. It was a stand-alone activity."

There are still times that students need to learn about how to use a tool, an example of technological knowledge, but Evan has included that instruction into real contexts where students need to accomplish some larger goal or outcome. Evan notes:

"And, you know, as I said before, that's, you know, one of the things that we used to have to do. We used to have to teach the kids how to do this stuff. Now, one thing that's extremely helpful when we do a new program is to say, okay, we're going to use MeoGraph to illustrate the changes in spending. So in the

first class, the introduction, I would assign something fun like lets graph the class's top ten activities this summer. We quickly collect the data using a Google form. And they're like, oh, I could learn this program, I could figure out how to do this. [Laughter]. And then you start the project the next day. If you don't do that and you jump right into it, they say, I don't know how to, I can't, and there's a little bit more resistance even though they could still figure it out. So that's, that's how I would do it today. But I don't walk them through the program. I allow them to explore.

I'd give them a day to work with it and then introduce the real activity it. So the evolution was we originally had to teach them. So when we first got the laptops we said, 'okay, everybody to this site.' Now, to create a new slide, you click here and then to put your text in you type here. And so we would have to run them through that. Now, you throw it out there on the table and you say play with it and they figure it out."

That evolution depended upon both students and teachers gaining more technological knowledge. It isn't just teachers who have had to gain new understandings.

"We had to have signs up on our doors, you know, bring your laptop for class. The kids weren't used to bringing them, so they need to be told, you have to bring this for class. So, today it's part of who they are, they carry them wherever they go. And there's the assumption that they have it. [Laughter] So, it has become so much a part of what we do, that they have that laptop all the time. And if we say 'go to my web page,' I don't have to give them a web address. I don't

have to help them figure out how to get there. They already have it bookmarked. I don't have to teach them how to bookmark stuff, they're there immediately.

They all get there in different ways. They all have their own methods, but they're all very efficient about that. And when we transition from going to a website to something else, they get it. They can transition from direct instruction to working on a computer back to direct instruction to group work, and it's very fluid, which is very different than it was in the past."

Evan has worked hard to master the digital information avalanche available to teachers today. He described the eventual adoption of Diigo, an online curating tool to store, organize, and describe websites.

"And so over the last few years, one of the issues that I've run into on my webpage is that, I was collecting links and putting them in there, and it became these long lists of links that were not user friendly at all. And so I had to come up with a new way to keep these things available to students, but make it very easy, and easy for them to look at. So I started using, playing around with using Diigo lists. And, using those list I was able to put a single link for, you know, a single assignment. If it was, for example, the Rube Goldberg assignment, a single link there that will take them to a list of several links. So, it added an additional layer, but I feel like it really improved the organization of the site. It allowed me to keep my webpage simple and not as busy. It allows kids to be able to find things quicker and also organize it.

Sometimes we have a chunk of websites that we'll have kids look at for a particular concept, to review a particular concept. And so by popping it into lists

for them, and I’ll order them so it allows me to organize them as well. And if one's not working, it's easy for me to delete it, and add a new one in there immediately. It's an easy way to access links and access information, and provide it, present it to people.”

Evan has curated sites for his students to use for assignments, but even after sifting through the myriad possible resources on the web, he still felt it was necessary to organize the curated resources. Using a service such as Diigo, he has made his resources easier to locate and find, and has developed a workflow that is sustainable over several years. “I can go in each year to Diigo and update these links or add to them without having to update my web page. The link to the Diigo resources never changes.”

That workflow even allows him to add materials on the fly as he is teaching or preparing for a lesson.

> “I mean, obviously we do a lot of other things that have taken different shape. There used to be web quests. That were, you know, collections of links with questions. And now that has changed with Diigo and Feedly. And it's changed so much because I can send stuff directly. I don't have to go in and open a document and copy and paste. I can send stuff directly to it and the kids automatically have it. You know, a few minutes before class, I might wonder if there's, you know, something on this. I can do a quick search, maybe a video or other interesting introduction and what a great way to start the class. I can have it up there, and it's ready for them to go, three minutes later.”

Evan recognizes that students need to be able to adequately sift through the resources available at the touch of a few keys. They need to be able to evaluate the quality of the information they are finding.

> "I feel like this is something we need to approach. It's not being taught at the moment. In the old days students used to go to the library to do research. And there was a specific approach about how they went about doing that. Today they have access to so much. And being able to be critical thinkers and being able to identify what is a valid website and what's not a valid website, and to be able to come up with multiple sources that support the same piece of information. I think is a challenge for kids today."

Evan does not speak about flipping his entire class, but has adopted aspects of that model.

> "And so this year in particular, we've been putting lots of answer keys for our kids online. In the past, kids had to be here in school. And you know, we'd go over stuff in school. And we're still doing that. We still go over it. But, it's also accessible to them on the webpage. So if they're working on something at night, they can check the answer keys as they're going through it, as opposed to waiting till the next day. Or, if a parent is helping them out with something, that's you know, that's something that they can access. Students often leave class thinking they understand something that we are doing in class and get home and are like lost. "

Evan is aware that the best way to communicate with students is to find the tools they are comfortable using outside of class. He posts to a Twitter feed and uses hash tags

to organize the posts within the platform. However, it is still an experiment as Evan notes,

> "We're kind of dabbling in social media is really what it is. We don't have a lot of kids, not a lot of followers yet. It's something new to use that we're working on and playing with. And as I've said, you know, the more you work with it and play with it, the more you use it, the more applications that you come up with. That's how you come up with a use of something that you never thought of before."

Evan has moved towards a more student-centered model of instruction in his classroom. He articulated some of the challenges that he and others face in letting students make more decisions about what they will do in class. "And in order for you to be successful within the classroom, you got to be willing to relinquish some of the power and be able to share that with the students and allow them to experiment and explore some."

Evan noted one of the issues that he and others have had to overcome in giving students more control over the course of a lesson. "When you give somebody the screen, you lose some control. It makes some people feel very uneasy... There's definitely a level of trust that you have to develop with the students to make it work."

Evan described how technology may have supported the shift. The myriad tools that can be used, and the pace of change in technology, have supported his willingness to give students more control and choice.

> "That's one of the things with technology that, you know, was drilled into us early on. You can't have all the answers and that's not the way anymore. That's

the way education used to be and that's not the way it is any more. And so, part of it is a new style of teaching. But the other part of it is the amount of access that the students have to technology within this building and within their lives. They play with this stuff all the time and so they like to figure things out. It's part of who they are. Because technology changes so much they get use to figuring new stuff out.

It's not having all the answers. It's being willing to say, well yeah, I don't know the answer. Let's find that out. Or I don't know how to do that. Does anybody else in the classroom know how to do that? I do that often with a new program. It's impossible to stay on top of the technology and know it to such a level that you can have all the answers for students."

Evan went on to give an example of using a tool, even though he doesn't feel very proficient with its use. He doesn't let that prevent him from using it; he just depends upon kids to do the instructing.

"With iMovie in particular I don't have the answers. If I had to create an iMovie I would probably struggle with it. I assign iMovie stuff and I require them to do it. I give them time in class to do it. If they have questions, I help them find the answers and most of the time you know, kids aren't afraid to ask me. And if it's not something that is readily apparent to me I'll turn around to the class, I'll say, whose an iMovie expert in here? And six hands go up and I'll pick one of them and I'll say, can you help them figure out how to, you know, rip this piece of this clip? And then I'll watch and I'll learn as they're doing it. And I'll say, thank

you. I didn't know that. [Laughter]. And so, I have experts in the class. There's always somebody that knows something about what we're doing."

When asked why that shift is hard for some teachers when using technology, Evan said:

> "I would think their classrooms are oriented much more toward control. And having control… And whether they're doing something that they shouldn't be or not. ... They don't know exactly what the person's doing when they're working like that. And as with anything kids are going to try to get away with some things, it happens, and you just have to be okay with that."

Evan is comfortable not being the expert about all uses in his classroom, and turns to kids for support in addition to his colleagues. That, as he notes above, sometimes creates issues, but not seriously enough to change his approach.

Summary.

Both Evan and Logan provided examples and descriptions of their use of technology in assessment, curriculum, and instruction. They both identify pedagogical aims for their choices of tools to incorporate into their teaching and into student learning. They speak of uses for formative assessment, differentiation, and content specific applications, such as modeling and timelines. Evan has incorporated video into several assignments to uncover student thinking about their science projects. Both Evan and Logan discussed the use of video to support students when they introduce new materials. They have introduced several new tools, which were unique to the building, to their practices. Logan discussed his use of video and his blog to flip his classroom, while Evan noted the use of his blog, video for student products, and the tool Diigo to deliver

curricular materials. Logan and Evan both use Google Forms and polling software such as Kahoot for formative assessment.

They both provided extensive descriptions of the evolution of projects over time: Logan while discussing his mitosis unit and Evan while describing his unit on Rube Goldberg machines. Both of those units show an ongoing evolution in their practices. Both teachers point to changes made over several years to improve and modify those projects, based on both student outcomes and changing pedagogical aims. For instance, Logan discussed how he has incorporated comparison and contrast into his project (with various types of images) to give students practice with that critical-thinking skill. Evan noted that video has helped him capture student thinking and has provided insight to how well students understand the simple machines in their projects. Additionally, in many other places, both noted other changes that have occurred in their practices as they have participated in the MLTI deployment. For Evan, those include the reintroduction of timelines into his instruction because of the relative ease provided by the tool Meograph. Logan noted that his students can now do the ecosystem modeling that he once was only able to demonstrate. Both teachers have noted that they now choose and focus on tools for what they can accomplish. The tools are no longer an end in and of themselves. They teach with the tool not about the tools.

The Early Majority

Members of the early majority can be described as deliberate (Rogers, 2003). They interact frequently with other members of a system, and serve as a link between early adopters and later adopters. They maintain strong relationships with many of their peers, are sought out for advice, and provide interconnectedness between all members of the

social system. According to Rogers (2003) they are often the catalyst for more systemic adoption of an innovation. Their adoption of an idea often provides the most visible adoption of an idea, reducing uncertainty for other members of the organization. Unlike the early adopters described above, the early majority as defined in this study often experimented in one of the three domains of knowledge but not in all three. Their use is more deliberate and less immediately obvious to other members of the middle school, but their use can be immediately translated into uses in other classrooms.

Matt Doyle.

Matt Doyle is in his 21st year as a teacher at Walden Middle School. He holds an undergraduate degree in psychology, and earned a master's degree in the University of Southern Maine's ETEP Program. He taught fifth grade at the beginning of his career, and has taught seventh grade for the last 19 years. A coach and father of three children who live and attend school in the same district, Matt has deep roots and connections to the community outside of his role as a teacher. He teaches ELA and mathematics at WMS.

Pedagogical Stance.

Matt's beliefs about teaching and learning are clear, as described below. In many places he referenced research literature to support his beliefs, much of that on how the brain works.

> "But I do think we're much more in tune with how the brain works than we used to be. I don't remember middle school ever being anything like it is now. There's plenty of research out there that says really ten minutes of me talking is a lot of time, before we need to change gears. Do

> something, talk about something different or just change gears a little bit and we joke all the time with the kids. I don't pass out papers anymore I put piles down and the kids come up and get the papers just so there is a movement break. We talk about that beautiful ten minute window. That you can pay attention ten minutes, you can listen for ten minutes. After ten minutes you might have to talk to your partner about what we just said, you might have to change gears and do some work on what we just talked about. You might need to get up and move. I said the research is out there that you can't stay with me for ten minutes. So I am going to have a 50-minute class that is broken up in five different things. … It's not always the case, that clean I mean, but it's also about building up their stamina."

His pedagogical beliefs often reflect current beliefs in the literature, even when not cited explicitly. His assessment and homework practices are an example of them.

> "We don't have grades in seventh grade now. Most of our assessment is formative and doesn't count and the kids know that. Even our quizzes get dropped. So we do a lot of check-ins. The other day for example, instead of me just posting homework answers and just going over them and then doing some corrections, two or three at a time brought their work to a back table and we reviewed it. So our assessment, I like to think, is ongoing all the time as we help kids work through problems…I remember turning in a lot of paper when I was a student and not getting it back. I don't collect homework. We correct homework and analyze it. And

we tell the kids that their job is to make corrections. If they can figure out where the mistake was we're all set. If they can't, their job is to come ask for help. So we talk a lot about student responsibility in learning, and try to share that. So the kids know that we don't collect homework."

Those practices align with his approach to mathematical fluency and even to how he sets up his room.

"And there's a big push now. Jo Bowler's a great researcher out at Stanford. She's a math researcher. We've been reading her blogs and articles quite a bit. And her push in math education has been, don't forget about the number sentence, don't forget about having some discussions in class. Just let the math kind of bounce around the kid's brains. Too often, kids think you have to memorize everything, and fast math is good math. [Laughter] And I think sometimes that actually can really cause some fear and anxiety in kids, if they don't get all 60 of their math facts, or whatever it might be in that minute, done well.

So I think about all of this and this is a very interesting idea, because it's really built around class discussions. Which is one of the reasons I got rid of my desks and eventually got tables. We just didn't do row work. Most of our math is group work. And the kids are encouraged to talk through some of the stuff and work together. When I was brought up, you were in rows, and you did it as fast as you could as far as you could. I'd memorize stuff. I knew I could solve a proportion by cross multiply and dividing. I didn't know why it worked. So, that idea of

reasoning and having to stop for class discussions, and being able to show multiple representations of it on the board, or on a graph, and discuss why that makes sense, I do think makes for a better understanding of math."

Matt is a constructivist in philosophy. He shares several examples of that approach in mathematics, and they flavor some of his other comments, such as the preceding quote.

"Some topics within the curriculum we're trying to build meaning. We don't for example, …we don't teach kids to cross multiply and divide. That's how I learned to solve proportions. Because, when they do that they just follow that rote, and they don't necessarily think about what they're doing. Now at the end of the year we might say, here's a shortcut to do it based on setting up two equivalent equations, and why that works mathematically. But we don't teach them that shortcut first. So, making meaning is a big deal in seventh grade math. You know, some of the kids know that negative times a negative is positive, but they can't prove why. So we place an emphasis on proving why, don't just memorize it. There are some times where we let the kids muck around and stuff, to try to come up with an understanding why this works all the time. Which is different than the way I was taught, much different. And I tell the kids that all the time. I had to memorize this. You know, we had to memorize what Y = MX + B is. And memorize that slope intercept theorem. We want to give you examples of the use of the equation. … And it just ties something concrete to what was a pretty abstract concept. The making of

meaning, the constructive approach, I think is vital and useful. I think it also helps motivation, like why are we doing this?"

Matt differentiates in his classroom, and described the methods they are using in both ELA and mathematics.

> "Language arts are much easier to differentiate because of the nature of the beast. I'd like to think that assignments that we do are open-ended enough that kids can take it as far as they want. Although we do provide a lot more choice than we used to. For example, we just read yesterday in class the story of the Big Wave, by Pearl Buck, who's a fabulous author. I will be giving the kids the questions to respond to. And some of those questions are much more involved than others. So I think the differentiation in language arts comes that way. And we're getting in the habit of doing a lot of leveling, such as that, in our mathematics classes. Probably a handful of times in every unit, there'll be a leveled assignment. Level one and level two. Level one is if you don't get it. It's more practice. Level two there might be a few common problems to level one, but level two is a much more, there are more extension problems, challenge problems. There is less repetition than some of the level one problems. So that's become a common practice of ours too. So, getting to those areas of difficulty, the level of homework problems, the options for special education, for extra credit. And providing some of the projects that maybe the math science guys and the GT guys work for and having these

open for every kid. We'd like to think we keep most of our kids pretty challenged."

His beliefs about student attention spans and engagement are informed by both experience and research.

"There have been some cool articles out there about today's generation not having as good of an attention span as ours did. And there was an interesting counter to that recently. Someone said no they do. It's maybe that it's different what interests them. But it's funny, because if you saw when we did the Hour of Code, there's a half hour of focused quiet. Bam, and they're on it. And they're doing some good math and they're having a good time with that math and they are focused as can be. So, I do think our kids' attention spans are no different than mine were. But I think they're so used to different presentations and different mediums for all this stuff, that they're looking for the thing that does get their attention. I think it's sometimes harder to get their attention and keep their attention, but when you get it, their attention spans are every bit as powerful as ours were. I've often thought that some of this has always been on the inside. But now, we can sort of see the evidence, as kids click around on the site, what is going on in their heads when they didn't have anything in front of them. We just couldn't see it. [Laughter] We couldn't see it. Right. So they're thinking about their interaction with the girl on the bus. They're thinking about missing lunch. But it was not obvious, you know. So, they

were bouncing from thing to thing looking for something. Always bouncing. Always bouncing."

Finally, Matt values communication with parents.

> "So sometimes I'll send them an article that says I really like this both as a teacher and a parent. And so I think I've sent five or six to the parents this year. Some of them are about teaching; some are about coaching that could apply to teaching. Some are about parent and school communications, some are about parenting. If I've liked it I share it [via email]. … I find a cool article I like and boom there it goes. So, things like that we really like, it fortifies our communication."

Sharing with parents opens the window on what he values as an educator. His beliefs are embedded within the articles he chooses to share.

TPACK in the Classroom.

Many of the beliefs that inform Matt's pedagogy can be seen mirrored in his use of technology in the classroom. His constructivist and kid-centered approach is illustrated in the following description of technology use in his classroom.

> "I would like to think it's less teacher directed than it was 20 years ago when I started and more interactive and more kid directed. The technology piece helps a ton. There are certain methods that we do that are more visual than others. And with the technology kids can project up on the screen what they're doing and what they're thinking. We call it having

kids drive the lesson. Kids take turns driving and will walk through a graph or a problem that we're working on."

Later Matt described a series of examples of technology use that support the pedagogical beliefs outlined above.

> "But, I like the idea that the technology now allows us to get to those discussions as opposed to, this was so time consuming to do by hand that we never get to the discussions. [Laughter] Or if we did get to them, we had short discussions. Now, that's probably where the technology has helped the most. It allows us to talk more. It's a tool; it allows us to talk more about what we want to talk about."

Over the course of the interviews, Matt shared examples from both ELA and mathematics that illustrate the ability to focus more on making meaning and improving understanding. He described a graphing program, and explained why he uses it with students.

> "There are features in our graphic program that we intentionally have the kids click on or off because we knew it would make their graphing easier because we wanted to get to reading the graph not constructing the graph, and making predictions with the graph. We do not worry about teaching the same things anymore. For example, we used to get all crazy about having kids pick the range. What we found was if we click auto scale you know, the range is set for them and we can talk about the graph. We'll get to that range idea later. Right now we're looking at trends and what does the relationship mean. We can look at what the

computer selected and maybe discuss why they selected it. We allowed the technology to make things more efficient and faster. Without technology, we'd have to get graphing paper, we'd have to set up our axis, and we'd have to decide how we want to label them and decide on the range, and if the range was wrong and the graph screwed up we'd have to start all over again. I mean, I remember math classes where we'd get, two graphs done in the whole class. Now we can put multiple lines on the same graph.

I think we're doing a better job introducing linear equations than we did with just graph paper, the plotting points and all the other stuff that we used to do. It took too long. And it was so much more about making a graph than interpreting a graph, which is really what the math is supposed to be about. So, I like this [pointing to a graphing program on his computer screen]. It automatically does your table for you, because we're always comparing tables, graphs and equations. Those three things back and forth, back and forth, it does it for you, wonderfully. And you can experiment with it. And all of a sudden it's changed our graph. And then we can look at it very differently. We can talk about, well, why do you think they're all squished now when before they were spread apart? And kids will hopefully understand the idea of range, and when you focus in on a certain part. And there are just so many different things we can do with this graph-it site.

And visualize it in ways that maybe you never could. Oh, never could. The fact that we can do different colors, you know, or the fact that

we can manipulate this and un-connect and connect, and scatter things, and move groups of points. I mean, how long would it take to do by hand, with multiple lines on a graph by hand? And then when you did make a mistake. Kids were like, oh I hate graphing. And I kind of felt their pain, you know."

Matt, like almost all teachers at Walden Middle School, uses the Google Docs suite of applications. His emphasis in his practice is on using Google Docs for the writing process.

> "With Google Docs, the ease as opposed to having to handwrite or type something up, hand it to someone, have them write all over it, you take it back and start typing all over again is the biggest benefit. Now students send a Google Doc where they want, there's an app where their audience can just go in and make a comment right there. And they can choose to ignore it or not. And someone can write a suggestion, a suggestion line or if they even make a change you can go back to the document that you have that didn't have that change, the version of that, and still use that. So, you know, writing is all about revision, revision, revision, and the revision process has been made exponentially easier with these machines and applications. We have a fabulous language arts gifted and talented teacher who's a published author herself; she's here three fifths of the time. She's a very well respected and very well-known author and publisher, author and artist. And she not only works with our top three to five percent, she'll take anyone's writing. And with Google Docs, kids

can share with her and she'll give feedback even if it's not one of her students. So to get multiple eyes on your writing and to get all that feedback, this wasn't available when I started teaching.

But, well, you know I think that we see how much our kids can do with this. I know my kids are better writers with these tools. So I want to use them more. And again, it's not just about the word processing, but it's about the access to information, the exemplars, and the revision, and the sharing, and the non-laborious revision is so important I think. It's just, it's exciting, and it's contagious!"

From Matt's perspective, asking students to discuss their work with one another and to share their writing with others has more benefits than deeper understanding.

"Our kids, I think, are much better speakers, presenters than they ever used to be, because they're so comfortable sharing stuff now. And they share it on a lot of multiple platforms. We'll even have kids who don't want to maybe get up and share something. They'll go home and they'll videotape themselves, and they'll project it. And they'll be in the class, but they don't have to get up and say it. That's a step towards them maybe doing it themselves. When they can do it safely at home and edit it, and get it out how they want it to look. And then show it. And, that's a pretty cool middle step to have that we never had before."

In other examples, Matt shared how the conversations in his department and team have informed their practice.

"We're realizing that some of our kids don't have the basic number sense that we'd like them to have. They don't have to memorize all the divisibility rules, for example, if they can figure them out. If I don't memorize them can I figure them out for example? We found this great website to support this understanding. So, that came out of that planning for that class, and then having that discussion."

Matt takes advantage of the technology to support other pedagogical beliefs. Personalizing or differentiating is accomplished by accessing materials digitally.

"I know this one student I have in class, he's really struggling in math, and I know his parents really well. On vacation, I found a website that reviewed, it was a Kahn academy website setting up proportions and ratio proportions. Stuff that we had just started doing before vacation, stuff we came back to doing after vacation. And I didn't want him going a week without hearing it. I sent an e-mail to her and said, hey, will you have your son watch this a couple times and she couldn't have been more appreciative. Now, how many times are you're going to send homework to someone on vacation and his or her parents are like, what are you talking about? But, she knew that I knew that she was struggling with him at home, and he was struggling at school. I said, these might help if he watches these two or three times. It just may help keep some of this knowledge current. He needs to hear it again, and he's a kid who needs to hear things two or three times.

> So the communication piece allowed, has I think increased my teaching and the results ten-fold. Recently, I had a father say; I check your homework calendar. I know whether or not to believe my son if he has any homework. It's there every day. If I don't post it, he doesn't have to do it, that's the deal I have with the kids. So the father, again, is reinforcing the expectations for school. Don't ask your kid if he's got any homework. Ask your kid, have you finished math section 3.2, and show it to me. Because too many times kids will say, no I don't have any homework and the parents used to have no way to check.
>
> We also have introductions to each unit at our blog that we just started. And again we'll put up main points for the first investigation. So, we really want to have parents use this as a resource. We posted the study guide for the unit we just finished. Kids can literally click on this and it will download. So all of a sudden there are literally ten pages of practice problems for the test. And, we also send the parents this link and a reminder, hey we just posted the study link, hey we just posted the study guide, the answers are at the bottom. This is what your kid should be doing for homework. I think this has made me a better teacher because I'm a better communicator with parents."

When asked about how he views his technology integration relative to his peers, Matt described himself in the middle of the band from laggard to innovator.

"Yeah, I'm definitely part way to innovator. The frustration is I don't, I can't call myself an innovator because I just can't find a lot of the stuff that I'd like to find on my own. But, if Logan found it, likes it, I'm all in. He doesn't have to show it to me. He might say to me, he might text; hey I found this cool thing. I'm like all right we'll do it tomorrow. I mean, I'm all in because of the level of trust. I don't need to see if it works. If someone I work with says it works, I'm going to run with it. And so, I'm probably in that upper half, but it's certainly a sliding scale depending on what we're doing.

I'm a pretty good critic, I know what I like and I have a pretty good idea of how it will work. So even when we have a lot of things that are shared with us, we have to kind of thin out what we want to use. There's definitely a lens that I use. I like to think, I can look at something see how user friendly it would be for our kids. You know, one of the biggest struggles we have in middle school kids is that whole reading for understanding and reading for comprehension. And for a site, is this user friendly and will they understand what all those things mean. Because, too many times, kids will scan and click. And they'll scan and click without knowing why they're scanning and clicking. Just like they'll scan an article and look for the bold words. However, we want them to read for understanding. We want them to use this for understanding. So, it's really getting kids to slow down."

Those comments align with the description of members of the early majority as described by Rogers (2003). Early majority representatives readily adopt those tools that others share, while being reflective enough to choose only those tools that appear to support his or her beliefs.

Evolution of TPACK.

Matt's reflection on the changes in his practice is often sprinkled with sports examples and metaphors. He views the fields of education and sport as sharing very similar values and philosophies. In describing the changes in the use of technology, Matt shifts often between examples from teaching and coaching.

> "So I think in the past twenty years, my lessons and my teaching, even my coaching, have become less teacher directed, much more student directed. Technology has played a large role in supporting my shift. I don't think there has been a huge shift about the need to embed technology in everything we do. I think that's always been pretty clear and I think we've just gotten better at using it. Though we've also gotten better at understanding, like I just mentioned that teaching thing. Just like with teaching and with coaching, you're never done. You know, you're always reflecting on what I've could've done differently, what I could've done better, what else I could do. And getting comfortable with that feeling of never being done took a while… And I didn't think that way when I first got into teaching. When I first got into teaching it was 92ish, 93ish, and, you know, the Internet was just kind of feeling its way around. How is this going to affect education? Now, literally we were in a class the other day and a phrase came up. Without being asked, a kid says where'd that come from? And I said,

well and another kid Googled it, fast, had the answer. It made for a good conversation, and we went with it, we went on with our conversation and it was great. That led us on another tangent. I have become more comfortable letting the students' interests inform the day's lesson."

He realizes that the information explosion has changed his focus in the classroom, and the skills that he sees as essential for students.

"The other day I heard an interview with a lady, a 58 year old doctor, who had some neuro-psych degree and some experience in teaching. She was fascinating. The first ten-fifteen minutes were great for kids, the second ten-fifteen minutes, it was an NPR interview, were great for adults. And I listened to the whole thing the other night and it talked about, and I shared this with the kids, it talked about how medical school is changing now. Because, we're in the information age now, and there's so much information out there. That instead of having doctors memorize things, like they use to have to, there's much more time spent on being able to access accurately and efficiently, all this information out there. So if we go to doctors now, a lot of them have an iPad an iTouch. All our medical records are electronic, but the emphasis is on now being able to analyze and access and find the information, not just memorize it. And that's what we're doing a lot now in school, you know; we do less memorization, because we have the information right there. I think we're creating better critical thinkers than we used to. Now, we don't memorize everything, because we don't have to. Now, I don't know if that's good or bad. I think it's a good mental exercise to memorize some things and have some stuff in memory, whether it's at a cocktail party,

whatever it might be, you know. But, I think we do a much better job now, helping kids to analyze information, cite it, you know, see if that's a credible source and then critique it. Ask, how can I use that information for me, for my purpose, for whatever I'm doing? So, I feel like this laptop initiative has really taken us so far in that vein. And then to hear the other night that that's where medical schools are going. It just felt really kind of reassuring that maybe we are doing the right thing. So, again I have to use that filter when thinking about the changes technology has brought. I guess we're going back to how do we teach kids and adults to make decisions and analyze, scrutinize what's coming in. I do find it more engaging."

Matt acknowledged that it has not been easy, for him, to develop the skills needed to access information "efficiently" as he describes it or to help students also access it.

"That fire hose of information, you know you turn on the Internet and you have to be able to sort of sift it. Right? And we spend a lot of time now on this. It's hard for middle school kids to do that. It's really hard even for me. But the educators that are plugged-in, tuned-on, like the John Bernards of the world, the Logan Ackermans of the world have helped me kind of realize that it's not as hard as it appears. You really can do it."

Discussing the ability to access digital information Matt was reflective on how his approach to preparing for class has changed with the advent of the Internet and the wealth of knowledge available.

"I used that online-math book we talked about. And I'm able to access online materials. I'm getting more efficient. But there's just so much more

research. There's so many more resources shared online to support regular teachers that just have a book. … And so, I know that I'm looking at more resources and finding more ways of how to maybe present a new idea because of our online versions. And that's more engaging to me. It's a necessary tool now. And the more we use it, the more efficient we become as educators. So, I think it has changed teaching incredibly, but it had to. You know, we have to, our kids, this [the laptop] is what they learn from, and lean on so much more than we use to."

Several times in the exchange, Matt mentioned that it has made him more engaged as he has incorporated more digital materials into his practice. When asked if that made him feel more creative he noted:

> "I like to think when I see something I like, I will use it. And because I see more things, I have a wider choice to pick from. So, I think, I'm not sure if creative is the word that I would use. I have more ideas to pick from and more ideas stimulate what I might want to do… and I'm much more willing to try more things because of this [pointing to the laptop]. I just have to make sure I'm being selective and as we tell our kids."

Matt is selective about the innovations and uses of technology that he will incorporate into his practice. Not everything his peers are doing has struck him as important to add to his repertoire of teaching strategies.

> "There's another teacher at Walden who has all of his kids deliver their paper electronically in drop boxes. That's another way you could organize your classroom. I still want a hard copy. I want to write my comments by hand. It's a

comfort level for me and how I read stuff and how I can process, you know. So, when they [other department members] brought that idea about let's reorganize, let's have everyone use the drop folder, I said I'm not going to use the drop folder. I respect that you guys want to do that, but I'm still going to use hard copies, and everyone was cool with that."

Overall, Matt noted another change in both his and his peers' practice as the MLTI has matured.

"Originally, as with any new ideas, I think we tried to fit it in places where it didn't fit. We tried too much and we went overboard a little bit. And we realized that sometimes just having a book in your hands was ok… We're now really comfortable knowing this is a tool that's there. We don't need it if we don't need it. It's okay if we don't use it. And it's really fine if we don't use it, we don't feel the pressure to have to use it. So we look at it as just another tool that we have in our teaching bag. But I think initially we tried to force it places. It didn't make things more efficient. You know, there was some math programs that it just took even longer to figure it all out than it did just to do it sometimes [non-digitally]."

He went on to make a distinction between grading and providing feedback, and revising writing. That distinction illustrates where he has and has not integrated technology.

"I'm not yet, in my language arts, using Google Docs in the grading piece. I am, though, in the revision/conferencing piece because we'll just pull a screen up and we'll look at a student's work together. Or they'll share or talk with me online, which I think is really cool. We don't have to look at the same screen; we can look

at the same paper on two different screens. That is a cool thing to be able to do because you can do it from home, you can do it wherever it might be. We can even have our GT writing teacher be on the same document at the same time, and all three of us could be writing comments. That piece is really neat, so I bought into that. So, it still comes back to what I feel really comfortable with doing."

Summing up the impact Matt noted:

"You know, you're always reflecting on what I've could've done differently, what I could've done better, what else I could do. And getting comfortable with that feeling of never being done took a while."

Matt also sees a change in how he interacts with other teachers because of the technology he and others have incorporated into their practices. Matt shares a classroom blog in mathematics with another teacher, Logan Ackerman. He described the sharing of resources and assignments via the blog in both their classes.

"Logan is amazing to work with. Logan created a blog, so we share the blog now. So, instead of me creating my own, we have a math blog together. And so, we'll post homework, we'll post links to materials. You know if we found something in Kahn Academy we really liked, we'll put a link in our blog to the Kahn Academy that explains something in a way that may be different than the way we did that might help the kids. So all that sharing is just contagious."

He then noted that sharing has opened his practice up in the non-digital world also.

"We share everything and we communicate much more with one another. So, you know, we have teachers in and out of our classes all of the time as well.

Logan Ackerman who teaches two rooms down, he and I both teach math and were always bouncing back and forth.

One of us might say we're altering a homework assignment or found another way to solve a problem, whatever it might be and we will pop into each other's rooms to tell the other. Jen Jorgensen is our math lead teacher and she's popping into our rooms all the time too, and chiming in. So it feels like a much more open classroom then it was 20 years ago, and the kids are really comfortable with that."

Finally, Matt noted that MLTI has changed the dialogue in his middle school, and he can identify the changes that he values tied to his developing understanding of technology integration.

"And we, so we talk a lot, I think, in school now, much more than we did, especially seventh grade and up, about being efficient. You know, and I think the MLTI has allowed us very real ways to do that in our research, in our communications, in our, especially the research. I still remember learning how to use the first search engines. If you didn't put the word in your search and you didn't put the right things in quotes, you couldn't find anything, now you don't even need to spell it right. [Laughter]. We can find so much more to use today and it's so easy to share."

Lauren Maddox.

Lauren Maddox is an eighth-grade science and social studies teacher who is extremely comfortable with technology. A veteran of 24 years, Lauren has an undergraduate degree in education, and a master's degree in administration. She is currently working on another master's degree in technology integration. She has spent 20 years at Walden Middle School, most of them teaching eighth grade.

Pedagogical Stance.

Lauren refers to her experiences in grade school and college when describing her approach to middle school science and social studies.

> "I struggled as a learner in school, and I've tried to emphasize that I'm here to help them. So if they're not getting it, then they can't expect me to know that, unless they tell me. So I really try and encourage that. I learn a lot orally, and so I need a lot of different perspectives. Always hearing the same perspective is not a great way for me to learn."

She expects students to question their understanding, and to embrace struggle as a component of learning.

> "I try to be enthusiastic about learning and experimenting and struggling and learning, and learning from my mistakes, and acknowledging those mistakes and working with others and getting help and really pushing kids to be resourceful. So if they have a question, and I can't answer it, where can they go? Or questioning results when we do data collection, which has become great recently, especially with this new program we have at school. Often they say, this doesn't make a whole lot of sense, and I'll encourage that, and say, well keep

checking the data. Let's see why, and then they come up with these ideas. So it's really encouraging that questioning piece, but also that, if I can't answer it, I will try my hardest in a different way to answer it. And if I can't, then I will send you in the right direction or help you find the right resource that will help you."

She then reflected on her own struggles, and how those impact her practice.

" I think it helps me realize that there are struggles. Kids here struggle. There are always areas in which kids struggle. When I was in seventh grade, I loved our teacher, our math teacher and science teacher. I thought she was a wonderful teacher in a lot of areas. But since I've learned how to teach, a lot of those areas were really bad teaching. She used to hand back tests, highest to lowest score. I never cared at the time, because I was always one of the top five. And so I think that I can help kids in the science, math pieces because I struggle in the other components."

Perseverance through struggle is also important to her view of learning and by extension her teaching practice.

"So for me, if they ask questions about the math and science, I can help. I might say, that might work, you know, this time, but let's see how you got that answer, because next time it might not work if you don't have the right strategy. So I think that it's looking at that perseverance, of never giving up. I was never a strong reader in school, had a very, very hard time reading. My parents actually think that there might have been an undiagnosed disability. Then there was, all of a sudden, that time in my life where I could choose what I wanted to read and all of a sudden, it clicked. I fell in love with reading.

> And so to me, that's also what I try to teach kids. You might not get it now, you might not like it now, but if you persevere and if you really push yourself in it, you're still learning other worldly things. You're still learning how to, you know, develop a work ethic. So, I try and show that there are other things in life other than just math, science, social studies, reading, but you know, we still have to do those things too. But once you get a little background in everything, then you can pick and choose what are going to be your strengths."

Like many of her colleagues at Walden Middle School, Lauren is careful to sequence her learning activities, and to provide several different components in a lesson. She described that learning cycle as hook/introduction, discussion, and application.

> "I like to think of myself as a teacher who is not a stand in front of the room and lecture teacher. Kids say they don't learn from lectures. They have no idea what a lecture is [Laughter]. I mean, I can talk for ten minutes and they think that's a lecture versus the hour and a half lectures I used to sit through.
>
> I like to do a quick introduction, go over what we're doing in class. I have the agenda on the board or at least on my chalkboard it says what we're going to do today in the order we will do it. I start by going over homework and taking questions. Then introduce something new and maybe a video start or teacher demonstration or animation. Something that will kind of grab their attention and introduce them to what we're going do. And then some kind of follow up, and I especially do that in social studies. There's some kind of activity that's going to help it stick for them.

> For example, we talked about Rockefeller, Carnegie, Baum and Morgan. Then I gave them a sheet that looked at their character traits and how they made their money, and how they spent their money. So, what would you put on their epitaph, and we talked about what an epitaph was. A lot of them wanted to look up what's really on the epitaph, I said, no it's what you can remember, what do you remember about them. I gave them gravestone and they cut it out and they wrote it up. So, I try to give them something hands on, after we've done some kind of conversation or discussion so that they're not sitting for an hour listening. I try to do that in both science and social studies. It doesn't always work with social studies, because we're going over notes, but there's always something that follows up with an important topic.
>
> And then in science we use more of the labs to do that. But we still do some kind of follow up with the worksheet. I hate saying worksheets because that sounds so dry, but it's really more so that they've processed it. If I'm writing it down, now I can go back and look at it. Versus just reading it once and never seeing it again."

Her approach is similar to the Madeline Hunter model of instruction which includes providing clear objectives, an anticipatory set and guided practice. She is aware of the importance of student's learning the material correctly at first and not with misconceptions. She described why she reviews reading notes with her students.

> "We go over the notes that they should have in their text book, which is very dry, from both of our perspectives. In order to make sure that they have the right information in the notes."

Lauren is reflective about her practice and identified an area that she feels could be improved.

> "I think that one of my challenges as a teacher, is grading. I'm so involved in how can I make tomorrow's lesson impact them and stick to them that my grading tends to be put off, longer than I personally like. Which is always, it's a goal every single year.
>
> So I try to give some feedback, especially, I mean, to kids who don't do as well as they should on a project or a presentation. I will immediately say to them, was that your best? If not what can you do and we'll talk about it. And I'll give them a chance to get some more points back but it really is that encouragement on the spot that I think is much better than my written response later on.
>
> I'm so focused on what's tomorrow's lesson is going to be and how can I make sure that those links work for that assignment and how can I make sure that this is all ready to go, that my grading just, isn't where I would like it to be."

Lauren's other assessment practices emphasize choice and differentiation. She sees performance assessment and techniques such as cafeteria-style assessment as opportunities for students to demonstrate what they know, without always being asked to use the same format.

> "When I first came here after I had been in another Maine middle school I really tried to emphasize constructivist assessments. When we were done with sound, I would give kids certain materials and say, create something with these that demonstrates you learned something about sound. And, the kid who might not be able to do anything on a written test could string up the needle in a paper

cup to vibrate the cup to tell that there was sound because they could feel it through the string.

To me that was great, there was success there. So I think that my beliefs about assessment have changed over time. Also, I think the expectations have changed over time with state standards. So I think that what we try to do is give kids opportunity to demonstrate learning in other ways then just written.

Evan and I never used to give multiple-choice tests, but now since a lot of state tests are that way, plus we switched to a new science program and they provided us with a lot of assessments that were multiple choice, we have started to use them again. We wanted to emphasize that [taking a multiple choice test] as being a skill also. But we almost always, and not just with labs for demonstrating learning, do some kind of performance-based or some kind of hands-on, even if it's not a graded assessment on the learning. Kids can experience it without just doing question and answer.

We try and do what we can to help it stick. I always used to think that if I, you know, can give them something hands on, that they can remember doing, it's going to help them stick to the content better.

So we try to do that a lot, and in social studies, I have found that with the technology, I can have them do research that is current. With science, I can send kids online to see many more visuals that might help them see the big picture. And, in social studies I find that they do a lot more creating of the content to make it stick."

Lauren uses summative assessment to continue the learning in her units. The cafeteria-style assessment allows students to select questions on content or skills at the level of rigor they are capable of completing. So one student might choose questions that are low on Bloom's taxonomy, while another chooses questions higher on the taxonomy and both earn different grades. Harder questions are worth more in the model. That cafeteria approach extended to performance assessments also. Here she refers to a colleagues modeling of these types of assessment practices.

> "That was actually a design a former teacher who worked here used. …And so she came up with this menu idea for this book on the Gilded Age unit. At the time we were doing a lot with multiple intelligences, so she outlined this piece where kids had a choice of what they wanted to do to demonstrate they have learned the material. We still required them to take notes and we required them to take an essay test. But some kids can perform music, some kids can draw a political cartoon, and we've worked on it, we've tweaked it. Every year we look at it. I think, two or three years ago, we brought in this statistics piece, where they can compare statistics over time, so population from then to population now. Last year, we put in a Norfolk connection … what Norfolk is like in this time period, and add it to their presentation. So it's a great opportunity for kids to choose, how they want to earn their points. It's a great piece for differentiation. … And so we do a lot of choice in that way so that kids can learn, and pick and choose their areas of interest."

Lauren works closely with both her team member and the other eighth-grade science and social studies teacher. That collaboration is distinctly different from her first

experience in another middle school when she began her career. She started in this school working with students struggling with mathematics.

> "So I really wanted to be part of the classroom. So I tried to go into those classrooms, but at this school I heard a lot of, "You are younger than the years that I've been teaching, so this is the way you're going to do it." But I tried to get myself into the classrooms as much as possible and stand up for, which I didn't even know at the time was mainstreaming."

That lack of collaboration was not unique to her role as a special education teacher, but extended to her first full-time classroom position.

> "In my previous school at the sixth grade level I was teaching science and reading. I was on a four-person team and butted heads with a lot of people in there."

However, at Walden, Lauren has come to depend upon her colleagues as they have come to depend upon her. Here she describes her current team member.

> "This is the first time that I've been teamed with this other person. Evan has actually been teamed with that other person for six or seven or eight years. So it's just really nice, it's equitable and balanced in the work that we do. We work really well together and we support kids in the same way. We have similar expectations and we communicate to parents in the same way. If we have a concern, we make sure we both know that concern. We include each other on those emails to parents. We include responses, you know, if the parent just responds, sends an email to one of us, we'll respond to both of us so that we can see what's going on and it's all open and very, very supportive."

That colleague is new to her team, but her work with Evan Reed has been ongoing for years and their collaboration is frequent.

> “Evan and I share everything. I won't teach anything, well if I do teach something new, I will immediately tell him that day so he can either decide he wants to do it or not. I guess this is our 18th year together and I could never ask for a better teammate. Everything is shared. I made this, you know, do you want a copy? If something doesn't work, he'll tell me it didn't work today. What are we going to redo? So, we rewrite lessons for the next year, after they don't work. Or we make changes right away, so they're all set.
>
> I'd like to think that our science students have always had a common experience. We work through all the labs together. We kind of try to rewrite or prepare them in advance. Social studies we do a little differently. I, because of my personal history with history, don't always feel as though I'm as good teaching the content as I am having kids experience different things. So I tend to do a lot more of the hands on, I think, hands on pieces. Then I'll always give them to him and he might pick up on a few of them or not, but the content is always the same. And we always give the same assessments and whenever we refine content, we always do that in planning meetings.”

She appreciates the differences between her experiences at her previous school and her experience at Walden. “I used to call the teachers who didn’t want to try anything new the Jurassic. There just aren’t that many here, it is nice.”

Her colleagues are often challenging her to try new things. She is not the only member of the department or grade span looking at new technological tools.

TPACK in the Classroom.

She often is the first in the middle school to try a new tool and she explores the features thoroughly.

> “Because of my interest in technology, I wanted to be able to answer all the questions. So, I understand as the teacher that I don't have to know all the answers to those things, but I don't want a kid to get hung up on a technical piece of the technology if I wanted them to get the content out of the bigger picture.”

She often chooses technological tools to mix up the experience for students and to achieve her content goals.

> “Well, one of the projects that the kids are doing right now they can choose to do a reformer and tell us about their life and their contributions to the essential learning, and so forth. After having sat through 48 keynote presentations for the Maine tours [the last project in social studies in her class], I was done. I don't want to watch another Keynote, just like I didn't want to watch Power Points anymore. I just need more. And they need more because they're sitting through them also.
>
> So with these reformers, they are not allowed to use Keynote. They can't use Google Presentation. So we've said they can use Prezi or PowToons which both have come a long way. Prezi was very difficult in the beginning to work with, but now they have a lot of templates that do a lot of the flow. So they don't have to worry about how it flows right now, instead they're working with the information. PowToons also has some templates.

> They can use Meograph I don't think we put Animoto on that one. I did a presentation, a project recently with Animoto. I wanted them to work on vocabulary, teaching us what a vocabulary word means, but they only had 30 seconds. It's like I don't need all the extra words. I want to know what it means. Show me some pictures. I wanted it to stick. So that was a vocabulary project with Prezi, Animoto, or Meograph.
>
> And Thing-Link is really fun because they still have to narrow the information down. But they can bring in movies and they can bring in dictionary definitions and they can bring in pictures. But they have to pick a picture that summarizes the whole thing that stands behind it and I think that that piece is a really great synthesis of the information."

(Thing-Link is an application that starts with an image and then users can add interactivity and links to spots on the image. The reader clicks on these links to explore information about the image. In the case she discussed, student images were meant to convey something essential about the vocabulary, and then provide more information using the links.)

She uses those new tools to shift a student's focus from the presentation options, the bells and whistles available with tools, to encourage the focus on real understanding. As she continued to describe the vocabulary projects she uses, that becomes apparent.

> "In one of our social studies books, there's some pretty big vocabulary that comes to play throughout all of our study of the book.… So I gave them an assignment, they got to pick a word, a term, out of a basket. And they had to use Animoto to teach us about that term. I called it teach us a lesson I did not call it

vocabulary. So they had to use Animoto to create a 30-second video. I liked the focus of 30 seconds. Not too many words, not too much that you don't understand. You really have to narrow it down to getting the gist. They needed to learn about the assigned term and then create the video that would teach the rest of the class about it.

It was, you know, quick and simple and it got the point across. Because they were new to Animoto, they were not focused on all the possible extras. They needed to learn the basics of the tool, and it changed their focus. The kids really struggled with how do I do it in such a short time. And I really forced them to think about what does it mean, and how can you teach us that in that short time. If you use a lot of words we're going to be reading the whole time and we're not going to necessarily get it. So, can you flash the pictures in front of us, can you flash just single words in front of us?"

Lauren uses a new tool to focus the students on the content, realizing that their unfamiliarity with it will limit the possibility that they will only focus on presentation aspects at the expense of content or effective methods to present a lot of information quickly. Lauren's willingness to understand the tools she is using and therefore be able to answer students' questions quickly allows her to push kids to explore the content more deeply.

Lauren then notes another advantage of using that application when describing a student who due to health issues is only in class two times a week.

"Well, this is a student who's on a limited day because of her health. She's in class every couple, no, a couple times a week and she still was able to put in the

key terms the key ideas. She could work on this at home and though she missed the day we shared, we shared her video and we then provided her with everyone else's videos."

There the choice of tools has supported the learning of a student who has limited exposure to the class, a vast improvement over receiving photocopied notes or summaries when she is home sick.

In another example, Lauren shared a tool that she uses in social studies and science to differentiate for students, an online website called NEWSELA. The website provides stories on current events and other topics in science, social studies, and history. The website allows the student or teacher to change the Lexile level of the story while still obtaining the same content.

> "Kids can choose an article of interest and then choose a readability that's of comfort to them. They can change the Lexile. It provides Common Core type questions summarizing voice, message, details, and supporting evidence. They get four questions and what we say to them is if you're getting 100 on these, challenge yourself to try a little harder level of the Lexile style reading. … If I'm struggling and I'm not getting anything out of this article, let me go down a Lexile, become more familiar with this and with the vocabulary that's being used.
>
> But it also can be a different Lexile based on the topic. If I ask them to do a social studies or a history article versus a science article they can have different Lexiles and understand that that's a comfort level that they've built up in their reading or based on their experience. So they can have different Lexiles based on the topic. And kids can be successful where they are. And it is a really neat way

for them to get the information out of an article at a level that was comfortable for them."

The use of NEWSELA illustrates an intersection of all three domains of knowledge in Lauren's use of technology. Lauren's website has multiple links to student work collected over time. She points to those as exemplars, opportunities to publish to a wider audience, and access points for parents into her classroom.

> "So I think I've had that interest since the beginning and have shared student work as much as possible. Kids do this work, it's not just for me, and they need to see it's out there. I want them to see each other's work. Their parents can see it [and] their grandparents can see it."

Her classroom webpage has many of the elements that other teachers have, homework calendar, contact information, links to projects, and resources, but she has more student work posted than any other teacher participant. She has archived student work online for five years. She is also experimenting with other tools to showcase student work. She shared a use of Pinterest to house student projects. Each page in the website is a separate project and the 'pins' represent student work.

That experimentation extends to how she is organizing her online classroom presence. "I provide a lot of materials on my website but I also have started to explore Pinterest as a place to organize materials for students to use at home. I have boards organized by topic. I like it because it so visual."

She uses a combination of a Google website, a wiki site, and Pinterest to house her classroom materials and her students work. They are connected through her website, but each tool serves a different purpose, and was chosen for a specific reason.

Lauren views the tools students have available as one of the primary means of differentiating, and of providing students with choice. When asked if that really constitutes personalization, she explained her thinking in this way by showing a recent project on Newton's laws. Students were required to illustrate all three of the laws by filming and describing a real-life situation. In the example she described the student was shooting a hockey puck.

> "Yeah. I know what you want me to say. This is how I'm going do it, so it isn't personalized. But they pick the activity to film, now I'm personalizing it. They've picked it out. For this student that made all the difference. The student asked me, you know, how do I zoom in, in iMovie. I said I don't think you can zoom that much, but he wasn't satisfied. So he took a screenshot of it on his iMovie, put it into preview, zoomed it and then put a box around it. So then he put that picture back in that movie so it looks like it's zooming into the puck. And then he put arrows in to show the forces. There was a whole process there that really he was so excited about to learn. And he was so excited about his final product. It showed the information. But there was so much more. He was so attached to that project. He was so proud of it. I think it was personal to him, important to him."

Later while describing a vocabulary project using the web for images, Lauren again described the choices available in technology tools as providing personalization for her students. When reflecting on doing the project without technology she notes how it would be different.

> “It would have been much more of a, there's my stack of magazines to cut out. Make a collage of something. It wouldn't have had the music piece or that personalized touch but it still would have gotten some information across. I might have had to change the terms based on the magazines that I have. So, it would have been, definitely, a hands-on piece, but it would have been much more of a cutout with no music or anything.”

There personalization applies to the choices available in a technology tool or in the possible subject for a project.

Although Lauren is an innovator in her school around technology integration, she is, like many of her colleagues, careful about when and where she chooses to use or not use technology.

> “I think sometimes we get over our heads because we want to make the technology connections so much because it seems to be more engaging to kids. Every once in a while we do need to step back and say okay we don't need the technology. But I always think about where I should use it. But I think the interest and the passion that I have for technology and for teaching, I think it, it overlaps a lot.”

She will also have students hand write material that she wants them to process from some online websites so that they actually have to read the content, instead of cutting and pasting.

Evolution of TPACK.

Lauren’s evolution in her integration of technology reflects awareness that a product is not as important as the content. Lauren doesn’t teach about the technology.

Her projects are purposefully designed to keep the technology from interfering with the message students are asked to convey in their products.

> "And I think, now that we have one-on-one, I have higher expectations for content over what it looks like. I feel like now when we use technology for assessments, I'm much more interested in what they're learning and how they're learning it, versus how they make it look. And so I will challenge them to try new technology, because then they don't know all the ins and outs of it [the technology tool]. So they're focusing on the content and how can I get it to work. And then later on they can go back and maybe make it look better or maybe make it do different things. Because it's the information I want, I just want them to know that there are different ways to present it."

Lauren described a project that she and her colleague Evan Reed do in science that illustrates how her integration of technology has matured and changed with the one-to-one initiative.

> "I think that a lot of the value has to do with kids being able to personalize their education and their learning. For example, we were struggling with Newton's laws. How do these apply to kids? Years and years and years ago before they had the technology, I took 25 different cutouts from magazine articles and put them in a paper bag. And I said, okay, choose five of these and explain to me how Newton's laws apply to this action or this picture. I wanted them to get a variety so they had each of the laws. But the idea was, all three laws are applying, can be applied to each of these topics. So two years ago we realized that kids can record

their own action using the camera on their laptop, and then they have to narrate how all three laws apply.

The information that they get out of it is so much better than what they used to because they're doing it and they're saying, wait a second, in this action all three apply and it really personalized it. They got to do whatever they wanted. Some kids swim, some kids kick a soccer ball, some kids run into the wall, some kids throw things at the wall, and they really learn from it. So I think that it really is much more of an opportunity for what I used to call, you know, kids attaching information to the scaffold that I provided, and this is just a different way to, to do that."

When asked why that was a better way, Lauren noted,

"I think it was the choice piece. And, having to go back and watch it 100 times to get the video to work the way they wanted to. And to get it synched where they wanted their voice, and that process of slowing down and learning instead of just doing it to get it done."

That idea of slowing down is also implied in her descriptions of the vocabulary projects. Not being facile with the technology forces kids to return time and time again to the ideas they are conveying instead of dashing off a project quickly because they are so comfortable with the tool. That application of TPACK was also mentioned by Evan, "mixing it up on kids helps to keep them from wasting time." Those two teachers have found an advantage to tools that students are unfamiliar with, unlike others who, to minimize student struggles, choose tools those students know and are comfortable with.

Many of the changes that Lauren has undertaken are a product of her willingness to experiment with the technology tools she discovers. She described the various ways she tried to share student comics for a different project. She had very specific requirements, and experimented with a variety of tools to get what she wanted. She did not settle for a tool that met some of her needs.

> "Actually that took me awhile. I think that day I tried several different programs to try get that to work. I took pictures of them with my iPad first and I was trying to figure out how to get them to display like a comic book, or to display in a way that was fun to read. I mean I could have easily put them in a pages document and then turned it into a PDF and put that up, which I did with kid's comics in the past. That isn't fun to read. And that would have taken, well more steps along the way. But also, I was just looking for something different.
>
> So I tried I tried a bunch of different things. I even tried Picasa and uploading them there. And then, I think I tried Google Docs, Google Drive and Pic Collage. But they [the applications] lost the comic book format and they didn't show all at once [each student's work was on a separate page, not all on one page].
>
> So I eventually stumbled upon the answer on my iPad, because in one of the share options [on the iPad] is Pinterest. And so I decided that that might be an interesting place to try it. After I did that, I realized that in Pinterest, you could actually embed the board into Wiki Spaces. So that's what I came up with. It was a neat way to show it."

She wished to share the student's work, comics, allow other users to access it via the web, provide a forum for comments, and have it be embeddable into her classroom website. The final tool, Pinterest, accomplished each of those tasks, while maintaining a reasonable workflow to accomplish it. Pinterest, a popular social media site is the only type of social media used by Lauren. "Pinterest is the only one that I've actually gotten involved in. I am not on Facebook, don't do any other social media."

Her use in the classroom stems from her experimentation outside of the classroom. Many educators use Pinterest for their personal use, far fewer use it in the classroom. Lauren has found a pedagogical use for the website.

Lauren notes that in her social studies class she is now able to more effectively look at current events and recent history because of the access to technology.

> "So we do a unit on history in the kid's lifetime, and that's purely technology based. When we were in school we never got to present-day history. And with present day we are looking at things that they remember, things their parents remember, and things their grandparents remember. Things that are highlighted in the news and so forth. For instance one year, it was the weekend that bin Laden **[[he was actually killed]]** was caught I emailed my kids the night before a project was due and said we'll extend the date. I want you to be able to add this into your project."

Not only has technology allowed Lauren to focus on current historical events, but also facilitated her ability to contact her kids long after school was out to change the requirements.

Summary.

Matt and Lauren bring different strengths to their adoption of technology. Matt is very aware of his pedagogy, noting in many places the research underlying his teaching, while Lauren describes herself as being fascinated and excited by new technological tools. They both readily share their applications, and support their peers in the integration of technology. Both readily adopt the innovations launched by Logan and Evan. Matt describes the tools he has used, blogs and graphing software, introduced by Logan. Lauren and Evan's collaboration is more equal, though Evan uses tools for many different purposes. Lauren has adopted many tools primarily for student demonstrations of understanding. She has introduced and used MeoGraph, Prezi, Animoto and PowToons for student presentations. She has Matt uses those same tools and others for various purposes, experimenting with their value for different outcomes as he described with social media and video. Lauren has also employed several tools to showcase student work, experimenting with a webpage, blog, and Pinterest to share projects with a wider audience. Matt described experimentation with several graphing and modeling tools for his mathematics classes.

Both teachers provided descriptions of their evolution. Matt described his evolution in understanding primarily in pedagogical terms, noting that he has become more student-centered and less teacher-centered. That is also reflected in how he views knowledge, reflecting that much of what once needed to be carried around in one's head now is accessible through electronic devices. He feels free to focus on developing understanding. Lauren also noted that the availability of information has allowed her to change the content taught, bringing more current and immediate events into her

classroom. She noted that she focuses today on content over presentation when students use technology to demonstrate their understanding.

Late Majority

Members of the late majority can be described as skeptical. They often will adopt an innovation because of peer pressure or necessity. The norms of the community dictate their willingness to adopt an innovation, often requiring that the majority of their peers are using an innovation. They require that most, if not all, uncertainty associated with an idea be eliminated. They are rarely sought out for advice or help in adopting an idea. Two participants illustrated that cautious adoption pattern of technology into their practice.

Sharon Bishop.

Sharon Bishop has been a teacher for 35 years, 15 of those at Walden Middle School, where she teaches social studies and ELA to seventh-grade students. Previously she taught at other middle schools, as well as at elementary and high schools. She holds a master's degree in educational literacy, and spent 12 years as a lead teacher of language arts. In that role, she coached other teachers in literacy, but was only peripherally involved in the deployment of MLTI. Three years before this study began, she moved back to the classroom. As a veteran teacher just beginning to integrate technology into her practice she provides a lens on the challenges all teachers faced 13 years ago when the initiative first began.

Pedagogical Stance.

Sharon readily calls herself "old school" when discussing her beliefs about teaching and learning. Her beliefs are clear, and drive not only her practice but inform

other aspects of her career. She described how she came to be on a teaching team with another colleague.

> "I needed somebody to have the same philosophy of teaching that I did. I needed somebody that was not loosey-goosey. I'm not that kind of teacher. I'm old school. I have expectations, while I'm here, and their job is to learn, my job is to teach. I love them, but you know, we have a job to do. I knew that it would be a similar experience with him [her team mate]. I thought I could teach him things. I knew that he could teach me technology things. I felt like that was the right fit at the time.
>
> [My students], they would say I work well with my teaching partner, Mr. Ackerman. We complement each other, on a variety of different things, and he's young, but he's an old soul when I talk to him. I took this position, because of the team. I would have waited. I knew Logan's capability. I knew that we had different teaching styles, but we would complement.
>
> I'm a strict disciplinarian. I believe in having a shared community of learners, but having rules that we all follow…so, that to me is a traditional teacher, in the fact that I don't have class meetings. I do if I need to address things, but it's not every day. It's more these are the expectations. We're here for a purpose. We need to do what we need to do."

Sharon is reflective about her practice. She is thoughtful about her instructional practices including questioning, assessments, and homework.

> "I want to get better at what I do. I want to ask questions so kids have to work harder. So, I look at the kinds of question that I ask to make sure.

Sometimes it doesn't work and that's the other thing that I constantly look at is, I didn't get the answers I wanted out of this question. Out of this test. What do I need to do? How can I perfect this? How can I change this, so that this is what I'm eliciting from kids?

In social studies, I try to offer a variety of different assessments that appeal to different learning styles. So it could be group work, it could be a map they put together, it could be a writing piece that they show what they know, or it could be a multiple choice or an essay test. I try to appeal to different learning styles. I do that also in language arts, but in different capacities. My job, I feel, is to teach them to be able to interpret, to analyze, and to be able to convey that through writing. So, I do a lot of analysis in my teaching. Teaching them, modeling, reading it, doing some read a-louds, talking about how to do that, giving feedback on constructive responses so that they can see. They're grade driven, at this age. I hate it, hate it, hate it! I understand the standards much better than I do grades. But I know that, they're two separate systems that I have to match, and I don't like that. I love to be able to say you're meeting the standard, because they all want to meet the standard. And when they don't, they're not there yet, that's really hard for them to hear. It's just developmental.

I'm not a real believer in tons of homework. I just am not. I want them reading every night. If they do that I'm really happy. I want them to follow through with something that I have introduced that needs to be practiced, for the next day. But I would rather have them working in class so I can see what they're doing."

She often spoke about getting to know her students, which informs her differentiation.

> "We talked about one of the goals for our learning area is how do we know our kids as readers? We are totally independent reading at the middle school. We don't have books we force on kids. We have book groups. Everything is choice. The way we get to know kids is this [pointing to the reader's notebook], which is much harder than doing a novel study, passing things out, giving periodical quizzes, because you have to do a lot of reading yourself. You've got to be able to know the books. You have to conference. You have to know what kids know. You have to really push them in their thinking.
>
> And, you know, again it's more about the differentiation. Who needs what, who can I pair up with as good models? Constantly moving seats around. All of that type of thing, so that they can focus and function. Most of the challenges are attention, focusing challenges, and executive functioning. It's the differentiation piece. To be more aware of it. My subject just lends itself to it. So I don't have to create all these lessons. I've put the appropriate book in the kids' hands. I know the kids that I need to structure and give graphic organizers to in writing. I know the kids that I need to break down the lesson, and come over and speak to."

Those beliefs drive the areas in which Sharon has integrated technology into teaching and learning.

TPACK in the Classroom.

Sharon and her colleague have developed an online reading notebook. As she described the notebook, and how she uses it, her need to know her students and differentiate is reflected in her use.

> "So Jay and I, over the summer, created through a technology course, a readers' notebook for each grade level. We have a goal-setting page, where they set a goal each trimester and then they respond about how they've done at that goal. We've got a reading log where they can set the goal and then they reflect.
>
> I'm trying to get them so they can branch out in genres. They might be fixated on one genre or reading a lot on the weekends and not enough during the week. So, it's individual, I coach them on it. That's a part of a conferencing piece. The reading log is a place where they house their work. These are all their genres [pointing to the computer screen] and where they house all of the books that they've read. This particular student's first trimester, this is what she read in the summer, and this is what she read in the course of the year. They indicate the genre so they can see patterns. They can indicate if they completed or abandoned a book. It allows us to see patterns. We might look at if it was a just right book, too easy or too difficult."

The online log keeps track of the genres students have read and allows Sharon to use evidence to prod students towards a wider diversity in their reading. Because all reading is self-selected, the notebook helps students see their tendencies and provides an opportunity for Sharon to encourage more diversity.

The reader's notebook also serves another function: facilitating other teachers' abilities to "get to know" their readers.

> "So each trimester, we add things to the online reader's notebook. It houses all of their writing that they do about reading. When they go to eighth grade this will follow them there. They'll take the same notebook and they'll build

off of it. So their eighth grade teacher can turn and say, what books did you do your letter essays on? What books have you read in the past? The intention is to have this be something that is their middle school experience with reading."

The reader's notebook also has evolved to serve other purposes for her ELA class. As she pointed to each of the tabs or sections in the online reader's notebook she described the features available to her students.

> "It includes an interactive notebook where we post books. We have the age appropriateness, links to our library; this links it to the best teen novels ever by NPR. These are the young adult award-winning books. So, there are sources for them. If they get stuck, they still come to me. Just like we put books on our bed table or put things on our Kindle that we want to read, this is their source of books. This is a new category [pointing to a new tab or section of the notebook] that I have tried this year, as I've taught short stories. Here they've indicated the strategy that they've been using and here are their notes and definitions with links to them. So when I teach irony, they can write the definition down there and they have that. This is the first time this trimester that I've added any notes to this log. This last one is for the writing about reading. Each term they attach their reflections."

Although her use is just beginning, Sharon is an advocate for that digital tool. She noted again that it allows her to "know" her students.

> "Again, this is a piloted thing. Jay and I probably utilize it the most. Matt and Marsha are dabbling. Eighth grade is dabbling. So we've created a user guide, a friendly user guide, as we go along. As I use it for something, I write it down.

When you get to this part, this is what you can use this for. For me, it takes practice. But it's a tool for me to be able to immediately see their work and reflect on their work, give them feedback. At the beginning of the school year, the notebook from last year helps me to know how they value reading. It gives me my first snapshot of them as a student. The other piece that I would look at is the analysis. I'd look at some of the writing and how deep a thinker are they? Not the expectations of the teachers or what they asked them to do, but what tools do they have in their toolbox already that I can build on. And it's pretty easy to differentiate. What genres have these kids been exposed to? Where are they so that I can beef my library up?"

In ELA, her digital notebook is a major focus of her integration of technology into her classroom. In social studies, Sharon also utilizes an online instructional tool, a digital textbook and notebook. Here as with the reading notebook, Sharon can articulate the benefits for her students.

"Our social studies curriculum is online, as well as in the book, so it is a new curriculum this year. It's from TCI and it's ancient cultures. So we're studying ancient China. We did Egypt. And then we'll do India in the third trimester. And, so this is the first year of piloting the online version of this. So that's been quite a, you know, an experience in itself for kids.

We have an online notebook that and I'll just show you the site. So in this [pointing to the online site on her laptop], I have a tool that I can introduce the chapter with. It gives you the essential question, and it gives me a presentation for kids, and it helps me guide my practice. They have their own tool, which is their

interactive notebook. And so, in their interactive notebook, this might be where their preview activity is, and they have to check this off. The cool thing about it for them is that they go to the editing key, they can check things off, they can drop pictures in there, and they can take notes. And I go to my grade book and look through their answers and, and grade them on that. Kids love this. They don't lose anything.

I want to use this as a tool, because we paid for it as a tool. I think it's a cool thing. The kids love it. They have this heavy textbook that they were lugging back and forth. They don't have to do that. They actually go to the materials. They have the handouts, they have the visuals, and they have reading notes. I can also access the text, and when you access the text, there's buttons for them to get audio. They can listen to it."

Sharon can identify a few pedagogical changes she would like to see in the online program and text.

"They can click on the main idea [button] and it'll highlight everything, it almost gives them too much online. So it doesn't make them work to find that, so I struggle with the balance, because part of my job as a teacher of the content areas is to be teaching how to read for information, and to help them be able to talk about it. What was the central idea of this chapter, this paragraph, and yet they can just click on the button and it'll tell them. So I'm a little torn in my instruction, how am I using this tool? It'd be nice to give that kind of feedback to the developers. And say, you know, don't give that button away; because that's what we want kids working to do. It would be a great differentiation button, so

that I could provide that for students that need that. Just like we give for an assessment where students have the option to listen to their text online, or audio version of that. But given to every kid? It makes them lazy."

She is also gaining familiarity with how to problem solve the glitches and impediments that can arise in an online environment.

"The notebook doesn't always match with what is said here [pointing to the text]. So, it's a learning experience for me because I have to instantly make adjustments. For example, this particular activity that they're doing is looking at the picture and they're analyzing an image to label the interesting details. Well, there's no place to label in their notebook. So, well, where do we do this? So, there's a note taking section at the top of their site so I'll tell them, "click on your Notes and Add Notes." So I have to preview the notebook to see, does the notebook match with this [the reading portion]? Even though it's a lovely guide, it's not foolproof. Though, I don't have to do a lot of planning, I have to evaluate how it's going to work for my kids. Because there's been some activities where I'm like, nah, I'm not doing that. Because, I know the nature of my kids and I know it won't work."

She recognizes that she may not have to find the resources, but she still has an obligation to vet them before using them in her instruction. She brings an experienced eye to the components that she will use. She can identify what works, and where she still must modify the curriculum.

"It will be better once we start supplementing next year, because then we can look at the units and say, you know what, I bet there's more that we can find

about Egypt, or about China, or about this experience. I mean it's has some very cool things but there's also things that need to be supplemented. What I do love about this is the variety of different assessment tools that we can use. For instance they're collecting evidence as they go along, and then their final assessment will be to verbalize, I mean to put that in an essay. They have your standard test, and also assessment that you can do online. They give some nice differentiation activities. So there are some hands on activities, there are some writing components. I like those pieces of it. But there's a lot that needs to, in my mind, be adjusted to help in the job of becoming a better content area reader and writer.

I don't want to lose the essence of why this tool is helpful. I still need to know them as, as learners. There's a lot of creativity that can be used with this. I like it all, but I want to see that there is an increase in the level of their thinking. And sometimes you're wowed by the presentation, but not of the thinking. I don't really care about that. Do you know what I mean?"

Sharon has incorporated major digital components into both her ELA and social studies curriculum and teaching. However she still is wary of the overall benefit, and has concerns about several aspects of technology integration. For her, the time required to become fluent is an impediment.

"Okay, so time is definitely one. The constraints of the day, the amount that is required. Part of it is me, the kind of person that I am. I spend so much time looking at student work and preparing. I know that the way that I'm doing it, I feel, is the right way and if it's giving feedback and working on Google Docs,

that's okay for me. I'm sure there's ways that, auditorally, I might be able to get through things faster. But, then, I think of the kids that are the visual learners and, and how they need to have that written feedback and I'd like to be able to do it all. So, part of it is just who I am. And the fact that I spend a lot of time just being a teacher."

Sharon also sees a downside to the technology available to her and her students, even as she incorporates it into her practice.

"It's also the distractions. It's not that I don't think that they're learning. I just have to build that trust, and that trust is a hard thing for me to do, because I understand how tempting all of this is. And that's the management piece. Everything that we do is online practically. I mean when Power School [the school's online grading program] goes out we're all like, oh my gosh, what do we do? I mean how sad is that? I'm like wow! Wow! We can't do the assignment, because guess what? It's online research. Aw gee we don't have any books to research. It's just too funny and kind of too sad. I mean I'd like to access the computers, what a tool they can be for kids. But it's a challenge. No question. It is a challenge.

I've noticed in years past that kids' focus seems to be decreasing. I don't think it's their ability, I think that they're just unwilling to focus. And I say that because there are just rapid shifts of attention at all times. I don't think they read as comprehensively as they used to. I think they're used to skimming things. So, I see that as a change, and the focus while directing instruction.

I think they have an appetite for endless entertainment, and that computer screen is that. Bouncing from one screen to another, whether it's screen savers or whether it's applications or not. But, I just find that kids are not as willing to stay focused as they used to. And I don't know if it's MLTI, or it's just the generation now. It's a variety of different things, but we identify more and more students with attention-deficit disorders. All the time. It just seems to be increasing more. And so I don't know but I feel that obviously technology has impacted us a lot in that respect."

As she described the issues that are new to her practice because technology is available, she bounced between the pros and the cons. and can identify what role her beliefs play in her comfort level.

"If I can project something, if we're engaged and I have the control and I want to show them these cool things I love that. I love that. Or when kids are showing things, you know, showing projects and what they've done and it's actually showing them learning, I love that. The engagement isn't necessarily always there. But sometimes I don't know if all the time their screens are open that they are actually engaged in the project that they're working on. Or are they flitting through other things? I don't know. It's that control piece for me. It offers too much, just too much for them to be able to see and utilize. I have to see their screens. And I have to monitor all the time and teachers aren't good at that. Or they don't care to and that's where problems start arising. You'd like to think that kids are honest in their work. But they're kids, it's not malicious. They might even think that what they told you is true, right, even though it's not. Early on I got

three emails from the tech people [student computers can be monitored remotely by the technology staff] saying this child was on this and this one was on this, and this one here. It's almost like it's personal. I feel disrespected because you're giving this tool to a child and he's still a child."

As she described her experiences, Sharon demonstrated wariness of the value of technology in her practice, and her reluctance to move too quickly.

Evolution of TPACK.

Sharon reflected on aspects of technology integration that have been in place for years at WMS, but are relatively new to her: digital grade-books and communication tools, for examples.

> "It's so much more advanced now than what it was. I mean, what we expect kids to do, what teachers know how to do. How we manage our classes, never did I feel like I was going to do all my grades online and manage accounts. Kids can access their grades online all the time. Or that there would be no paper report card, that all of your communication is through email. Email! Or that we would not talk as humans. So everything now, we're moving to being able to blog, being able to have units, and share everything online. I never envisioned that. I don't know, you know, I never did."

She was reflective and willing, recognizing benefits, even as she struggles with the changes that have occurred in the classroom during the implementation of the MLTI.

> "I had hundreds of files in cabinets. One of my goals was I'm going to go through these and I'm going to pitch things that I didn't use. I didn't use them more than twice all year. My food's in there, so I do go in there, but it's not a tool

anymore where I store things. So that piece is different, everything's online. I still do have the plan book I still do that, but I think that the needs of children are so different that, you know, you have to change. There's a lot that's different. The parental demands are different. We are constantly sending emails, mass emails home to parents about what we're doing in class. And they can access our teacher page, they can find out exactly what kids have to do, so there's no question what's expected for the next day…I don't want to be one of these teachers that people talk about, saying she needs to get done.

So, yes, it has changed. I'm not so fearful of it. It's part of our culture, our society. I couldn't live without it, because all of my records, everything is archived. I had two-three file cabinets that I downsized to four drawers. And even then, if I counted the time I opened them up this year it's probably two. Which tells me that all of my, you know, all of the things as a teacher that I have [pointing to laptop], can be archived here on the drive."

Although ambivalent about using technology to support her, she isn't ambivalent about the need to have students using technology.

"I understand that this is a tool that they need, in our culture today, and I've created things online. The way I communicate, the way that they respond, everything is through email, so that they can copy and paste their assignment. Or it's sent right to them so they can have access. That's the way they are. They can write well. They can type well. So I have to be able to also.

I want to have my kids have a laptop as a social studies teacher. Well, I mean, for me it archives their work. I can communicate with them on an hourly,

> daily, minute basis, on what they're reading and writing. And they can communicate back. I can see the revision process. When we were in school that was harder. I can look at their history. I can see the feedback, whether or not they've made the changes. So, I do love that piece. And I didn't think I would at first. I kept printing everything. And making my own copies, but then I'm like you know what, I can't do that anymore. I have to be able to communicate with Google so I can see what I've written down. So that piece would be something that I feel is a huge, huge advantage."

Sharon has incorporated technology for other pieces of her practice, even when it was not her natural inclination. She has overcome her reticence because she believes it is best for students.

> "For writing conferences I give a couple kinds of feedback. They house their documents in their readers. When writing about reading, anything that has to do with the reading, a reading assessment, an analysis, they house it in their reader's notebook. My conferencing with writing is usually through Google Docs, and I give feedback all the time, that way. I wouldn't say it's easier because I'm a paper/pencil person and I like that. But it's more efficient; it's more immediate for kids. They can make adjustments right there. I can chat with them while they're online. They will comment, make comments back to me, they'll ask me specific questions. So it's better for them, and I guess if it's better for them then it's better for me. Whatever works for them that is going to get them to improve their practice, works for me. They're able to get more feedback from more people. And before, I think for many students, we might've had peer revision, where they

would read their story aloud, and people would give them feedback. But those kids never saw that piece again. Here, they can share with five or six other people, and they can constantly look at their writing. So I think it's better that they get more feedback.

I still love the one-on-one conversations. I'm not going to tell you I don't. But sometimes that's what they need. They need to be able to see things in writing. I know there are a couple of options online that kids can do that are auditory pieces that I have not practiced yet. But it's on my to do list of ways to verbally communicate with kids. So those auditory learners can listen and not necessarily get caught up on the reading of feedback. Because sometimes it's easier to have conversations."

At another point she described a situation where she holds onto a form of non-digital communication with students even though they struggle with it.

"I spent a lot of time with my letter essays. I write back to kids. So they write their pieces. Their job is to analyze literature, analyze the writing of literature. No, not the plot summary, that's not what I'm asking them to do. I'm asking them to show me what they're like as a reader. How do you do that so you talk about yourself as a reader? And so they write me a letter. It's more personal. I still like to write back to them, and do it on paper. I can write much faster than I can type, so I like that piece. It's a different type of communication. They can't read cursive, so I end up reading most of it to them because I can write faster in cursive. It's kind of crazy but I do. With Google it's that impersonal piece, but it is

their world, and that's the piece that I need to communicate with them most of the time."

However, Sharon has incorporated technology when she can see or articulate the benefits of using it. In a series of quotes, she described why she has incorporate a digital version of the readers' notebook based upon Nancy Atwell's Reading Workshop's approach.

> "Based on the reading goal of our learning area, which is how do we know our readers, we started work on this online notebook. I think, I did, because everything was in a different place. They had a paper copy of the notebook. They just didn't archive everything together. I wasn't afraid to do this. Some of the things I didn't know how to do, such as link to different sites, Chris was really helpful in that. But I wanted to put my piece of what I thought was important to me into the project, to know my readers.
>
> And I think for me it's a managing tool; it's a conferencing tool. And I think every teacher, any reading, any language arts teacher, wants to get better at conferencing with kids. And this to me is the tool to do it. Because I can sit, I can read it. And I'll be ready for you, when I sit down with you and say, you know what, I read your response on *The Giver*, and there were so many powerful details that you could have added. It just gives me more things to give them feedback on, so that they can improve their practice. So, for me it's an accessible tool that I can get better at my practice when using. Be a better teacher and give them more feedback. I'm not hauling home, you know, a carton full of notebooks."

Sharon described other areas that she anticipates incorporating technology into, building on her emerging comfort with the digital readers' notebook.

> "This summer we'd like to add the writing portion so it's our reading and writing notebook. All of their writing of poetry, all of their persuasive essays, all of the short stories that they write will be on there. Things that they've generated, even in social studies, it would archive everything together. For me, it's at my level and I'm getting better at using this as a tool, mostly for conferencing with kids. This is my piece when I'm doing my correcting [pointing to a website on her computer screen]. I go right to their reader's notebook. I have them all stored right on my site. So I just go right to their name. I can click on this, everything is shared with me and that's how I score things. So I don't have to go looking for anything. I don't have to look through emails, it's all archived right here."

Later Sharon reflected on other areas that she would like to improve upon when using technology, but again struggled with the relative importance of technology in her practice. Her adoption is very deliberate.

> "I'd like to get better at managing all of the folders and accounts. You attend workshops and you think, this is cool. And I see it once. [Laughter] But again, I don't put time into practice like some people do. They go home and try it, and I'd rather garden, or I'd rather get outside and, you know, ski, or snowshoe, or do something or read, or do some things that I like to do, as opposed to explore and practice on those technology sites. But, I would like to better know all the tools that I have at my fingertips that could make my practice more organized and efficient. But, is there anything out there that is screaming to me, that I'd like to

know? I'll look at Evan Reed and think teach me that! He's doing a Google classroom, and he's doing all this cool stuff, and I am like that'd be awesome. I'd love to do that. But you know, I think if I could put literature in their hands, if I could make the kids love reading and writing by teaching the things that I do teach, I'm all good."

Daniel Gallagher.

Daniel Gallagher, who has a master's degree in literacy, has been an eighth-grade social studies, English and math teacher for 29 years, the last 15 of those at Walden Middle School. He always wanted to be a teacher.

> "I was one of those few kids who early on knew what I was going to do and I actually stuck through it all the way through. I mean if you asked me in third grade what did I want to be, I wanted to be a teacher and I don't know if I knew why back then but as I got older, I certainly knew. "

Pedagogical Stance.

Daniel approaches his craft in a straightforward manner. He appreciates the differences between his primary subjects of mathematics and English.

> "And I really like the difference between math and language arts. I mean, completely different. I get to see students showing different strengths. Sometimes you have students who are really strong in math and maybe they struggle with writing. Or both, and sometimes it's the opposite. When I used to only teach math, if that wasn't their subject it was almost like they equated the difficulty in that with, you know, me. I was the bad guy. So this way I get a chance to see kids in completely different disciplines and I really like it a lot."

When asked to describe his classroom and the approaches he takes to instruction, Daniel detailed his content and approaches in terms that can be seen in classrooms across the country.

> “Well the subject matter themselves are very different. Except, I can use my knowledge of reading, content area reading and apply that into math. We do reflection questions, mathematical practices work, and this involves some writing. And so, I find, I know what we expect in writing. I think that might make it more cohesive for them.
>
> But there, I mean, there are differences in a lot of ways. How I grade. I might conduct a lesson in language arts with one or two mini lessons for whatever aspect of writing that we're doing. And then they get to apply that. Right now we're in poetry. So students are applying mini lessons of the power of I, or beware of the participle, or figurative language, which are maybe five to ten minutes of the class, into their writing. I can conference with individual students on that.
>
> In math we use the CMP Model, the connected mathematics project. You know a lot of problem solving in there, a lot of exploratory approach. We're in the Pythagorean theorem unit right now. We don't come right out and tell them a squared plus b squared equals c squared. We actually explore why and it solidifies their understanding.”
>
> Daniel described a typical class structure in his mathematics classroom.
>
> “Students would come in. They'd start off with an agenda on the board. What they would start with quite often it's a skills practice, skill practice problems. They

receive a sheet on Monday, we do two on Monday, two on Tuesday, you know, et cetera during the week. These are basic skills, could be multiplication of fractions, division of fractions, percent, could be any of the basic skills.

So that's the first five minutes of class, five to ten minutes of class is working on those. I may go around, quite often, and check for homework completion, so they have that homework out. They're working on skills practice. When they're finished with that, they work together and compare answers to their homework. A lot of times I will tell them, you have a question? Ask at your table first. Quite often it can be solved right then at the table. If not, if you're all stumped that's a good question to ask, once I bring class together as a whole.

I'll then do an introduction to the new problem of the day, the new CMP problem. And students will then work together, collaboratively, with you know, with their table partners. They have what's called ACE questions, Applications, Connections, and Extensions. Those are typically the homework, which they may start in class. Depends on the length of the problem.

I'm monitoring around the room, answering questions, posing questions, and going around to get them to do whatever today. Recently, we did a proof of the Pythagorean theorem using puzzle pieces so that was more hands on. Which most of it is. We have labs. They build paper bridges and, you know, test the bridge length and bridge thickness to the breaking weight and things like that."

Daniel went on to explain how those "labs" are used to demonstrate mathematical properties. He pointed to a spreadsheet that he has created for student's to use in Google

Docs. The spreadsheet is projected from his compute, and students record their data in the spreadsheet.

> “You know, they can see this example. But they can then put a chart in. So, we take the mean breaking weight, and we look at that. And then from that we gather that yeah, well, it's certainly not perfectly linear. This is experimental data. But, what does it appear to be? So we start getting into that whole line of best fit and we talk about if we only took one group's data, probably it wouldn't look so clear. But as you can see once we get more data in there, it starts to resemble a linear relationship.
>
> The next day we do another lab but this time we fluctuate the bridge length not the thickness, so the thickness is always the same. The groups find, you know, some different kinds of results here when they look at their mean. They definitely see a different type of a graph. It's just introducing them to this curve. It's increasing at a decreasing rate. And again, with the data it, the more you get, the more from the class you get, the more it starts to resemble this curve. But, they can still tell in their own individual data that it's certainly not linear. So, I use that spreadsheet. And again, the kids will come up and record their results. And it's just a nice visual for them.”

His use of the projector and screen with a Google Doc still seats the activity in the teacher’s hands. It is more of a demonstration than a laboratory. The pieces, the Google platform and graphing software, would allow for a more student-centered activity, but Daniel has chosen to undertake the demonstration as a full class activity. The platform would readily facilitate students sharing data directly in the shared spreadsheet, on their

own devices, instead of each group coming up to add it to his computer's version. The tools have been used to digitize a task to look like a non-digital version of a graphing activity.

His description of the current English unit on poetry might also be described as "typical" except for the opportunity provided to students to publish for authentic audiences.

> "So for the poetry unit as you can see on the board there, they're signing up when they're ready for a conference on their final draft. We discuss the poem that they will eventually submit to me for their final score on that particular poem. But they're also conferencing with me on possibilities for publication, and I have some sites on my webpage they can choose if they want to submit to this contest or just send it to this magazine.
>
> And so a conference will come up, we'll talk, I'll use the mini lesson ideas. I'll look at the poems that they've selected and are trying to choose between and offer my two cents worth, you know well this, they're both strong. This one has a lot of nice figurative language in it. I think there's more promise maybe here. But ultimately it's their choice. I find most often we're thinking the same."

Daniel's respect for his students as writers and people is evident in many of his descriptions of his role as a teacher. Though his lesson may follow a typical framework, he gives feedback carefully to students, so as not to squash their creativity or ideas.

> "I like to do an editing phase with them at the end. Once we've got the content the way we want it, now let's look at the editing. I ask them to first make all those corrections that they know that they can fix on their own. And then we

look together. I think I mentioned before, we have that program, the MUGs program, which is Mechanics Usage Grammar. And so I can use that vocabulary to say, you know, to simplify that maybe a hyphen. But I try not to make too many comments initially on the editing. …Or I might write something and say I'm not going to comment on the rest of your editing just now. So they don't feel like that's the only thing I had, but we will get to that later on, in the editing phase. I try to keep it strictly to content."

Instruction, as described above, is whole-class instruction. Differentiation, in his English classroom, is achieved by giving students some choice in their reading. But Daniel still maintains some control over the content studied.

"We have a unit on a classic, *Animal Farm* by George Orwell, which we do as a read along. So the students have a copy and I'll read aloud. And then we have discussions throughout that story. That's the only whole class reading done; we've kept that one. Atwell's [Nancy Atwell] vision is pretty much everything is self-selected. We do for the most part. I'm a firm believer in that."

He then described an approach that provides some choice but not full choice.

"We also have two non-fiction units. One is coming up in January and it's non-fiction survival storybooks. So, I have like eight from them to choose from. And I give them a blurb online so they can read about each book to get a sense of it. And I have a Google form where they actually rank them in order of their top four. And then I take that information and knowing my students and good working groups. I put together groups of three to four based on one of their top four choices."

TPACK in the classroom.

Daniel is very conservative with his use of technology in the classroom. He readily admits that he has been hesitant to try a new tool unless he is sure that he has mastered it. He described that hesitation, but also his desire to use more digital tools.

> “And so I am very well prepared for my lessons in what I'm going to do. But all of a sudden I think, oh, this will be great right now. And there's no way I could do it, because I can't be sure I can do it. [Laughter] Sometimes, I'm into a class and think; oh this would be great to try. I wish I could get this or this, and I think Lauren could probably immediately open it up and it's done. I would have to spend time thinking of where do I go, how do I do this? So I wish I was better at that. That's, that's one thing I wish that I could just adapt something, right on the fly be able to, you know, incorporate something. That would be helpful, that is something that I could use.

At another point he described a professional-development opportunity to learn from his colleagues that illustrates both his desire and the need to be fully confident in how to use a tool. Speaking of the use of Socratic, a polling software, Daniel said:

> “I wanted to do one of those I can't remember the name of it. I think it's Socratic. Where you can ask students questions and they can vote and it will show you a pie graph of the class, how the class is doing. And I wanted to try that. That was the result of a staff wide look at some new software. We have a database full of different links to places that we can try different things. And then we jotted down what we tried and how it went. Just to share with everyone else.

So I did that. And I can't even remember what class it was for. I was giving a kind of a dipstick reading on how they were feeling about a certain topic that we were talking about. And it was neat. But then sometimes later, I have a hard time using this. And I'm trying to get the class going and I just can't think quick enough to remember how to do that again. [Laughter] So I don't. It's something I would definitely use more. I just think I need to practice it more myself."

Daniel's preference in learning about new digital tools is to observe his colleagues use them, and then use them for support.

"There have been some things that I come across and I think, this would be kind of a neat idea. And my first reaction is to get my colleagues to buy into it, so that we all do it together. I just learn better that way. I could probably try it myself. I don't think I would get very far. I might get frustrated. Time might be an issue. But, if we said okay, let's all meet on our next flex day. Do you want to get together and talk, and then I can see what other people think about it? And we have a common plan of how we're going to do this and how we're going to present this to the students or whatever."

Daniel recognizes that his technological knowledge isn't the same as his colleagues. He also recognizes that he is learning and making improvements in his understanding of the technological domain.

"And I'll even say to Lauren, hey, I got that done all by myself this time and she'll laugh, and then I may have to go for a question on something else. I mean, early on it was silly things like oh, I forgot to share it. You know, they

couldn't open it because I forgot to share it. Well, now that's pretty much, you know, I'm good at that. [Laughter] I can remember to do that, you know, for documents and things. But I think probably, I mean, I'm never going to be like some of my colleagues. I just wouldn't be able to do that with everything you need to know. How do you know? How did you know to go there and do that? You know, [Laughter] I'm just kind of not, you know, necessarily gifted it all of that stuff, but there are certain things I can do and by doing and sharing it with others I feel I have something to contribute."

When asked about where he feels he is contributing, Daniel identified his comfort using spreadsheets for data analysis.

"Spreadsheets are probably the number one thing. Ira, another staff member, it's just not his thing. He's doesn't get that kind of stuff. So I will help him a lot with that. And so what I'm really doing is, I'm transferring what I've learned from my other peers. And, since he teaches the same subject as me, language arts, it makes sense that I've already done this, so then he comes to me for that also. I have worked with Lauren. She came to me and she was doing something for a class she was taking, and was having trouble with the spreadsheet. And she and I sat here, and I think it was a Friday afternoon, for two hours, and it was a tough one. And finally, I was able to get it, and she's, like, that's it, that's it! And so, I felt good that I could help her because she helps me so much all the time. [Laughter] All the time. So that just feels natural."

That familiarity with the technological domain of using spreadsheets still has not fully merged with the pedagogical in Daniel's use of spreadsheets. He talked about using spreadsheets in his mathematics classroom.

> "They have their homework, they'll have whatever they've written on their paper. And they know when they come in to bring these up and as I'm coming around to check, they just click on a tab and say here's my graph. And, I will usually then say, can you click in one of these cells, and click in one of these cells so I can see what their formula is and I can evaluate that quickly."

Daniel takes time at the beginning of class to review individually, as he walks from student to student, their spreadsheets and formulas. He could easily accomplish the same check digitally by asking students to share their work with him via Google. That tweak to his workflow would save time each day spent just checking for compliance and student understanding. He knows that they can do that as he has done it on some assessments, and he knows his colleagues collect homework using a shared Google folder with each student. He is aware of the opportunity.

> "You just drag them in and out of a Google folder. So that's something I'd like to do. I get the idea. I'd like to hear a little bit more about it. And it is something, I'm going to pursue so that we can do that before this year is out. Not wait till next year."

His use of Google spreadsheets has begun by replacing the tedium of plotting data and calculating quantities, typical skills in any mathematics classroom, regardless of whether they are a one-to-one classroom or not. The overlap with good pedagogical practices is still emerging.

At other times the overlap is more complete. Daniel uses a shared Google document to have groups reflect on an assignment or problem in mathematics.

> "And sometimes in math we have what's called reflection questions. So I have at times had an open document shared where kids can go in and share their answer for this question. And we blend the two groups that are doing the same question together. They can see it as it's going on. They can see it right on their computer screen, what other groups are thinking about. It might be questions where they're more like paragraph responses."

The sharing of long responses is facilitated by the use of Google in that example. Many of the benefits of capturing student thinking in that manner, such as a permanent record of their thinking, the ability to share seamlessly with multiple editors or collaborators, and the ability for a teacher to provide instant feedback, are possible in other uses of Google Docs described by Daniel, were he to alter his approach to instruction.

Daniel often integrates technology in support of approaches he has been using for years without technology. Here he describes the digital components of his book study groups.

> "Well, going back to the book groups that I've done for a number of years, one of the Common Core standards is making comparisons between text and video or some other format. *The Miracle in the Andes* is a book we use. When students complete that book in their groups, they're not all going to finish at the same time. Their next job is to complete a document with post-reading activities. And for that particular group, they will look online. There's a documentary that

they can get right on the web. And they actually see Nando Parrado, who was the author of the book and the gentleman who led the way out, talking about the adventure. They actually get to see him and they get a visual representation of it [the mountain] as well. And so they can make comparisons to what they read in the book and what they're seeing on the screen and they get other people's perspective. So, that's definitely something the technology helps me do. I mean, they can do it right there in class with headphones. They can see that, and then make their comparisons."

Later Daniel described his beginning use of blogs to digitize some of his book discussions with students.

"Well for example on that blog site that we have I have the students talk as a group. When they come in, there'll be a prompt question posted. The first day's prompt was, what is the setting of this story? Be sure to be specific with time, and place and share any significance it has and or thoughts you have on the setting. So, I engaged the students in a conversation. They elect a recorder. A different one each day, who records the thoughts of the group I then look at that on the blog. Then I go in and comment on that. And it sparks a conversation. I can make comments on what they wrote and then also pose some questions. And then, I'll get kids to respond back so there's the writing aspect, working on our writing as well. They're seeing what I'm thinking, what I'm wondering, and they're responding to that. And a group will respond to that. For me personally I think that's good teaching because I think it's getting kids to reflect on what they've read, share that information with others, hear different perspectives. So I just

think that's a neat way of doing that. Which we also could do it with actual good, old fashioned voices."

His use echoes non-digital approaches he would enact if there weren't a one-to-one deployment. Those applications of technology are initial steps in creating a blended learning environment. He described another brainstorming session that has been digitized, but in a manner that reflects the same process that would be accomplished using chart paper.

> "And take notes for kids when we talk about let's say, rules for our book group. What are the rules for the book, what do you think, you know, the rules for book group are? I'll have the small groups chat about what they think. You know listen to everyone's ideas, don't be judgmental, those types of things. Then I'll call the class together and I'll have a document up on the screen and I'll type it so it's there for everyone to see and then share it."

Those forays into digital substitutions for non-digital instructional approaches are peppered throughout his interviews.

Daniel has also adopted some other digital practices that begin to create a blended learning environment. He described how he uses his website to provide students and parents with synopses of books so that they can make choices for their reading outside of class without visiting his classroom library or the school library.

> "I have my classroom library available on a Google Doc. When, when we first started doing, you know, using Google. This is so much easier to use Google because I can go in and add a book. Now my kids can have access to the books in my class as well as the parents."

In the following example, Daniel articulated why using a Google Doc is easier than just putting his books online using a webpage or static site.

> "I had my classroom library available for years on my webpage. I said let's do it on a Google Doc. When we first started using Google, I thought show me the benefits of how I can use it. I use to have to make one [list of books] and then import it, then put it on my webpage. This is so much easier to use Google because I can go in and add a book. I can easily search. I know how to use a spreadsheet, so I can do that. But now my kids can have access to the books in my class as well as the parents."

There are areas of Daniel's practice where he takes full advantage of both the technological and pedagogical tools he is using, but at other points he fails to implement the same opportunities, especially around the use of Google Docs' sharing functions.

He described the making of an online slideshow that introduced how to use iMovie to make a book trailer. Students were to report on their reading by creating a book trailer, but Daniel didn't take class time to teach students how to use the tool, instead he developed a step-by-step slide show for students to access on their own.

> "They actually do like a movie trailer but it's a book trailer and they create it. She [a colleague] helped me update my sources and she helped put it onto the slideshow. So, the slideshow showed them the requirements, how to create the trailer, and links to where they could go. We used class time to create the movie."

Instead of fully flipping the instruction, Daniel created the digital resource for use in the classroom, but at the students' discretion. It is a simple step to require the slideshow to be reviewed outside of class and capture all of the class period to work on

the project. Although not a fully flipped model, his use achieves many of the goals of a flipped classroom.

Like many teachers at Walden Middle School, Daniel has adopted Google Docs to support his writing curriculum. That use illustrates a fairly complete use of the possible tools available to him with the platform.

> "In language arts I do the writing pieces I do because they'll do it on a Google Doc and share it with me so I can actually go in and make comments. During the writing process you know, through out on the side [of the document], you just enter a comment. When kids mark it as resolved, I know they seen it and they continue on.
>
> If they have a question about it they can leave it for me in the document. I would say more often they ask me in conferences than class when I come around. Do you think I should do this? Should this move up here. We give them feedback but try not to write it for them. I often like to say what would happen if you inserted a paragraph here. You know and let them go with it.
>
> And we see that running record, you know, of the work in progress. So, that's really helpful. When I have study period time or after school or on a Saturday morning, I can just go on the computer at home and pull up memoirs and start going through them. And, so it's that technology piece that I really like. … It's just this running document that's there."

Daniel noted that he could reach all his students now, not just a fraction during class.

> "Well, it, it wouldn't have been nearly as immediate, the feedback. It couldn't be, you know. I would have to collect a draft periodically or sit with them

as they're writing. But, how many can you get to that way. I mean, I can get to all of them this way that I couldn't get to in the classroom. I do it from home or after school. I still conference with them in the classroom. But it may be targeting individuals. Maybe someone who I can tell from here, [pointing to Google Docs on the screen] which are really struggling. While others I know with my feedback on here, they're on the right track. I don't think we could produce the quality pieces that we have in the time that we do without it. I really don't. This is a huge help."

Daniel also sees another advantage to providing feedback using Google Docs.

"And it's easier for them to share sometimes, you know, send it to their friend, or send it to me, without me sitting right beside them, or their friend sitting right beside them. I think some of them need that initially at least. And I think that builds, that confidence builds the more that they get the constructive feedback."

When asked what tool he shares with the stream of visitors who visit Walden Middle School to observe its technology integration, Daniel notes Google Docs without hesitation.

"Well, I would say, for language arts, any written piece that we do with kids, when we're trying to give kids feedback on their writing, I would show them the benefit of having that on say a Google Doc. You can, even when the kid is typing, still get right on there and have that conversation with them. Or, if I'm at home and they're at home after school they don't have to wait to pass it in and have me go through all of these papers and make all these comments and hand them back. I can go in and make that comment. It gets them that more immediate

feedback. I would tell them, I would argue that that's definitely beneficial for them in the writing process because there's not a lot of gap in between revisions. … I think probably in the old days, they would probably lose interest if they had to wait five or six days to receive information back about their paper to then go on. They've lost the train of thought. So this is a little bit, certainly more immediate. I would have a hard time imagining any teacher of writing who would not see that benefit. I wouldn't want to give these up. I mean, there's very little of what I do now that I would want to go back to the old way of before technology."

Daniel has used technology in his mathematics class to help with instruction. Like Matt and Logan, he is careful where he introduces the tools. He described his decisionmaking about, and use of, graphing software.

"With the graphing we do, you know, early on I personally feel like there is a need for students to be able to take some data and be able to construct a graph, without just putting in the data [to a computer program] and having it done for them. At first I think I feel they need to know how to set up a scale. If the scale's already set up for them they don't necessarily have to. I might say early on in the unit, this needs to be a handmade graph. And then once I feel comfortable that they're all set with that, then to speed things up I would say this one you can use your laptop to create this graph. And then you wait and let them choose the graph program they want. But other times, I would say we're going to use Google or some other program. Quite frankly, if I ask them to create every single graph by hand, they probably would lose interest and not want to. And then not be able to go further and get the real learning we want them to get."

Evolution of TPACK.

Daniel's evolving integration of technology in his classroom has been a deliberate and gradual adoption of some tools and applications. When asked to reflect on the changes that he has undertaken over the 14 years of the MLTI program, Daniel noted that it has been a dawning appreciation for how he might use those tools, even as he worried that he was not taking advantage of their potential.

> "Well, I think everything is so much more fine-tuned now. When we first started, I remember at first wondering how is this going to work? You know, I was a little apprehensive. I mean, in my mind I kind of thought this has got to be a good thing. But, you know, probably the common misperceptions, that people have, you know, about how students wouldn't be using them for learning they'd be using them for other things, was also in my mind. And I think until we actually experienced it in the classroom, and saw what a great tool this was, we didn't appreciate it. I mean, I'm probably sure that I thought the same thing like you know, they're not going to be doing that, you know, and now I see the value to it. I mean not to say that there aren't some inappropriate uses. We have rules in place. And we deal with those as they come along, but you know, for the most part it is ok. I have a math class with 28 and I have only 18 in the other one. And then, in language arts, they keep us to 24, you know, a lot of kids. But I can go around and I can see what they're working on. And I can see it on my screen, you know. So at first, I was a little bit wondering how this would work. And I feel probably maybe the first couple of years, I didn't tap into as much as I could. But I guess because I didn't really know, but now I mean I use spreadsheets for math.

So well I'm not using it right now in math class, we definitely use it more in language arts you know, almost on a daily basis there. Whereas in math there'll be days when we don't use it or need. And I think as the years have gone on I feel more comfortable in knowing when it's appropriate, and when there's something we're doing where we don't need it and we're not using it. But I think early on, I didn't feel confident. Like, oh my goodness, you know, we've invested all this money in this program, and am I not using this enough? And someone said to me, well, if it's not appropriate for what you're doing, you don't use it, use it when it's appropriate."

Daniel referenced his use of spreadsheets often in his comments. His comfort with using spreadsheets was a touchstone for many of his comments about technology, especially in his math classroom.

"We use them for many of our units setting up tables. We even, you know, learn how to create formulas. They love it because it's so new to most of them. Very few students have had much work with spreadsheets. They can see their math problems set up in a table. And, I can do this, absolutely. They can insert a chart or you know see the graph and it's just speeds up things so much for us. We can get through so much and see it without, you know, taking the time. I mean I think there's some value in them making a handmade graph and we do that at times. But then there are other times where it's just something we need to see to process something else and it's much quicker that way."

That application of technology to his content area represents a tool (spreadsheets) that he is comfortable using, and he can articulate a pedagogical reason (focusing on the

meaning of charts and graphs instead of the mechanics of creating them) for their use in mathematics.

The use of spreadsheets was one of the initial forays into technology integration in his classroom. As he digitized some of his previous pencil and paper projects he began to appreciate the power of using a digital spreadsheet program for developing student understanding.

> "The whole math piece with the spreadsheet was the biggest aha for me. Because when we get to units like Growing, Growing, Growing, which is exponential growth, I was like, all of a sudden, I was like, goodness that was probably the first time I really was like wow, you know, this works. My students really got it."

Daniel then described another use in his classroom that has evolved from its initial beginnings. He undertakes a stock-market simulation with his students that allows them to invest and track the progress of a fictional amount of money in the stock market. The task asks students to do research on possible investment opportunities, and to track their success and failures using a variety of graphs and tables.

> "Early on it was like a once in a while you could sign up for the lab, you know? But when they came in and everyone had these laptops, things got easier. I have a stock market unit that we do every year. I've taught the stock market from 1986 where I used to go in early in class before school and make photocopies of the newspaper and have ink all over me. Kids would try to find their stock and keep track of it. But now, you know, it [the stock market] opens at 9:30 and we'll be in that class period and the classes rotate so everyone gets to experience it.

They do it on their computers, no more newspapers. Oh, you know, that excitement, they see it in real life, what's happening. They can do the research for their companies. That project went so far beyond when they had the laptops. That's probably, if I think it about it, the number one project, that I do, that I saw such a change, such a change from before to after."

Daniel has substituted digital tools for research and representing data (graphs and tables) for non-digital tools. His descriptions of how the project has evolved focused on efficiency and immediacy in obtaining and tracking each portfolio. The research is easier, the tracking is easier, and the representation of the data is easier. Fundamentally, the learning is the same.

Daniel shared his perspective for providing digital resources on web pages.

"We've been talking in our school-improvement team meetings, been talking about teacher webpages and how can we make them more uniform. Right now there's a wide range, from bare minimum information for parents and students to those who wow [Laughter]. The frustration is we have parents who will contact the school and say, you know, I was looking for such and such a rubric or something on my son or daughter's teacher's webpage, and it wasn't there. I had to go to another teacher's to find that. I don't think it makes us look good as educators. And so, I think when it started, when we first did webpages way back, it was basically your contact information and a homework calendar. That was it. Well, people have taken it further than that. So, some of us will provide a lot more resources and others won't update anything. So, one thing I've heard recently is to now work together to create sites so that all the teachers of

language arts can put that up on the web page. And, not every web page is going to look the same. I don't think we want carbon copies of the whole school. Yet that key information that all students and parents of students, who are taking language arts, should be there on each teacher's page. So, it's one link that we all share and we can put it on there."

The ability to share and collaborate with others has produced a willingness to broaden his practice and try some new digital tools. Daniel depends on a colleague on the eighth-grade team for much of his support in trying new ideas around technology integration.

"Things that I couldn't have done earlier on, now I can do, because she's taught me, but back then I couldn't. So, I think that early on, for me, I didn't use it as much because I didn't really have as much of a background as I needed to. But having peers who do and from my practice in doing it, I started to add things. … So, it's very collaborative. We have teachers on my team that range in ability from here to here [spreading his arms apart] and we help each other."

Daniel's experiences with technology have been positive enough that he can't imagine going back to a pre-digital classroom as noted in his quote above. It has become a normal part of what school looks like in his classroom.

"I mean, it's just like your pencil or it's another tool that we're using. It's not that special when we're going to open up the laptop. Yeah, I feel that way. I mean, it's just like you come to class with your textbook and you get your pencil and your pen and you get your laptop. It's just all part of the whole package that you bring to class.

I mean, there's not a day goes by we don't use this [pointing to the laptop], you know? With email and, and everything and creating documents and revising tests and, you know, making docs of those tests, so that we can modify year to year and change. And so we need to use these every day and it's our language. It's another language that we have."

Despite that experience, some concerns that echo his original sentiments about the MLTI project can be heard as Daniel reflected on the next wave of changes he sees on the horizon.

"Well, there have been things in the past which, when I first heard, I was one of those like we can't do that. The kids won't use that the right way. And now after doing it, I thought, oh, you know, they can do that. So, I'm sure that what I will say now probably will change. [Laughter] Right here [at Walden Middle School] they are talking about smartphones in the classroom. And I think, oh, they're just going to be fooling around. You know, and it doesn't make sense. Because they're just going to be texting each other and they're not going to be using them correctly. But if the material is engaging to them, they're going to use them appropriately, and kids could be emailing each other in class on the laptops, and I'm fine. I feel comfortable if that does happen that we can deal with it appropriately. So, I guess, I'm probably apprehensive about some things, but I feel like the more we've done this I can stop myself and say, mm, you thought that before. You know, I probably had thoughts, oh we're going to have laptops in the classroom, what are you talking about? [Laughter] You know, and now I could couldn't dream of not having them to do the work that we do."

Summary.

Both Sharon and Daniel have adopted technologies that are widely used throughout the school. Sharon's use of Google Docs and a digital textbook are also commonly used by other teachers. Daniel also uses some aspects of Google Docs and depends upon spreadsheets in his mathematics classroom. Both teachers noted that they wait and see when it comes to adopting a new tool. Sharon specifically joined the team she is on so that she could work with Logan, whom she knew could help her get up to speed on technology. Daniel describes his relationship with Lauren as fundamental to his understanding and adoption of tools in his classroom. Neither of these teachers described a tool that they had introduced to their teams or departments. They are aware and note that they have an obligation to use the laptops in their classroom, though they readily acknowledge that they would not be able to accomplish that without support.

Their evolution has been primarily in the technological domain. Both have adopted tools like spreadsheets and Google Docs to substitute for more traditional non-digital tools. They have fewer descriptions of how tools change their pedagogy for the better; they both acknowledge that those tools they have adopted have led to positive student outcomes. Sharon and Daniel have both adopted the most commonly used tools, and can be described as cautious or skeptical of integration in general. Daniel is more cautious because of a perceived lack of skill in using some tools such, evident in his description of his reluctance to try Google Forms for formative assessment. Sharon is more reluctant because of her pedagogical beliefs. She is unsure that students would remain engaged when using their laptops, and she also values face-to-face discussions and reflections with students.

Chapter 5: School-Wide Factors that Influence Teachers' Adoption of Technology

In addition to the participants' individual comfort with technology, there are school-wide factors that all participants discussed, and which are presented in this chapter to partially determine what factors influence teachers' decisions to change and adapt their practices as a result of their schools participation in a one-to-one technology environment.

Modeling by leadership, and continuous learning were the two factors that emerged from the research. There are two themes that emerged from the words of the participants at Walden Middle School that suggest why they have been successful in integrating technology throughout the school. These themes represent the reflections from participants on what has supported or hindered their adoption of technology into their teaching practice. These themes were building-based and are discussed below.

Modeling by Leadership

The modeling, structures, and support provided by the leadership team at Walden Middle School have influenced the adoption of technology, as well as the willingness to do so. The school's leadership team has three members: Mark Davis, who has been the principal for 22 years; Sarah Wallace, the assistant principal, who is a former Walden teacher and a mid-career administrator; and John Bernard, the technology director. They described their individual roles in promoting technology integration. John summed up their philosophy:

> "As far as the success of any one-to-one implementation, it is leadership. If you have a leader that doesn't support it and doesn't at least model it, the

teachers see no reason to do it. So that is something that we have really tried to push for, so ok let's model this well. So that we can show teachers what we want and give them some ideas as well. If he [Principal Davis] is doing that, then I should probably be doing that in my classroom. So that does take place.

And so seeing what I can push into our work as we are working with staff, so that we can model some of the things we want to see happening in the classroom. It started when we first started going to Google Apps a number of years ago. We started piloting the idea of each teacher has to do a portfolio over the course of three years. And so we were like, ok let's make this electronic. So Mark and I and our assistant principal Sarah as well, worked on that. We first started with just year one. We made a Google site, so that they can grab that template. They worked with that model for a year. Over the summer that following year, Mark and Sarah got together and tweaked the format a little bit to make it more suitable for what they wanted, where they wanted things to go. And then we did it a third time actually. There was another tweak and that is what we are on right now."

Their modeling involves more than just using technology in their jobs, and extends to how they work with teachers. John Bernard noted a change in how the administration deals with paper work.

"You know we try to create an environment where teachers can't do their job without the technology. There is no faculty handbook anymore, it is all digital. And so if you can't navigate that you are going to have problems. And there is

very little paper, unless it is something that has to be signed, faculty here don't get much on paper. It is typically contracts."

The focus on digital paperwork is intended to both model a paperless classroom and, as John noted, force familiarity with it. That theme of modeling has informed other initiatives at the school. John describes recent work on differentiation and how the administrative team modeled it for staff.

> "Before we were working on the common core, we were doing some work with differentiated instruction. And we did that in a differentiated way. We let staff choose from a whole bunch of different differentiated instruction books for book talks. And we used a site for that. We were putting their monthly reflections online. And so people from other book groups could see what the other groups were saying."

They modeled both a method of differentiation and technology integration in their roll-out of the work on differentiation for the school. John went on to note that it had the effect they were hoping to achieve.

> "And so from there our 8th grade language arts teachers are doing book talks between their classes, and not just one class, using that same kind of format. And so a lot of it [integration] comes from the modeling that Mark and Sarah do, as far as what they do with teachers at faculty meetings. I spend more time with him (Mark) than I do any teacher in the building. And that is a big part of people seeing it."

Principal Davis and assistant principal Wallace also use a digital portfolio to collect and store observations, and the artifacts created by teachers for evaluation

purposes. Each teacher shares a Google folder with the administrators, and shares lesson plans, exemplars of practice, and reflections. Administrators can comment and share their feedback within each portfolio. Principal Davis noted that too had changed teacher practice.

> "Our 5th and 6th grade teachers wrote a grant to our local education foundation to get these reader's notebooks. And a couple of the 7th grade language arts teachers were like, hey we can do that but we don't need the paper books we can do that electronically. And they were thinking of the model of our portfolios. We can make a template site, put everything we want in there for the kids and let them roll with it. They made that template and pushed it out to the kids. Kids are now doing notebooks electronically, and they have also then sold that idea to the entire 8th grade team. The 8th grade team is doing it as well electronically now. These kids will go up next year to the 8th grade teachers with a full year of this electronic portfolio. The teachers can then see everything and learn about those kids as readers before they even see them. There is a lot of power with this electronic format. But they started with this paper version and thought, we can do this differently, do it our way, if we do it electronically. That was a direct correlation to seeing what we were doing with portfolios with staff."

In other ways the administrators model other approaches. The two principals co-write a blog called the WMS Newsbug that appears on the school's webpage. Both principals also communicate with parents and staff through email as a matter of course. Sarah Wallace noted: "If I'm trying anything new I will try to model. I'm never without my laptop."

Faculty members recognize that modeling. Matt Doyle shared an example around faculty meetings. He noted that the principals house all their faculty-meeting materials digitally.

> "We have a faculty website, a faculty page where all these links are housed. And we have to, and he'll say things like, I need you to go there and find new pages for today's meeting. We will be in a meeting sometimes and Mark will be like, hey John [Bernard] will you come help me get past this blip that I'm having? So, it was absolutely modeled from day one. It was funny because we'd all laugh at each other, you know? And I think everyone was comfortable enough doing that.
>
> They say it plain as day. They say we want you to try stuff, we want you to be excited about it, and don't worry about it if it doesn't work. And they'll laugh right along with you. And so it is absolutely plain as day. And they are completely okay with it, and they encourage it."

In that instance, the principals not only modeled the use of technology in their interactions with staff, but also modeled a positive response to difficulty. Matt has taken the same approach over the course of his learning how to use technology.

> "Stuff crashed all the time. So all of a sudden we're in the middle of a lesson and it crashes. And what do you do? [Laugh] We'd have the whole lesson planned and the Internet, whatever, the connection was gone [Laugh]. So, we learned early on, back up plans were a must. Things were going to fail sometimes, things aren't going to work, too many people on at once, all the other stuff. And

we, and we all kind of laughed our way through it. If you're not flexible in middle school, you shouldn't be in middle school."

Daniel Gallagher shared his perceptions of the principal's modeling.

"When Mark has our school-improvement team meetings it's expected we all go to the web, the link that we have, and there's the agenda. You wouldn't dream of coming to that meeting without your laptop. You wouldn't dream of coming there, 'cause you know we're going to do that. By his showing his modeling he says this is the way we do it. And that's the way we do it."

Daniel notes that the modeling can extend into actual teaching. He described a different set of experiences with the administrative team.

"And Sarah, and certainly John Bernard, are always great about coming into team meetings to do a workshop if we need to. So we see the value of the one-to-one. I mean they [teachers] wouldn't want to not have that, in that way. To have to go back to the old days of the computer lab that you sign up for and go into."

John Bernard often goes into classrooms to co-teach or help with the use of a piece of technology. Logan noted:

"He [John Bernard] will come into a class when you're doing something like that. And then give help, support, you know? If you're introducing something for the first time he is willing to co-teach. Then you have two people there, you know, willing to answer questions with the 22 kids in your class or whatever it is. That's the kind of the support I would say that is needed at times."

Others see things similarly. Evan noted that the principal's modeling sets priorities for staff.

> "We're using the technology every day. And I see Mark come in and do a faculty meeting, lead a faculty meeting using technology. Just by showing us that, by doing that, he's showing us the importance of it."

Lauren said:

> "Well, our administration is great about it because they pick something that they want to try, and they use it. You know, there are faculty web pages in Google sites that have our agendas on them. It has the notes on it, so that when we come to a faculty meeting that's where we're supposed to go. And all the minutes for SIT [student intervention team] meetings are on those sites. So I think that really promotes that piece. I think that their support of the professional portfolio, in how they give us feedback in there, and then we have conversations back and forth, I think that's all great. I think they really do model it in that way. I mean I think it's something that's a common foundation, Google you know, Google Docs, Google Drive, the spreadsheets, the shared folders, those types of things."

The modeling and encouragement from the administrative team also creates a space that staff feels is safe to experiment within when learning new technology or approaches. Logan describes that as support:

> "So, I think, they [administrators] allow for teachers to take a look at their practice and say, oh, here's how I'm going to integrate it. This stuff

> works. Here's something new. I'm open to trying it and I'm supported by my administrators in this and so here you go."

Lauren agreed: "I always get administrative support for things I try." That administrative support from both the principals and the technology director are an important factor for Daniel Gallagher.

> "I also think if the leadership wasn't you know, if John wasn't constantly keeping us up to date on the latest bits that are coming in, I might not be as committed to continuing on, possibly."

The building leadership at Walden Middle School models both new programs and attitudes towards change for staff. They have utilized many of the same tools expected by staff when leading and communicating. They have created a safe environment for staff to take risks within. Their approaches are noted by staff members.

Continuous Learning

Norfolk has provided several different styles of professional development for teachers over the course of the MLTI deployment. Those opportunities for teachers to learn and work together are embedded into their regular meeting structures, department-, team- and faculty meetings, into a summer program providing extended learning opportunities, and into a regular collaboration with the technology coordinator in the middle school. Each of those has provided support to the teachers participating in the study.

When asked how he stays current and improves his technology integration, seventh grade ELA and math teacher Chris Burns notes:

> “Lots of ways, mostly through professional meetings. So we have, you know, on Mondays after school we have staff meetings. Sometimes it's whole staff where Mark and Sarah might ask somebody to share out. We also meet in content areas. So all the science teachers get together and have a meeting. And I find, actually, that's the meeting where most of the sharing comes out about new tools and things we're using. And then again the summer tech course is another place where you get to try things. I think we meet for three days in the summer. We have a check-in meeting in September. Another one happens, kind of like finalizing your project, in October. In October is the presentation. And so, at the presentations you get to see everybody's project. I've actually done the tech course the last two years in a row. And so at the end you get to see all these different things that people are using. It is great.”

Logan feels that technology integration is still an important school-wide initiative at Walden Middle School.

> “Technology is still one of the cutting edge things that is expected to improve here. I think, well, part of that I think, is that teachers know what is expected, but I think it's how the teachers have been given the support that makes it work. And I think I mentioned in one of my previous answers to you that we're very fortunate in Norfolk to be able to have you know, the John Bernards, the Tricia Millers, the Stephanie Trasks [technology integrators at each school] at our different levels to be help in

integrating. And then there still is release time, there's still time during in-services, meetings and the summer workshops."

Teachers have taken advantage of each of those types of support and professional development.

The summer technology course is structured to provide teachers with extended time to accomplish a project that integrates technology into their practices. Teachers participating meet for three or four days in the summer to plan and develop their projects. Each teacher may work with others, or alone, on a project. In those courses, technology coordinators, other teachers, and even students, may be available for help in developing the project. The teachers participating in the course meet again in September after classes have begun to check in, and problem solve any roll out of their project, and then meet one final time in October to share their work with one another. Those fall meetings occur on a Saturday. Teachers who complete the course receive "Norfolk credits." These credits are counted locally towards teachers achieving different levels of education on their pay scale. A teacher can earn "Norfolk credits" towards post bachelor or graduate certifications in Norfolk.

Evan Reed identifies that course as one of the important pieces of his growth in using technology in the classroom.

> "One of the things in Norfolk that they've done so well is support, they have support with Norfolk classes and there's a technology class that I've taken numerous times. And that has been a huge piece of my success, success that I feel when using technology. It's the ability to have time to work on the technology and develop new things."

Logan also identifies that class as important to his learning:

> "And the neat thing about Norfolk is that they do the tech class, which you get credits for. You're building a project, which then you're using in your classroom. So, it's immediately used which I think, is just a fabulous way to do it. You know, and it sort of took, I think it took the place of some of those MTLI workshops that you might have gone to over the course of the year. They sort of did their own class here in Norfolk, which is a neat model."

Lauren appreciates the opportunity to experiment with new ideas and applications.

> "I really like taking our summer class just because it gives me the time to poke around and play with the new programs or look at the new image and see what new is being offered. Because I want to be able to go in, in September and I don't want to have to do that then. Plus I know that I have teammates who are going to do that. But I really like that summer class because it really is, these are the new things out there, pick a few and learn then."

Matt views the course as both a source of learning and a method to encourage technology integration.

> "I think the encouragement that we've had here to use it ourselves is awesome. A lot of our professional development, we can take a course every summer with more implementation, is aimed at using these [pointing to the laptop]. And the, the way the course is designed is, let's

design something with technology that will make something you already teach better, not to design something just to use the technology. I've taken the course two or three times over the years. I'll try to take it again. It just is a great tool. What's been great is that it's often been driven by who takes it with you. Because the times I've done the course, I've never done a project on my own. It's always been with a colleague in seventh grade. So, if another math teacher is taking it, we might try to tighten something up, got a language arts teaching taking it, we might do a project in that class."

Not all teachers use the summer workshop model. Daniel notes:

> "I know that they exist and will most likely take one of those sometimes. [Laughter] It's just my schedule and where I live doesn't work out so great with my summer schedule. But I've heard great things about them."

Daniel does take advantage of other professional development opportunities at Walden Middle School, however. And, like every other participant, noted the importance of John Bernard, the technology coordinator, to his use of technology in the classroom.

> "Right from the get go, John would send us an email with something that might appeal to math teachers, might appeal to language arts teachers, might appeal to the entire staff depending on the situation. And so he's always looking for this next thing that's come out that people might not be aware of. So that's helpful.
>
> I'm able to not only call him up and say, hey I'm having trouble with the projector here, but more so, like, hey I want to do a blog for my

non-fiction book groups. How do I set that up? And he'll sit with me and set that up. I can come up with an idea, or something I want to do in class, and I can bounce that off him, and he'll give me lots of ideas of how to do that. At other times if I need a reminder I go to Lauren. And so, she's a team member that I often access. She and Evan also are natural resources I would go to, people I would go for quick questions. And so I need those people. If I didn't have those people, I wouldn't be able to do nearly anything that I normally would do."

Not only do staff members depend upon John Bernard for background information, support and learning, they also utilize John for teaching. Logan appreciated this aspect of John's role.

"Then when I need support you know, John is there. He might come in and teach a piece of the class. And then I'm good, you know? And so, each year you might build on something like that. So, having a tech lead who can be integrated into the classroom with you and co-teach is a wonderful model."

Matt Doyle is also appreciative of that model.

"John Bernard, who I can't say enough good things about, is really good about guiding us towards things. He's great about guiding us towards some new thing, and he's a former high school math teacher, so he obviously has a little math focus in his searching. I mean, imagine having three technology coordinators in your district. [Laughter] Again, how spoiled are we? So they give a lot of good guidance with what they see,

they're good filters for that hose [information stream from the internet], to say this might apply to you, this might apply to you, this might apply to you."

Many teachers take advantage of multiple sources of information and learning opportunities. Evan Reed notes:

"Yeah, so my primary source is my colleagues within the middle school, my actual colleagues that I teach with in the classroom, we're always sharing ideas and new things. Our technology integrator or lead technology person, John Bernard, also sends us information and shares new things with us. So that's another source of information. And if I have questions about things, I typically go to colleagues first, and then I'll also go to John with questions. I'm also online. I receive information from various sources. But depending on the time that I have, I'll, you know, oftentimes pick up, you know, read articles or pick up new information from things that I see online. Norfolk also offers courses, district courses, and so over the past well since MLTI started I've been taking courses. I've taken I don't know, maybe six or seven of the Norfolk technology courses."

Participants identified other areas of continuous learning involving outside sources of professional development: ACTEM, MLTI or ISTE, as well as local experts from their ranks. Evan Reed commented on the need to stay current in his job around technology.

> “The new learning doesn't stop. You don't walk in this year and say, okay, I learned. Learned what I need to know and so I can take a break, it's constant. You definitely have to stay on top of it. So, you have to constantly be trying new things, and I think that's probably the biggest, looking at teachers that have been successful implementing it. It's the ones who are willing to say, when someone tells them about a new program in the hall. They are willing to try it in class and five minutes later they are like, well, okay, let's try it and being willing to just throw it out there and try it. It is an important piece of it.”

Principal Davis notes that is a systemic response, a cultural piece of how the teachers at Walden Middle School operate.

> “Teachers are always learning. I am always learning. For example this morning, I was out doing something, and I was downloading a document and I was doing it the long way. John was there and he said, you know there is an easier way, you can do it this way. Instantaneous learning and that’s sort of an example of the entire building. Some teacher will learn something and they share it with someone else. Say, hey take a look at this. For example, Lauren Maddox, an 8th grade science/social studies teacher just sent me something called ThingLink to look at. It is happening all the time.”

Logan sees that need for continuous learning as essential to staying engaged with students.

> "And it's just great to try new things. That's me wanting to be a better teacher. And I hope that, my hope always is that you have teachers who want to be better at their practice. And that's just one way I know I can get better at my practice. Also stay on the cutting edge because our students are going to be changing, we need to be changing. Or else you're going to lose them. But I always think you can look at how your practice is going to increase. And you have to look at yourself as a lifelong learner if you're going to stay current, if you're going to continue to engage the students."

Trying new things and sharing was noted by Matt when describing collaborating with his peers.

> "I'm definitely, I would say, three-fourths of the way to innovator. The frustration is I don't, I can't call myself an innovator because I just can't find a lot of the stuff that I'd like to find on my own. But, if Logan found it, likes it, I'm all in. He doesn't have to show it to me. He might say to me, he might text, hey, I found this cool thing. I'm like all right we'll do it tomorrow. I mean, I'm all in, because of the level of trust. So I don't need to see if it works, if someone I work with says it works, I'm going to run with it."

Professional development and continuous learning are not limited to technology. Matt shares another form of professional learning he enjoys.

> "Our teachers are very well read. You know, one of the great things I've done in the past two years, which, I think, is exciting for

professional development, is you can now get continuing education and re-certification credits by joining a book group. And so Mark has started a couple. I've been in two so far. One was a book group about childhood development. It was probably a book that was as good for parents as it was for teachers. And the other book group I did was with Susan Ogden, our math lead teacher, on math practices.

We did it over a course of six or eight weeks, and those contact hours count towards your re-certification. But, it's professional reading and book groups are much different than if you read it on your own. That discourse is important. So, we meet for a half hour once a week, you read on your own, and then we discuss. You got credit for an hour a week. They gave you credit for some of the reading because Mark said, we can't give you credit for all the reading, because we expect you to do some reading on your own anyway. I mean, that, that's the expectation professionally. So you get six or eight contact hours by being part of a book group that makes you a better teacher. [Laughter] You know, it's a win-win. So, that has been a really good initiative as far as our professional development goes. But again it's that idea of sharing the ideas and sharing what you do and that no one teaches in isolation any more, and this helps with that incredibly."

That culture of active learning by teachers is appreciated by Lauren also.

"When I first started teaching I called some people who didn't want to ever listen to me because they had been teaching longer than I'd been

> alive, they were the Jurassics. There are some people that are not going to learn new things and they're not going to change and I can't do anything about that. I don't see that to the same extent here. I have colleagues that are always trying new things, asking about new things."

Each of the participants described formal and informal learning that they had undertaken over their careers at Walden Middle School. Many of those opportunities were centered on technology integration. That openness to new ideas and learning was evident in the comments of the participants profiled.

Summary

The leadership team readily shared leadership responsibilities with teacher leaders in several venues: faculty meetings, curriculum development, and within team and content meetings. Those opportunities for teachers to lead meetings and share their practices were commonplace at Walden Middle School. In addition, the leadership team readily modeled the use of technology in their practices with parents, community members, and the professional staff. Participants noted that modeling set expectations for them in their classrooms, and created trust between administrators and teachers.

Walden Middle School has adopted a unique professional development model that most participants learned from, and praised. The summer institute designed to support teachers integrating technology in their classrooms was noted by all, even teachers who had yet to take advantage of the opportunities. Teachers noted the level of collaboration present throughout their practices. Teachers readily share ideas and successes around technology adoption with one another. All participants noted the importance of learning

from their peers. Their opportunities were often informal and unplanned, but were also built into the meeting structure established by the leadership team.

Chapter 6: Themes and Findings

This study sought to address three research questions:

1. How do teachers in a successful school participating in the Maine Learning Technology Initiative describe its impact on their practices?
2. In what ways, and how, do teachers describe their evolving understanding of technological pedagogical content knowledge in a successful school's participation in a one-to-one technology environment?
3. What factors influence teachers' decisions to change and adapt their practices as a result of their school's participation in a one-to-one technology environment?

Each research question investigated in this study is addressed individually below. The major findings related to each research question are then presented. Finally, a complete discussion of the themes identified from the participants' words is presented to support each finding.

Impact on Practice

"I wouldn't want to give these up. I mean, there's very little of what I do now that I would want to go back to the old way of before technology."

Daniel, an eighth grade ELA and math teacher

The question of impact on practice is illustrated in the profiles of the six participants. They highlight a number of changes that have occurred in their practices from integrating technology. Many of the themes and changes can be found in the practices of other teachers in the middle school, as well as changes that did not emerge in their profiles. The themes are organized into seven areas, and are discussed individually

below. They illustrate the first finding of this research: that MLTI has increased the transparency of teaching and learning at Walden Middle School

- Teaching with the tool, not about the tool.
- Writing Digitally
- Information literacy.
- Blended learning environments and flipping the classroom.
- Communication and opening up the classroom.
- Student-centered practices.
- Growing importance of videos.

These themes, discussed individually below, illustrate the first finding of this research that MLTI has increased the transparency of teaching and learning at Walden Middle School.

Teaching with the tool, not about the tool.

Many of Walden Middle School's staff has gradually shifted focus in the use of laptops from teaching about how to use the tool to using the tool to teach within their classrooms. Logan talks about initially feeling like he needed to "force" the technology into the curriculum. Matt acknowledges that early on he found himself using math programs that took longer to teach and use than would have taken to just do things non-digitally.

That shift also occurred in how spontaneous teachers were willing to be in their uses of technology. Evan noted how he has moved away from always being deliberate in using technology. He later described this deliberateness or intentionality as similar to how he uses a laboratory experience in his science teaching. Today those teachers do not

speak of the use of technology as an activity, but as a process and tool intertwined within their daily curriculum, instruction, and assessment practices. Each of the profiled teachers spoke of becoming much more comfortable embedding the tool into teaching and learning. Several noted that they couldn't imagine teaching without the tool anymore.

There are still times that students need to learn about how to use the tool, an example of technological knowledge, but teachers have included that instruction into real contexts where students need to accomplish some larger goal or outcome. That evolution depended upon both students and teachers gaining more technological knowledge. It is not just teachers who have had to gain new understandings.

The collaboration that has occurred between Matt and some of his peers in sharing digital resources such as the blog he and two other teachers use, has also facilitated more open communication about many aspects of teaching and learning. He notes that he and his team share more and communicate more about many parts of their curriculum and instruction. He attributes that to the sharing that has evolved around their one-to-one initiative.

Viewing laptops as tools and not as a learning outcomes is a subtle distinction, but important if teachers are going to leverage technology to support teaching and learning of other content. Sharon, a relatively novice user, acknowledges that she is careful to not be "wowed" by the presentation options in PowerPoint's created by students, but instead focuses on the thinking captured in the PowerPoint, echoing the opening quote from Lauren or Evan's emphasis on content over presentation. It is the intersection of the pedagogical, technological, and content domains that interests Sharon and her colleagues.

Writing Digitally.

Perhaps the most universally acknowledged tool and change in practice from the teachers at Walden Middle School centered on the use of Google Docs for student writing. Although Google Docs can be used as just an online word processing tool, teachers at Walden Middle School have leveraged aspects of the platform to substantially change the writing process for students. Google Docs allows students to share their writing with others: teachers, peers, or outside evaluators. What makes that sharing different from sharing in other digital manners is that all collaborators access the same online document. There is only one copy of the writing. If a teacher marks up the writing, all collaborators see it: multiple copies are not circulating among collaborators. . The second feature being leveraged by teachers and students is the nature of the commenting and revision process itself. Each comment or suggested revision is highlighted and noted in a panel next to the document online. Students can see all comments made by various editors or collaborators and can choose to resolve them or ignore them. Further, the document is saved regularly so multiple versions are available for quick return to a previous version, or for the teacher to see what changes a student has made over time.

Matt's use of Google Docs for writing in his ELA classroom represents a change in instruction that has undergone some evolution over the course of the MLTI project. Initially, he depended upon the Apple word processing applications for his students' writing, which did make revision and drafting easier for students. Adopting the use of Google Docs for writing though, allowed him to achieve other pedagogical aims. He describes, as many of the middle school ELA teachers do, the ease with which students can share their work with him and others to receive feedback. The online nature of Google Docs has allowed his students to "revise, revise, revise" with ease. Although the

original word processing applications on the laptops made it easy to change a document, it still required students to send multiple copies to different editors (e.g., teachers, students, or the teacher of gifted and talented students), and then collect all the feedback and make revisions. The use of Google Docs has eliminated the multiple copies. Every editor is working on the shared document in the cloud, allowing each to see all the others' comments and suggestions on one document.

All teachers profiled above utilize those features and acknowledge that student writing has improved because of them. Sharon notes that it is "better for" students because students can make "adjustments right there…they will make comments back to me, they'll ask me specific questions." Matt states unequivocally "I know my kids are better writers with these tools." The ease with which they can get feedback is a significant pedagogical improvement from his perspective. Daniel noted that he could reach all his students now, not just a fraction during class. It has given him access to their work in real time, and provided feedback in real time, even from home for both Daniel and the students.

Jay another 7th grade ELA and science teacher appreciates the speed with which writing can be revised. While discussing Google Docs he compares it to his workflow prior to using Google Docs,

> "Right, right, as opposed to the old fashion way of writing it out, turning it in. At least having to wait a couple hours, if not overnight, right? And the end result is you wouldn't have two rounds of revision. You'd, you'd be lucky to have one, and out it goes. So again, conceivably you can have ten rounds of revision in the same amount of time."

As Matt noted above, that revision can be based on a much larger audience of readers. He notes that students regularly share their writing with the gifted and talented teacher in the middle school, even if they are not identified. She is willing to help all students with their writing. Even Daniel, a relatively slow adopter of the technologies discussed by many teachers, understands the value of using Google Docs from both a pedagogical and content orientation. Daniel appreciates the ability to provide continuous and immediate feedback to his writers. He can articulate the value in having multiple editors providing feedback on a single writer's work. He recognizes that a student's motivation is maintained with regular feedback. He also appreciates the ability to have a "conversation" in a Google Doc by exchanging messages in the margins of the shared document. Here the document is a simple substitution for paper, but Daniel has taken advantage of the collaboration tools built into the platform to change the experience and the outcomes for his writers.

Using Google Docs for writing at Walden Middle School illustrates an intersection of all three domains of knowledge in the TPACK model. There is an understanding of how to use the technology, the pedagogical practices of providing feedback and the improvement of content area writing in both fiction and non-fiction. The Google platform provides teachers with other tools that have also been adopted by a wide variety of teachers.

Information Literacy.

Information literacy is a broad term to describe the skills needed by teachers and students to be able to locate, evaluate, use, and share information in today's proliferating digital information explosion. Always the province of librarians and media specialists in

schools, today's access has shifted the focus for using those skills to all classrooms in a one-to-one environment. Gaining those skills, incorporating them into their practices, and helping students acquire them is another significant area where teachers' practices have evolved and changed.

Matt characterized the wealth of information as a "firehouse" when one searches the web. He speaks of becoming more efficient in accessing the vast set of resources for teaching, even describing it as a "necessary tool." His comments also point to a growing understanding of how to effectively find and use digital resources for his planning and preparation. He notes that early in the deployment of laptops, it was much more difficult to search for materials, requiring precise search terms and operators in the search engines. Today he notes how much easier it is to locate information and the importance of teaching those skills to students. He realizes that students and teachers have to carry less information around in their heads, but only if they can effectively locate it on the web. He describes that as becoming more efficient in accessing and using information. Matt is aware that ready access requires that teachers find ways to teach students how to read for understanding. The ease with which students can access and then cut and paste information from digital sources can inhibit students from reading sources closely. He notes that is one of the lenses that he reviews sources on the Internet through and considers when designing assignments. He wants to slow his students down as they read and consider information from digital sources.

All participants noted the shift from traditional classroom resources to digital resources. More importantly, most participants commented on the need to develop better information literacy skills, using words like "efficient" to describe how they hope to be

when looking for information. Teachers are no longer the only source of information in the classroom. Their classrooms depend upon a much wider selection of sources today then they have in the past. This has led to the need to provide information literacy skills to all students.

Access has spurred interesting developments in teacher practices. Evan described his adoption of Diigo, an online curating tool to store, organize, and describe websites. He has curated sites for his students to use for assignments in an attempt to address the "firehouse." He also described the elimination of web quests, which were often done to teach students to navigate the web while acquiring some information for a task or assignment in class. That type of activity is antiquated and rarely needed for today's students. They know how to search the web; they do not need to practice searching. Today teachers recognize that students need to be able to adequately sift through the resources available at the touch of a few keys. They need to be able to evaluate the quality of the information they are finding.

Interestingly, Evan recognizes that students need to be able to become better at sorting the web, but has chosen to curate many of these sources of information on his Diigo page instead of teaching students how to locate the most valuable information on their own. Those types of choices are made in every classroom in many contexts. He has decided that the content students need to read and access is more important to a lesson than the goal of learning how to find it independently.

Educators are also taking advantage of their emerging skills in information literacy to improve their own learning and teaching. Lauren describes several sites she uses to find relevant information for her classroom. She is deliberate in where she

searches for and accesses information to inform her practice, depending on Diigo, Pinterest, several web listservs and a handful of education sites. She is not the only teacher who has developed skills to find information on the web to support their professional practices. Logan, Matt and Evan all described various digital sources that they depend upon for information, ideas, and inspiration.

Blended learning environments and flipping the classroom.

A blended learning environment is a program where a student learns at least some of the content online, and has some control over time, place, pace or path. Flipping the classroom describes a number of practices designed to extend the school day, change where information is presented, and where it is practiced and used. The most common practice is to have students review background and introductory material outside of class, and do the practicing of skills within the classroom. A typical "flipped" mathematics lesson might involve students watching a video on a problem solving technique for homework, and doing the problems for the unit in the classroom, instead of having the teacher deliver the introduction to the problem solving technique and having students do the practice problems at home. The goal is provide students with immediate feedback and practice under the guidance of a classroom teacher instead of struggling with the problems on their own at home. Those practices have emerged as access to both technology and the web has improved. Examples can be found throughout Walden Middle School.

As Logan noted above, flipping the classroom was not possible before the advent of the web and a one-to-one environment. It also requires a digital presence for the teacher. Logan and several colleagues use a blog to provide the materials for students,

while others use a more traditional web page, and still others are experimenting with other digital tools. All of the participants maintain a digital presence for their classrooms, providing links to product descriptors, rubrics, exemplars and timelines, in addition to curated resources of sites and content. In Evan, Logan, and Lauren's classrooms, time is spent completing projects, while homework time is spent doing research and reviewing the requirements and examples.

Providing digital resources on their classroom sites also allows teachers to accomplish another goal: differentiation. Logan talks about creating video, and finding videos that allow slower processors to return to a topic and review it. Matt shared an example of encouraging a student and parent to access his blog, and review some material over holiday break so that they didn't lose a developing understanding during the break.

Several teachers use pieces of those practices to support their students, and extend the school day. However, they show a range of sophistication in their adoption. Logan clearly designs lessons and units with the "flipped" model in mind, providing much of the direct instruction online for students to review as homework, and spending class time developing fuller understandings through discussion or practice. He even accesses his students from home when he is sick, extending his presence. Others have adopted aspects of that model. Daniel and Evan describe less-sophisticated but still significant uses for their blended learning environments. They both noted that students often get home, and discover they really don't understand their assignments. Their classroom web pages have help documents, answer keys, and links to further explanations available from sites like Kahn Academy. Those teachers still provide much of the direct instruction in

class, but have provided students and parents access to that instruction and solution sets online for further review. That also supports the slower processors or absent students. And, as Logan noted, the teaching of topics like mathematics has changed, making parental support at home harder. Allowing parents to also see direct instruction helps them to be more active in their students' education.

Daniel, a less sophisticated user of technology, has also adopted some of those practices. He describes how he uses his website to provide students with synopses of books so that they can make choices for their reading outside of class instead of visiting his classroom library or the school library. At another point he describes the making of an online slideshow that introduced how to use iMovie to make a book trailer. Students were to report on their reading by creating a book trailer, but Daniel didn't take class time to teach students how to use the tool, instead he developed a step-by-step slide show for students to access on their own. Instead of fully flipping the instruction, Daniel creates the digital resource for use in the classroom, but at a student's discretion. It is a simple step to require a slideshow to be reviewed outside of class and capture all of the class period to work on the project. Although not a fully flipped model, his use achieves many of the goals of a flipped classroom.

Even Sharon, a relative novice in using technology, has adopted some aspects of a blended learning environment into her classroom. She describes, above, the online social studies curriculum she is using this year. She is using an online notebook in the course, as well as the digital content available with the digital text. Her use extends into ELA with the use of an online reader's notebook she has produced in collaboration with her colleague in ELA.

The experimentation continues in several classrooms as teachers at Walden Middle School look to take advantage of the trends in digital technology, and in the habits of middle school students. Several participants described the use of social media, primarily Pinterest, blogs, and Twitter to reach students, share resources, and open up their classrooms. Evan noted that it is still an experiment, and an open question, as to how to use some of these tools.

> “A colleague and I have been trying to figure out ways to bring social media into the classroom. Make it part of what we do. We’ve tried a couple of different and a couple of different ways. We've tried to have, find something, where students could communicate. You know, almost like a chat room. You know, a science chat room, a social studies chat room where if they were reviewing for a test, they could communicate and ask each other questions. So, we've tried pieces like that that have involved Twitter. That's still something we're working on; we're trying to figure out the best way to get kids engaged in that. And they love to use their phones. We’re trying to tap that energy and that source of enthusiasm. It is another way that we're working on connecting with the kids. For this particular application of Twitter we are trying to connect with the kids. Part of it is modeling an appropriate use of social media and we're sharing. When I find interesting science articles or current events for science or social studies I try to post there. We're also trying to post information relative to class, you know, you’ve got a test coming up, or here's some review materials.
>
> We're kind of dabbling in social media is really what it is. We don't have a lot of kids, not a lot of followers yet. It's something new to use that we're working

> on and playing with. And as I've said, you know, the more you work with it and play with it, the more you use it, the more applications that you come up with. That's how you come up with a use of something that you never thought of before."

Evan and Lauren are unsure where their experiment will lead but have faith that applications will arise. They innovate.

Communication and Opening up the Classroom.

Many of the teachers at Walden Middle School describe the impact of technology adoption on communication with parents, and how technology has made their classrooms and practice more transparent. Technology has removed a veil between parents and teachers.

Logan views the use of blogs, teacher webpages and email as a method to make his classroom more transparent and open. He uses a classroom calendar that is accessible to parents and students. Matt, in the opening quote, shares an example of how parents take advantage of an online calendar being used in all eighth grade classrooms Sharon feels the pressure to conform to those practices: afraid if she doesn't she will be "one of those teachers that people talk about, saying she needs to get done."

Although each of the teachers uses digital tools to communicate with parents and to make their classrooms more open, what they share, and why, is different. Lauren uses her website to share resources, assignments, and syllabi, but she has a distinct focus on sharing student work. Her site contains almost five years of student work accessible to parents, students, and community members. That represents a significant commitment to providing her students with both exemplars, and a more authentic audience.

Matt notes another explanation for why opening up communication has been helpful. He describes the ability for parents to let teachers know when students are either struggling or perhaps on “cruise control.” He noted that he believes he is identifying issues much more quickly with constant and easy communication with parents. The frequent communication with parents and the ease with which parents can see what their students should be doing has made home life more transparent to teachers also.

Others see that communication and the sharing of their classroom materials and expectations as an equity issue. Evan, Daniel, and Logan see the communication and access as equity issues. Teacher assignments, materials and expectations are all visible to parents and students. That has spurred a commitment to providing the same materials to all students, regardless of which teacher they have for a course. It has also led to six of the middle school teachers sharing all or some of their digital presence with each other.

The technology director agrees on the importance of this communication with parents: “They [teachers] can easily get things out to parents. And that has worked out well, and that is one of the things that parents really appreciate when teachers give them the heads up on what is going on in the classroom.”

The use of mass emails, RSS feeds as described by Logan, public links to blogs, web pages, and student work are all facilitated by the technology integration that has occurred at Walden Middle School.

Student-centered practices.

Several teachers noted the shift in their pedagogy to more student-centered practices as a result of the one-to-one initiative at Walden Middle School. Logan’s description of students using a Google Draw tool during a mathematics assignment where

he instructed students to do their notes by hand, illustrates how even sophisticated users cannot anticipate the ways that students may take advantage of tools. Later he says, “we learned early on in MLTI, that kids are going to be further along.” He readily lets students lead the programming in his robotics class, letting them work out the code, and share with their peers as they problem-solve some application.

Matt states explicitly “my lessons and my teaching…have become less teacher directed, much more student directed. Technology has played a large role in supporting my shift.” He describes that as letting “kids drive the lesson.” He has students share solutions, questions, and information, using technology to allow students to project their work on the screen, and to also find the information to answer questions raised in discussions. Matt also shares the example of students using their technology to share with their classmates, even depending on video to record themselves at home in a safe environment before presenting to their peers, a step towards leading the class on their own. He believes such opportunities have made his students better speakers and presenters.

Much of the reading curriculum in the middle school is student driven. Students are given a great deal of choice in selecting their reading. However, not all reading is independent. Daniel has used technology to continue to provide choice, but also foster collaboration in smaller groups for some reading assignments. Students are permitted to choose from a set of books, and then grouped for virtual book talks. Because not all students proceed through the reading at the same rate, he has used Google Docs to put the students into book-talk groups. He provides a prompt, and students respond on a common document to the prompt and one another. “As a group they talk about it, record

their responses to it." The setup allows for asynchronous sharing among members of a book group. The conversation is kid-driven and he adds comments, via Google, to their transcript.

Evan notes one of the issues that he and others have had to overcome in giving students more control over the course of a lesson: "When you give somebody the screen, you lose some control. It makes some people feel very uneasy... There's definitely a level of trust that you have to develop with the students to make it work." That unease was reflected in Sharon's profile. She identifies it as a trust issue also. "I just have to build that trust, and that trust is a hard thing for me to do." Later when commenting about the times students do not use the time or space she has given them to work independently she notes: "It's almost like it is personal. I feel disrespected…" Sharon has not made the leap from teacher-centered practices to student-centered practices. She talks about how when using technology, she is comfortable continuing its use only when students are engaged. She also notes that she needs the "control."

Evan describes how technology may have supported that shift. The myriad tools that can be used, and the pace of change in technology, have supported his willingness to give students more control and choice. Evan shared an example of using a tool (iMovie) even though he doesn't feel very proficient with its use. He doesn't let that prevent him from using it; he just depends upon kids to do the instructing. Engagement is an important consideration when making such technology choices. His descriptions are often shaded by how students will respond to the use of a technology for a given instructional activity or student project. That engagement extends to his response to students and their work. He notes how exciting it is to see a product that really "nails the content."

Growing Importance of Videos.

The role that video plays in curriculum, instruction and assessment has undergone a significant evolution over the course of the MLTI at Walden Middle School. References to it are ubiquitous in the comments of all participants. The shift is so pervasive that it can be missed in the reflections of the participants. No one identified video as a tool, but instead referred to it in the context of other tools. They often referred to video as being easier to share, create, or use when using other tools. In other words, some tools have been specifically chosen only because they provide support for the use of video. No one noted the shift from the spoken or written word for almost all instruction, access to curriculum, and assessment to the current situation where video plays a significant and growing role in all three. Mirroring the dominance of visual media in today's culture, that shift appears to have infiltrated educational practices with little reflection.

All the participants rely upon video to access curricular materials, which are primarily produced by other developers and made available openly on the web, or are available with purchased curricular packages. Such materials, once supplements, are becoming the only means of accessing the curriculum for some topics. In other classrooms, teacher-created videos have been introduced to reinforce or replace traditional modes of instruction such as teacher lectures or demonstration. That is most evident in Logan and Matt's classroom. The videos are usually created by Logan but are shared with Matt and the other seventh-grade mathematics teacher via their shared blog.

The use of video for instruction is not limited to teacher-created video. Teachers at Walden Middle School, to support instruction, use other sources. Half the participants mentioned Kahn Academy as a source instruction for students. In most classrooms it is

offered as a supplement to support students who may have not understood the classroom presentation. In others it is offered as a replacement or substitution. Logan uses video to present some new material so that it may be worked with in the classroom. His expectation is that students will review those videos at home, or on their own time, and he will spend class time applying the concepts in the video. Others use them as a replacement when students have missed class.

Matt has used video in his classroom. Two aspects of his use are illustrative of integration that doesn't have equivalent non-digital counter parts. In one case students have filmed themselves at home making a presentation, and then shown the results in class. He sees this as an intermediate step on the road to developing confidence and presentation skills so that students can eventually present in front of a live audience. In another case, he has used video to support a student who was struggling. He sent a parent and student some online videos on current math topics for review over a vacation, in hopes of minimizing the loss of the student's understanding during the break.

Video is an important tool in Evan's integration. Many of his products and assignments for students require the production or use of video. It has allowed him to help students be more successful, as in the Rube Goldberg machine, capturing segments of a complex process, and then piecing them into a completed whole. But it also facilitates a pedagogical goal in his practice. He notes in the same project that because students are required to provide voice over on their video of the Rube Goldberg apparatus, they must be able to describe how the simple machines work. It isn't just a hands-on application of simple machines: it becomes a tool to uncover how well students understand the physics behind the machines in a non-traditional manner.

Video also serves the purpose of archiving examples of past student work that he uses to build interest and create excitement. He also uses videos to achieve much larger outcomes than just the acquisition of content knowledge. His description of the Gilded Age videos referenced the feedback on how well the two boys did in communicating their points. He lets them know that some of their antics on the camera may not have contributed to their message. Archived videos let him help students see the best way to use video to communicate. He noted that he shares these with students not necessarily as exemplars, but as instructional moments focused on what works and what doesn't work when using video for a project.

Finally, video was mentioned as an assessment tool in four of the profiled teachers' comments. In several classrooms, students created video as a means to demonstrate understanding. Video was also used in several novel manners. Matt used video to allow students who were not yet comfortable presenting in class to present at home on video, and then play that video at school. Evan noted that he used video to force students to discuss their Rube Goldberg contraptions more fully then they did in the past when they demonstrated their machines live in the classroom. Lauren used video to force students to demonstrate their understanding of vocabulary in less than thirty seconds, recognizing that images and voice over can accomplish more than just words.

Video has infiltrated curriculum, instruction, and assessment to some degree in all teachers' classrooms. That is a significant shift in the means of communicating information that is facilitated by one-to-one deployments. Video and multimedia in general play a much greater role in the classrooms of Walden Middle School as a result of MLTI than they did in the past.

Summary.

The above themes illustrate the first finding of this research that MLTI has increased the transparency of teaching and learning at Walden Middle School. This transparency crosses many aspects of teaching and learning from communication with peers, students, and parents to the impact of video on making student thinking obvious. Establishing online presences in the forms of web pages, blogs, and social media sites has opened teachers' classrooms up to other teachers, administrators, parents, and community members. The feedback process utilized during student writing with Google Docs, and the use of forms for formative assessment, have opened the window on teacher grading practices and instruction. Substantially more permanent records of student work in the form of online archives of projects, and teacher products in the form of online assignments, product descriptors, assessments, and rubrics among other things, are available for all in the school community to access, reflect upon, and observe. Student and teacher work are shared more directly and easily as a result of the one-to-one initiative at Walden Middle School.

Not all of these themes have the same impact on increasing transparency. However, each of them have created a more open and visible window into how teachers are teaching, how they are assessing students, and what student work and learning look like. If the first requirement for change to occur is to see what another approach can do for teaching and learning, then the evidenced transparency supports the spread and evolution of new and potentially better practices.

Evolving Understanding of TPACK

"So I don't think there has been a huge shift about the need to embed technology in everything we do. I think that's always been pretty clear and I think we've just gotten better at using it. Though we've also gotten better at understanding, like I just mentioned, that teaching thing. Just like with teaching and with coaching, you're never done. You know, you're always reflecting on what I've could've done differently, what I could've done better, what else I could do. And getting comfortable with that feeling of never being done took a while."

(Matt, seventh grade ELA and math teacher)

The research question concerning the ways in which teachers describe their evolving understanding of technological pedagogical content knowledge is described below. Teachers did show a growing understanding of the intersection of all three domains (pedagogical, technological, and content) in their integrations of technology into their practices. That integration, however, was constrained by either a limited understanding of technological knowledge, pedagogical knowledge, or both.

None of the participants studied were aware of the TPACK model, but their reflections and descriptions illustrate various degrees of awareness and overlap between and among pedagogical, technological, and content domains of knowledge. The descriptions of their experiences integrating technology fall into various regions of those three domains, sometimes illustrating intersections, and at other times illustrating a focus on one domain over the others. Their words also illustrate evolution in their understanding of these domains and their intersections.

Logan provided the most illustrative example of a teacher's increasing understanding of the intersection of technology, pedagogy and content knowledge. The mitosis project described over a three-year period illustrates an increasing application of all three domains. The project provides multiple modalities to help students acquire their content understanding. The project includes written, kinesthetic, and visual opportunities for students to interact with the content. Those are primarily achieved through the application of several technological tools: Google Docs, cameras, and online resources for research. Each year the project was altered to achieve more sophisticated outcomes. In the most current iteration Logan asked students to acquire three different images (a picture, a professional diagram, and a professional photograph) of the phases of mitosis. That was done for pedagogical reasons: to ask students to compare and contrast what each type of image can convey. The project, over time, wove multiple components of each domain into student work.

Logan's current use of blogs to communicate with parents and students is illustrative of an evolving understanding of TPACK. The blog has become a "way to see into" his classroom. He clearly articulates his pedagogical belief that his classroom should be open and available 24/7. He uses the blog to accomplish both aims. He is also posting material, such as video lessons, that illustrate another example all by themselves of the intersection of technology, pedagogy, and content. That use of video is a relatively new tool in Logan's back of tricks.

The use of software for formative assessment also shows an evolution in Logan's technological, pedagogical, content knowledge. He a firm believer in the value of formative assessment, and uses it as entry slips to check on previous knowledge, to

"dipstick" during class, and as exit slips to plan for the next day's lessons (Pedagogical/technological content knowledge). As his awareness of other technological tools grew, he experimented with different methods to obtain that formative assessment, settling on his current favorite, which provides easy access to the questions for students, quick set-up time, real-time charting and graphing of student responses anonymously, and tracks student responses by name in the background for his use.

Finally, Logan provided a further example of his evolving TPACK when discussing the use of modeling software to explore the population dynamics in an ecosystem. Population dynamics (content knowledge) is a fairly common ecological topic. Logan notes that early on in the rollout of MLTI he found online models that he could show the students, but he was the one doing the modeling, he was the one "doing the science." He has since found a software tool (technological knowledge) that his students can download and use individually on their computers to model population dynamics on their own (TPACK). He believes (pedagogical knowledge) that letting students actually ask the questions and watch as the model changes populations in response to their inputs is superior to reading about those changes, or watching him conduct demonstrations, as was done in the past. Logan clearly has sought and used technological tools that support his beliefs, and has improved his students' understanding of the content involved. But he is not the only one.

An example of Evan's evolution can be found in his description of the Rube Goldberg assignment. Initially a typical project culminating in students bringing their completed machines to class, then demonstrating them to their peers, it now has a video component. Students still show their machines in class, but they use video to

demonstrate operations, and to communicate what they know about the simple machines. The use of video facilitated student success because they could film the process outside of class and be sure all stages worked. More importantly, Evan is able to review videos, and adequately assess how well the students have mastered the physics of simple machines. A stand and deliver description, as it was originally used, required that Evan listen very closely to the students' descriptions, and assess their understanding live.

Evan has also evolved in how tightly integrated his use of technology has become. As he notes above, he can't imagine how to untangle the technology from the teaching and learning. He also sees that process as continuing to evolve in an exponential manner as he becomes aware of more options. That evolution in use is also found in how he plans for technology use. Originally, the use of technology was a stand-alone project but now it is intertwined, and used for much smaller segments of learning, which are often unstructured and dynamic in their execution. That is facilitated by Evan's willingness to give up some control. He is comfortable allowing students to make decisions about where and when to use their laptops. That comfort extends to his teaching. He doesn't feel he must understand how to use every tool for every possible outcome. He will let the kids experiment, trusting in their abilities to learn new technology, and also to be the experts. He turns to students when he cannot answer a question for others.

Many of his descriptions of tool use reference pedagogical goals, in addition to the content being taught. His use of the timeline tool, MeoGraph, reflects those goals because it is faster for students to construct. He is less concerned with students laboring over making a scaled timeline, and more concerned with the type of content that students can embed within a timeline to support their demonstrations of understanding. The tool

extends potential learning by incorporating a variety of mediums, allowing multiple timelines to play at the same time, and providing geographical context to the events depicted on the timeline.

Using a website curating tool, Diigo, also accomplishes multiple pedagogical goals. It organizes the multiple websites he has linked to for various student projects. It is easily accessed. Students and colleagues need only to use one link for access to an organized, searchable, and live list of resources for each of his units. Those resources can be added quickly as Evan plans and executes his lessons. He has developed some information literacy skills and puts them to use by curating resources he has found for students. The result is an efficient culling of the resources on the web, but little development of student informational literacy.

Evan describes the essence of the TPACK model, though he is unaware of the model. He notes that one must understand content very well to choose a tool to truly support student learning. His descriptions illustrate that multiple times over the course of the interviews. Evan is a sophisticated user of technology and an innovator. He is depended on by colleagues for ideas and support in their applications of technology. His expertise is noticed outside of his school as well. He has been recognized in the state of Maine as a technology integrator of the year, though that is not his official role in the school.

Lauren is very savvy with technology. Her name was raised by every participant interviewed as a source of support and help in integrating technology. As she notes she is fascinated and excited by new tools. She feels motivated to understand the ins and outs of each tool well enough to be a resource for students and other teachers. Her wealth of

technological knowledge is evolving, and has led her to return to tools that she initially chose not to use. Animoto and Prezi, for example, were initially too difficult to use for student presentations, but have now been incorporated into some projects because the developers have streamlined the process by providing templates for setting up a presentation. By realizing that tools are constantly being improved by their developer, she did not dismiss valuable resources after her first use.

Her need to understand the features and workflows of the tools she uses doesn't extend to her students. In fact, she goes out of her way to provide students with tools with which they are unfamiliar. Her pedagogical rationale is twofold. She feels that when students are very familiar with a tool the myriad possibilities available in the visual presentation often distract them. She wants students to focus on the content and not the "bells and whistles."

Additionally, she views those choices as means to slow down students' thinking. If students are not comfortable with the technology, they spend more time on the content displayed. The idea of slowing down student's workflows was also described by her colleague Evan. They recognize that technology is a double-edged sword for supporting learning. The ability to cut and paste, and the ease with which a presentation can be made to look professional, can undermine students working with the information. She slows the learning down in other ways also. She describes a requirement on some projects to limit the presentation to 30 seconds, or some short duration, as an attempt to focus on the content and take maximum advantage of the technology. That idea was unique to Lauren. She realizes that the tools available to present multimedia provide students with an opportunity to choose the most relevant media to convey complex information in a

brief presentation. Much of that is accomplished with the use of images and video. The tools she introduces, Animoto, Meograph, or ThinkLink, allow students to combine many forms of information into complex presentations. Students are forced to grapple with both the content and the relative value of images, graphic, words, and video to communicate a given idea.

Lauren has also experimented with, and uses, a wide variety of tools to digitize both her instruction and her content. She uses the most complex set of tools to provide information to her students and parents. Her website includes an embedded wiki (to present assignments, syllabi, and readings), several embedded tools (Pinterest and Google Docs) to share student work, a calendar for due dates and reminders, and a Twitter feed to share images and posts about the daily life of her classroom. In each case she has chosen the tool that she feels best addresses her needs as described in the use of Pinterest above. She doesn’t appear to settle for the features that any one of these tools may limit her to using. Instead she is willing to research and learn various tool. Her technological knowledge has allowed her to accomplish multiple pedagogical goals.

Lauren has a unique view of differentiation among the participants in this study. She sees the technological tools she asks students to use as a vehicle for achieving differentiation. Because students can often choose the content they use to demonstrate their understanding, and because the tools often allow them to choose various media to convey that understanding, she feels her assessment is differentiated and personalized. She uses other assessment practices to provide what she feels is differentiation. The use of cafeteria-style assessment as described above is an example of that.

Lauren uses a variety of technological tools for summative assessment. She readily acknowledges that feedback is an issue for her, and has chosen few technological tools to support her formative assessment practices. Her uses of technology in assessment are focused on student demonstrations of understanding. Technology is used less regularly to support instruction (graphing programs for instance) and formative assessment (polling software or digital check ins) as described by other participants. Many of the examples shared focused on the outcomes she is expecting of students, with fewer examples of how technology might be used in helping students acquire those outcomes.

One tool, NEWSELA, is an exception to. It supports students by providing leveled reading on the same topic to students. Students can find information at a level that is appropriate for their reading abilities. NEWSELA eliminates the barrier of reading from the acquisition of information. It is an instructional support, and represents a true example of differentiation. Lauren also acknowledged a real struggle with reading as a young student, and NEWSELA would have been a valuable tool for her.

Matt has shown an evolving understanding of how to use technological tools to support curricular aims consistent with his beliefs about good teaching. Matt shares and adds to the same blog discussed above. His descriptions of the importance of the blog illustrate different pedagogical aims. Matt points to the efficiencies and collaboration that it provides for him and his colleagues. He also believes the blog serves students and parents, but the collaboration allows for a richer set of resources available for his students.

His profile is filled with his ongoing learning about teaching (Pedagogical Knowledge) and these understandings can be seen in his practices. His description of the changes used in teaching graphing and linear equations (Content Knowledge) is a good example of that evolution. He describes the pedagogical reasons for his use of a software product (Technological Knowledge) to do graphing, emphasizing pedagogical reasons. He believes the time savings gained by not graphing by hand allows him and his students to “talk” about the graphs, to “interpret” the characteristics of the lines and equations they generate and to “experiment” with the terms in a linear equation. The program also allows his students to visualize those linear models “in ways that maybe you never could” (TPACK). His understanding of the program (Technological Knowledge) is such that he will turn off some features so that students focus on certain learning outcomes, and do not get lost playing with the bells and whistles available in the program.

Daniel’s integration of technology often represents simple substitutions for non-digital tools or approaches. His adoption can be described as attempts to meet school-wide expectations, or attempts to improve the efficiency of some of his or his students’ workflows. Often his use stops short of fully realizing the potential to alter learning outcomes, even with tools used by his colleagues to achieve those outcomes. The use of shared documents represents an example of that type of adoption. In describing the use of a shared spreadsheet to collect and project student data on bridge strengths, a mathematical activity used in his classroom, he has students come up to his computer to add their data. That is unnecessary with the Google sheet he uses. Students could add data to the spreadsheet in real time, on their personal devices, if he shared the spreadsheet with each group before the activity. He recognizes that he can share the data with them,

as he notes that he sends it to them after the data input and collection. Here he has substituted the computer and projector for a whiteboard or chalkboard that might hold the student data in a non-digital classroom, but has not altered the workflow to take advantage of the unique sharing characteristics of a Google Document.

That substitution can be seen in his use of spreadsheets in other activities. The tool has often replaced hand calculations and calculators in many of his projects.

> "And they do a lot more with spreadsheets. When we used to do these problems, we used to use calculators all the time. And, as with most things there are some kids who really take off and want to apply it further. And others who are happy to just do it this way. And others who are happy to just use a calculator."

The fact that students can accomplish some of those activities without their laptops demonstrates that the integration of technology into those applications represents a direct substitution of one workflow for another. The use of Google Docs in his English classroom for writing does represent a change in outcomes and practices that cannot be equated with a simple substitution of a digital tool for a non-digital workflow.

Sharon, Evan, and Lauren note the importance of slowing an activity down when using digital tools. Sharon worries about the ease of cutting and pasting, or of finding the central theme of a passage in their online texts by pressing a button, which doesn't require much processing, yet she is at a loss on how to "slow things down." She speaks of reaching out to the developers to remove the button. Her technological knowledge and pedagogical knowledge limit her ability to force students to be more reflective.

Both Lauren and Evan employ technological solutions to improve content understanding and reflection with their projects. Lauren introduces new tools to keep

students from being focused on the bells and whistles. Evan requires students to record themselves over their movies to improve their depth of engagement with the material. Both approaches are attempts to use technological tools to improve the understanding of students. They are evolutions in their practices that reflect a deepening awareness of the pedagogical and technological domains. Technological tools are double-edged swords, and Lauren and Evan have harnessed the positives, while striving to eliminate some of the negative impacts on student learning.

The teachers show a range of evolution or growth in their practices. In some respects integration is dependent upon the amount of technical and pedagogical knowledge each teacher brings to the table. In the interviews, no teacher demonstrated a lack of understanding of their content. The three domains of knowledge in the TPACK model have different degrees of overlap for each of the teachers. The overlap appears to depend mostly on their relative understandings of the pedagogical and technological domains. The larger their individual understanding of each domain the greater the overlap observed based on their descriptions.

Logan demonstrated the most thorough appreciation of pedagogical knowledge as described above. He also has a thorough understanding of technological knowledge, as do several of his peers. However, his pedagogical knowledge in combination with technical knowledge has led to very sophisticated intersections of all three domains. He is doing unique things with technology, fully flipping instruction, or providing many aspects of his practice online to make his classroom transparent. His ongoing reflection and revision of lessons and assignments is also clearly driven by improving appreciation of each of those domains. He has experimented with many tools (technological knowledge) to

improve his formative assessment. He also has taken his mitosis unit through many iterations to achieve greater understanding by reflection on both pedagogical (incorporating movement or comparing and contrasting different images) and technical (experimenting with the tools to achieve these aims) to develop better understanding of a curricular goal (mitosis).

Other teachers (Evan and Lauren) have similar understandings of technical and pedagogical knowledge. Their descriptions illustrated multiple examples of practices demonstrating the overlap of all three domains. The practices extended beyond the use of technology for planning and instruction, and incorporated pedagogical goals designed to improve student understanding, such as the use of video or tools such as MeoGraph, ThinkLink, and Animoto. Those tools were chosen specifically to achieve content understanding by considering pedagogical factors.

Some teachers' evolutions in practices representing a full overlap of all three domains was hindered by their technological understandings. Matt references a considerable amount of research about learning and pedagogical practices. He is similar to Logan in his understanding of pedagogy. In Matt's case, his technological knowledge limits the number of examples shared of instruction or assessment that demonstrates a complete overlap of all three domains. Sharon is another teacher with similar pedagogical knowledge, but less technological knowledge. For Sharon and Matt, the size of their technological domain has limited the overlap with pedagogy and content.

Sharon, a relatively new integrator of technology into the classroom, describes her use of an online curriculum for social studies. Her descriptions of the product and her students' use illustrate a teacher reflecting on all three aspects of the TPACK model. She

speaks of wanting to ask the developers to turn off the button that highlights for students the main point of the passage (Technological Knowledge) because it undermines the opportunity for students to develop the critical reading skills (Pedagogical Knowledge) she expects for her students. She also describes her problem-solving glitches with a software tool even as she continues to use it for students. That evolving technological knowledge is mirrored in her recognition that she must provide other materials to supplement what she wishes to teach about the topics of Egypt and China (Content Knowledge)

Sharon's evolving TPACK understandings are less developed than Logan and Matt's understandings. She readily acknowledges her lack of technological knowledge. There are places such as the use of Google Docs for writing, as described above for Matt, where she has used the tool to support her pedagogical goal (Feedback) to improve student writing (TPACK). However, other uses illustrating her TPACK understanding differ from Matt and Logan because they are teacher centered and not student centered. The use of the online reader's notebook is illustrative.

As she describes the tool housing student reading and writing about reading, she speaks about it terms that illustrate what she gains from it. She gets to "know her students better as readers." Next year's teachers will be able to get to know their new students before the school year ends. Those are very important pedagogical outcomes. However, in her descriptions of the tool, there are no references to how it improves students' reading or writing abilities. The online reader's notebook, is a digital substitution for the traditional non-digital bound notebook used in the past. The approach, well documented by Nancy Atwell, does provide a model to improve student reading comprehension, but

the substitution doesn't change the content understandings achieved by students over paper versions, at least as described by Sharon. The intersection here is primarily in the pedagogical and technological region, with little improvement in learning outcomes from its adoption.

Daniel's descriptions of his practice and use of technology suggest that he may have the least understanding of both pedagogy and technology. He has adopted practices learned from his peers, but applied them in stilted and minimal ways, as described in his profile. Additionally he has chosen to use some tools in manners that undermine pedagogical best practice. His instructional approach when using Google Docs for data collection minimizes the pedagogical value of having students collect mathematical data from their bridge designs. By collecting the data on his computer and projecting it on a screen, he transfers a student-centered activity into a teacher-centered demonstration.

Those overlaps in the domains of all three areas reflect a snapshot of teacher practices in time. The words of many of the participants acknowledge that their current understandings are different from their understandings when MLTI was first deployed. In each case, teachers described changes in their understandings and practices as they gained knowledge of a technological domain. Each teacher described increasing understanding over time, which translated into practices and approaches that demonstrated an overlap of all three domains.

Summary.

Each participant described aspects of their integration of technology that demonstrated an evolving understanding of the intersection of technological, pedagogical and content knowledge. Although no participant was aware of that model of technology

integration, their words support the following finding: technology integration has evolved, but is constrained by a participant's technological knowledge, pedagogical knowledge or both. No one's descriptions of their practices suggested that their integration was limited by their content knowledge.

The two early adopters in this study also demonstrated through their words the most understanding of pedagogical and technological understanding. Logan and Evan shared examples of their practices that illustrated how technology could support differentiation; assessment practices (especially formative assessment practices); remediation for struggling learners; feedback; support for the developing executive functioning of adolescents through the use of digital organizational tools; and communication with parents and the larger community.

The two members of the early majority illustrated the limits that technology integration faces when one area or another is less developed in a teacher. Matt spoke and referenced many educational practices recognized to support student learning similar to those noted for the early adopters. However, his readily admitted, less-developed technological knowledge limited the applications of technology described in his classroom. He has adopted several of the practices utilized by others and recognizes how they support student learning, but noted that he is not the first to try new approaches. He represents an important connection for other teachers, though, because of his ability to articulate why some tools and practices can benefit teachers and students.

Lauren, another member of the early majority has the opposite set of strengths. She is readily acknowledged as a significant resource for new technological tools, and notes that learning about new tools is a passion for her. However, her uses of such tools

seem constrained by her pedagogical beliefs or understandings. Many of the tools she describes support her learning or instruction, teacher-centered practices, or were limited to the use of technology for summative assessments for students. She has experimented with many tools, described most as tools for students to create products. There were few examples shared that illustrated a use of technology for the myriad outcomes noted for Evan and Logan. Her digital presence is centered on sharing student presentations and work online, but when asked if she shares with parents she noted that she doesn't direct parents to the pages as a matter of course, but instead assumes they are looking at their students' work. She also failed to describe any use of those student products as exemplars for new students.

Finally, the late adopters in this study support the contention that technological and pedagogical knowledge can limit a growing understanding of the intersection of the three domains into effective integration. Sharon is similar to Matt in her understanding and sharing of pedagogy as it applies to her content area. Unlike Matt, though, her willingness to adopt technological practices and ideas is limited by her skepticism of the benefits for her practice or students. She is extremely deliberate, and seems limited both by her technological knowledge and her focus on teacher-centered practices. She readily acknowledges that she is uncomfortable releasing control and trusting students to do the right thing.

Daniel provided an example of a teacher less in step with both current pedagogical practices and technological knowledge. Although aware of his need for support around technology, his awareness of student-centered pedagogical, and other potentially constructivist practices, was also limited, but not noted by him as a needed

area of support. Such limited understandings in both domains created applications of technology in the classroom that may have actually had little impact on student learning. The example of using a Google spreadsheet to collect student data but to do so in a manner that simply mimicked collecting the data on a white board illustrates that contention.

Teachers at Walden Middle School did show a growing understanding of all three domains, but limits to pedagogical understanding were as important as limits to technological understanding in limiting that evolution in practice. Their words illustrate examples of refinements to approaches or the adoption of new approaches to support teaching and learning. They all stated in one manner or another the recognition that teaching about a technological tool was not a valuable outcome, and instead noted that they were much more interested in using the tool for some outcome. The sophistication of those outcomes was limited by either technological or pedagogical knowledge, or in one case both.

Factors That Have Encouraged Teachers to Change and Adapt Their Practices

> "So, I think, they [administrators] allow for teachers to take a look at their practice and say, oh, here's how I'm going to integrate it. This stuff works. Here's something new. I'm open to trying it and I'm supported by my administrators in this and so here you go."
>
> (Logan, seventh grade science and math teacher)

The research question, W*hat factors influence teachers' decisions to change and adapt their practice as a result of their school's participation in a one-to-one technology*

environment is discussed below. The major findings relative to this research question are presented at the end of the section.

Four factors emerged from the words of the participants at Walden Middle School that suggest why they have been successful in integrating technology throughout the school. They are: a common software suite; social networks; modeling by leadership; and continuous learning.

Each of the four is explored below to address the research question about what factors influence teachers' decisions to change and adapt their practices as a result of their schools participation in a one-to-one technology environment.

Common Software Suite.

The adoption by Walden Middle School of the software suite Google Apps for Education (GAFE) has been a significant factor in the wide spread adoption of technology in the classroom. There are two primary reasons for the importance of GAFE. The first is the protean and versatile nature of that suite of applications. The second is the universality of GAFE's learning curve.

Google Apps for Education provides a variety of tools that can be used for many outcomes in an educational environment. It is a communication tool; a sharing tool; a website creation tool; a digital content tool for words, pictures, images, and video; an assessment tool; a blogging platform; and an organizational tool for all those products. Most importantly it lives in the cloud. Each of those uses was observed at Walden Middle School.

And each has provided teachers at Walden Middle School with multiple access or entry points into technology integration in their school. Each teacher uses the e-mail

capabilities of the suite for communication with staff, administrators, students and parents. Several participants noted that use as one of their first introductions to using their laptops for school related tasks. From that point, the adoption of technology into each of their classrooms followed unique and multiple pathways. Some teachers of writing were quick to adopt the platform for online writing assignments. Those, as noted by Daniel and Evan, began as substitutions for other digital-based programs for writing. They initially were viewed as ways to improve the formatting and presentation of student writing. However, the unique nature of the shared document on the GAFE platform allowed for substantial improvement to the writing process. Because a document shared between teacher(s) and student(s) is in fact a digital link to the same online document, teachers found that they could provide feedback to students directly on their documents in real time. They were accessible from any computer, and multiple people could view and edit a document simultaneously in real time. Combined with GAFE's capability of saving multiple versions of a document, teachers and students found the editing and revision process to be streamlined and enhanced.

Other aspects of GAFE's document-management system were utilized for collaboration. Documents could become digital whiteboards where multiple students or teachers could collaborate and brainstorm on the same document at different times and without being in the same place. Evan describes how students use Google Documents to work on a project from their own homes. Others shared similar examples, including the use of a shared document by teachers to build curriculum and lesson plans together.

Others began to use GAFE's forms-tool to build formative and summative assessments. The ease of creating those surveys (forms) allowed teachers to create entry

and exit slips based upon homework or lessons, or to dipstick during class to check for understanding. Such formative assessments were enhanced in the GAFE suite because of the reporting tools created automatically as responses were collected. Teachers received, and could share with others, the results of the questions in various graphs and diagrams. That made checking responses fast and efficient, or provided opportunities to share responses with students when it served the purpose of uncovering misunderstandings or misconceptions.

Still others adopted the use of GAFE's website creation tools to digitize portions of their practices. Some focused on building websites that provided access to calendars for assignments, materials for class, videos for instruction, or assessments for practice. Still others focused on providing a public place to share student work with a wider audience than just the teacher or classroom. Others built blogs to accomplish similar outcomes, while at least two teachers have incorporated most of these uses into their online presences. The participants in this study shared myriad ways that GAFE has been incorporated into their practices.

No teacher was forced to adopt a specific tool or build a specific product. Instead, each teacher had a suite of tools capable of accomplishing their own pedagogic and content-specific goals. That created an environment where teachers were learning tools that had meaning for them, and which served to provide incentive and motivation to solve problems and integrate technology into their classrooms.

All that would be significant enough to improve the adoption of technology in a new setting, but another feature of Google Apps for Education enhanced the adoption of technology. It provides a common learning curve for all of those tools. Although some

tools have features unique to a tool, each is accessed in the same manner, logged into in the same manner, allows for sharing and publishing of content in the same manner, provides compatibility across each of the applications so content created in one is available to be used in any other tool in the suite, and houses all those products in the same digital repository.

The importance of that feature is that mastery of one tool by a teacher for one particular goal allows for the transference of those skills, comfort levels, and understanding to another tool for another aim. Thus, teachers can begin to use digital tools for an important personal educational goal, and then expand that use to other tools and uses which might not have been important enough to explore had that been the only use for GAFE. Mastery of those tools along the way is synergistic and builds a fuller repertoire of tools and a deeper understanding of the possibilities available with digital technologies.

All of these benefits are further enhanced by the well-developed and robust social network at Walden Middle School.

Social Networks.

Social networks are viewed here as connections between individuals that facilitate cooperation between members of a group because of shared norms, values and understandings. They facilitate collaboration, reciprocity and trust, creating social capital. Walden Middle School's successful implementation of the Maine Learning Technology Initiative has been strongly influenced and facilitated by social bonds and networks that exist between members of their middle-school team. That collaboration and communication has included technology integration throughout the tenure of the MLTI

deployment. The communication has depended on the channels present among members of the group of middle-school teachers.

Daniel Gallagher and Sharon Bishop both acknowledge the importance of those relationships in their integration of technology. They describe their dependence upon other members of their team for help, support, and ideas about how to integrate technology in their classrooms. Sharon describes choosing to return to the classroom as being dependent upon the opportunity to work with Logan, whom she felt would be able to support her nascent technology skills. Each participant described other members of the middle school as supports for their adoption of technology, or as recipients of support from them. Often teachers inhabited both roles. Even Daniel could describe his support of other teachers in their use of spreadsheets, an area of technology with which he felt very comfortable.

Those relationships and networks were facilitated by the established meeting structure at Walden Middle School. Teachers meet four nights a week in either grade-level teams or content teams. The meetings were described by all participants as often focusing upon technology use in their classrooms. There is also a built-in time during lunch for teams to eat together and further build networks of collaboration and support. The extent of that willingness to depend upon one another was noted Logan and Evan in describing the frequency and comfort of teachers walking into and out of one another's classrooms during the day. Lauren noted that teachers often pop into her classroom to ask questions about technology. Such constant collaboration has established trust and comfort for all participants. The least technologically savvy were open about their needs for support, and effusive about how much they depend upon their colleagues. Not all

teachers are as willing to open their doors to others or acknowledge their weaknesses as the teachers in this study have been.

The collegial communication is also supported by the faculty-meeting structure at Walden Middle School (WMS). Participants described how they have presented to all faculty aspects of their integration, or how important those presentations have been to their adoption of new ideas. That collegial sharing is also embedded in their professional-development model. Participants in the summer sessions of technological professional development are expected to share the work they accomplished with one another on a Saturday in the fall. Each noted how important that was in spurring new ideas.

The diffusion of ideas is dependent upon a teacher's access and response to the social networks. At WMS that access is also available in informal connections and relationships between staff that are more transitory and immediate than those provided by the formal structures of team and content meetings after school. Lauren Maddox and Evan Reed both work closely as two members of the seventh-grade science and social studies team. Their communication about ideas is immediate and informal. As described above, they often share ideas immediately throughout the day with one another, illustrating both the informal nature of some of the networks, and the need for even the most sophisticated users to have sounding boards and peers to float ideas past.

That network of collaboration and sharing also helps to alleviate the common constraints of time and expertise required for new adopters to implement technology integration into classrooms. Regular and constant interaction between peers of various abilities allows adopters at all ends of the spectrum to acquire skills over time, and within the normal flow of a school day. Teachers can acquire knowledge and understanding in

small bits and bytes, as described by Daniel's gradual adoption of Google Docs for his writing curriculum.

That social capital is also exchanged as social pressure. Both Daniel and Sharon, novice users of technology, acknowledge the need to not be left behind, or as Sharon noted, not be seen as one of those teachers that must retire. The social pressure also influences the more sophisticated users of technology at Walden Middle School. Matt, Evan, and Lauren all pointed to one another as examples of how to integrate technology at levels they have not reached yet. They are all aware of what might be implemented into their teaching that others in the school have tried. There is a healthy level of competition or social pressure for each of them to continue to explore and adopt new ideas.

Through both formal and informal structures, staff at WMS share and learn from one another as they integrate technology into their teaching practices. They depend upon one another for help, inspiration, and to lighten the burden of changing practices. The shared work not only benefits each teacher, but also the entire seventh-grade student population, bringing coherence to their experiences with various teachers, while allowing teachers to share the load associated with creating curriculum and instructional materials. In many examples above, the social network is robust enough to help members of the middle-school team implement new ideas on a regular basis. It extends beyond the peer-to-peer collegiality of teaching colleagues, and includes administrators.

Modeling by Leadership.

Participants at Walden Middle School identified several aspects of leadership that they felt supported their integration and adoption of technology. Some of those were

direct interactions with leadership, and others were an indirect function of structures established and supported by the leadership team. Administrators and teachers each identified several aspects of direct interactions as sharing leadership, and modeling by the leadership team.

Leadership at Walden Middle School is a shared responsibility in several areas, and has significantly influenced the integration of technology by teachers. Examples were shared by participants of the opportunities for teachers to lead faculty-, department- and team meetings regularly. Several participants noted that it is a common expectation that they will share their integration and technology practices with their peers and the administration in those meetings. Others, who may not be presenting, noted that such opportunities were significant for their ongoing learning. In some cases, teachers were asked by administrators to share, and in others they volunteered to present their work.

Those peer-led presentations support integration in several ways. They make the work of each member of the middle school observable, an outcome also supported by the comfort members have in stopping into one another's classrooms during the school day. Observability is an important component of the diffusion of innovation noted by Rogers (2003). Furthermore, sharing by staff with one another establishes proof that practices are manageable and valuable. Teachers vouching for the value of a particular technology tool are much more credible then other sources of information that may advocate for a certain tool or practice, especially for teachers who are not early adopters or innovators. Finally, that type of sharing creates an exchange of social capital as social pressure. The pressure, as noted above isn't coercive, but in fact serves as an incentive to try new ideas.

Teachers might still be unwilling to take risks in adopting new techniques if leadership wasn't clearly supportive of their experimentation. At Walden Middle School, support was demonstrated in the leadership team's willingness to model technology integration in their own practices. All participants identified the modeling and use of technology by the leadership team as important in establishing their comfort with trying technology in their practices. In fact, at least two teacher-established practices were modeled upon uses that were first tried and used by administrators: the evaluation model and blogging.

There was also an intentional expectation set up by administrators to create a culture where teachers "could not do their job without technology." Participants recognized that social pressure. Participants noted that they would never come to a meeting without their computers because it was expected that most materials would be shared digitally. Technology was used in their evaluations, meeting structures and communications. and established a culture that recognized that education was moving into a digital era.

As important as modeling the use of technology by administrators was the modeling they did when things failed. Administrators and participants shared examples of technology not working during faculty meetings, and the comfort of administrators in the face of difficulty. Technology glitches were laughed off, and administrators readily turned to more experienced users for help in front of staff. That willingness to not be an expert created an environment that was safe for teachers to try new approaches. That was more important to the savviest users of technology than to the least savvy users. Evan and Logan both acknowledged that they readily turn to students, or the technology integrator,

when they hit roadblocks in their use of technology. On the other hand, both Daniel and Sharon described their concerns about not having everything work correctly, or their unwillingness to adopt a tool or technique if they were not sure if they could use it well.

Other aspects of leadership influenced adoption more indirectly. The meeting structure for teams and grade levels created natural incubators for ideas. Participants noted that in some ways those informal opportunities to share and to hear what other teachers were doing were as important as any other source of information in supporting them to try ideas. The opportunities to listen to the ideas of peers were then enhanced by the willingness of all participants to share technology adoptions directly with peers. The participants in this study noted myriad uses that were shared, or built-in collaboration with one another. There are blogs shared between classrooms, tools such as the reader's notebooks shared with one another, and ideas exchanged between all participants. Examples of sharing and collaboration were ubiquitous in the words of all participants. That culture of collaboration was enhanced and modeled by the structures put in place by leadership.

Continuous Learning.

Teachers at Walden Middle School have had access to an ongoing summer institute to support their integration of technology. The institute, established by the technology coordinators at the elementary, middle and high schools, was cited by participants as one of the most important pieces of continuous learning available to them. Several aspects of that model make it valuable: differentiation and personalization, transparency, and a meaningful reward structure.

The summer institute provides a differentiated and personalized learning experience for participants. There are no pre-established goals for teachers participating in the institute. At the beginning of the summer, each participant identifies an outcome or structure he or she would like to integrate into the classroom. Their projects are unique and personalized. The technology team then provides the supports, logistics, and expertise to help teachers develop their projects. That model makes the learning meaningful and relevant to the teachers participating.

It also provides transparency to leadership and peers about the learning that is undertaken. Participants are expected to share their work with one another during two Saturdays in the fall. They present their final projects and their outcomes to one another in the final session of the institute in October. Not only does that model provide opportunities for teachers to learn from one another across the K-12 grade span, but it also established a natural accountability of their work. Such transparency creates a meaningful audience, peers, for the participants. It is also another example of the exchange of social capital in the form of social pressure.

Finally, the model creates a meaningful and appropriate personal-reward structure for teachers. Although completing a project to be used in their classrooms with students is often reward enough for most teachers to invest time and resources, teachers receive graduate credit for completing their work, and sharing it with their fellow participants. The credits, called Norfolk Credits, are counted towards a teacher's ongoing education and professional growth. Thus, teachers can move up the established pay-scale by accumulating those credits, and the credits serve a further purpose for the district. Because Norfolk Credits are not associated with a college or university, they are not

transferrable to other districts. That situation creates a natural incentive for teachers to stay at Norfolk instead of seeking employment elsewhere. In a highly competitive job market that serves the district well.

Summary.

The finding that social networks support the integration of technology to the classroom is certainly prevalent in the literature: (Frank, et. al., (2004), Goos (2009), Frank, Zhao, and Borman (2004), Sahin and Thompson (2006)). At Walden Middle School the networks and collaboration may be the most readily identifiable aspect of the school's culture. The words collaboration and sharing were used over and over by all participants, both teachers and administrators, to describe themselves and their colleagues. The social network was equally important to the most savvy and least savvy users. No one viewed himself or herself, or was viewed, as an island within the school. Structures and opportunities to collaborate and share were abundant in formal and informal ways.

Each participant identified the support of their peers and administrators as fundamental to their willingness to integrate technology into their practices. As important as the support for their integration was the continuous refinement, as evidenced in the examples shared, of approaches, because of the regular sharing of outcomes at team and grade level meetings.

Similarly, the willingness of Walden Middle School's administrative team to model technology use, share leadership with teachers and provide meaningful opportunities for teachers to learn and improve their practices was cited by all participants as a factor in their willingness to integrate technology into their practices.

The continuous learning opportunities available to staff through structures such as the district's summer technology institute, and the common expectations of teachers sharing with one another in multiple forums, were enhanced and amplified by the decision to adopt a common software suite, Google Apps For Education (GAFE). That suite of technology tools allowed staff to enter the digital realm in areas of interest and importance to them. However, each tool adopted by a teacher provided a gateway into the entire suite of tools because of the common interface and skills needed to use any of the tools. Thus, teachers who perhaps began with GAFE for writing could easily see and choose to adopt other tools, such as those that support assessment, when they witnessed how other teachers used those. The learning curve flattened out after the initial foray into the suite. Once a teacher mastered a tool, or was at least comfortable with it, the barriers to adoption of other tools were significantly reduced. Each adoption of a GAFE application or tool made subsequent adoptions easier.

Conditions for Success

Does the investment of time, money, and human capital in large-scale deployments of computers or tablets change teaching and learning to an extent that policy should encourage the adoption of ubiquitous computing? This study has found evidence that teacher practices and pedagogy have changed over the course of the MLTI deployment at Walden Middle School. Significant changes in the openness and transparency of the teaching and learning processes have been documented. Teachers described a growing understanding of the potential and use of technology to support teaching and learning at Walden Middle School. Social networks, common tools and

software, leadership and continuous learning have all supported the adoption within this high achieving and successful one-to-one middle school.

Understanding why teachers have adopted, used, and embedded technology into their practices is necessary to interpreting all evaluations of technology in an educational setting. This study identifies from the words of teachers several ways that technology has been embedded and adopted into their practices. Teachers at Walden Middle School had observable role models and supportive structures to facilitate their adoption. Still, despite the best laid plans of policymakers, technology enthusiasts, and administrators, technology adoption, integration, and implementation were seen to be unique, contextualized, and teacher dependent. That may suggest that answering the opening question is also unique, contextualized, and school dependent, but the observation is consistent with the outcomes to be expected of any initiative involving new understandings.

Walden Middle School has changed as a result of the deployment of the Maine Learning Through Technology Initiative. There are many changes to teacher practice captured in the words of study participants, and there are almost as many different uses of technology within their classrooms. However, some outcomes are shared widely. Walden Middle School has a robust, professional, and reflective culture of collaboration and sharing. In some ways, that culture may be as important as the actual tools adopted by the district and teachers to integrate technology. It was reflected in all participants' words, and was evident in the classrooms observed, the materials created and shared with colleagues, and the willingness of teachers and administrators to risk and adopt new

ideas. That willingness was supported by the strong social network and significant social capital available in the Middle School.

Was that culture of collaboration and strong social network in place before MLTI's arrival in the school? Probably, but certainly there was a synergy created between the school-wide technology initiative and Walden's culture. For schools like Walden Middle School, MLTI provided an opportunity for teachers to focus their professional learning communities on a shared learning experience. Walden was able to practice collaboration, and the building of strong networks focused on the same vision over a sustained period of time.

In a profession, education, that often swings from one new initiative to another the MLTI has been stable. The teachers in Walden were expected to experiment, reflect and embed technology into their classrooms from the start. They, like so many teachers in Maine, acquired, practiced and refined skills over a significant period of time. Their comfort and integration took time to acquire. They started at the beginning of what has become a very steep learning curve. They would not be so adept if they had squandered the first few years, when many teachers had the opportunity to acquire new skills, by avoiding any significant effort to understand the technological knowledge required to effectively integrate. Today a neophyte user of technology would require time and study to reach the level of understanding achieved by the least savvy users at Walden. Sophisticated uses of technology assume a level of understanding of how those tools work, so that the emphasis is placed upon the intersection of technology with pedagogy or content or both. It is not sufficient, though it is necessary, to learn how a browser works, or how a platform like Google Apps is accessed. Teachers at Walden had the

luxury to acquire those basic skills before the expectations were raised that technology should support practices such as formative assessment, flipped classrooms, or online collaboration. No school could expect initial outcomes such as Walden's when providing ubiquitous access to technology. Teachers and students must struggle with substituting digital tools for non-digital tools, such as writing online or by hand, before they can appreciate the innovation and possibilities of a platform such as Google Docs with its ability to collaborate in real time, or to provide feedback to authors.

Schools hoping to achieve the successes of Walden Middle School must be patient and focused. They must be led by leaders willing to share decision making and willing to model the same skills, ideas, and tools expected of teachers. They must invest in tools, such as Google Docs, that support multiple outcomes, and provide multiple entry points for staff to learn and use. They must provide space, time, and support for continuous learning and sharing driven by peers and colleagues. Finally, they must recognize that there will be no one-to-one correlation between the adoption of one-to-one computing and standardized test results.

This study purposefully ignored measures of student learning. The lever of technology is only one--and one a long way from student assessment results--tool required to affect student learning. There have been few studies that support a widespread improvement in student learning because of technology adoption. There are smaller learning targets that can be improved by the adoption of a particular program or technological tool. Some relatively simple outcomes can be improved by technology's ability to provide practice and differentiation. But widespread improvements in student

learning are less clear cut because of the myriad other factors that influence student learning.

However, this study has found that teacher practices can be changed, for the better, because of the factors and experiences shared above. This study serves as one example of the types of outcomes and changes enabled by the MLTI deployment in a high-performing middle school. Gauged against the original guiding principles identified by the Task Force on the Maine Learning Technology Endowment, Walden Middle School's teachers have illustrated examples of improved teacher preparation and professional development; technology uses that are integrated and supportive of the Maine Learning Results; and equity for all students. It remains to be seen if the impact on long-term economic development will be achieved. However, Walden Middle School has achieved the three school-based outcomes expected in the original policy adopted by the legislature. In at least one Maine middle school the vision articulated by Governor Angus King is being realized.

References

Ainley, J., Banks, D., & Fleming, M. (2002). The influence of IT: Perspectives from five Australian schools. *Journal of Computer Assisted Learning,* 18: 395-404.

Archambault, L., & Crippen, K. (2009). Examining TPACK among k-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education,* 9(1): 71-88.

Baker-Eveleth, L., Eveleth, D.M., O'Neill, M., & Stone, R.W. (2007). Enabling laptop exams using secure software: Applying the technology acceptance model. *Journal of Information Systems Education, 18(1), 413-420.*

Bala, V. and Goyal, S (1998). Learning from neighbors. *Review of Economic Studies,* 65, 595-621.

Beaudry, J.S. (2004). *Use of laptop computers and classroom assessment: Are teachers making the connections?.* Gorham, Maine: Maine Education Policy Research Institute.

Bebell, D. & Kay, R. (2010). One-to-one computing: A summary of the quantitative results from the Berkshire Wireless Learning Initiative. *Journal of Technology, Learning, and Assessment,* 9(2). Retrieved 10/15/2012 from http://www.jtla.orghttp://www.jtla.org

Berry, A.M., &Wintle, S.W. (2009). *Using laptops to facilitate middle school science learning: The results of hard fun.* University of Southern Maine, Gorham, Maine: Center for Education Policy, Applied Research and Evaluation.

Black, P. & Wiliam, D. (1998). Inside the black box: Raising standards through classroom assessment, *Phi Delta Kappan*, October, pp. 139-48.

Black, P., Harrison, C., Lee, C., Marshall, B., William, D. (2004). Working inside the black box: Assessment for learning in the classroom, *Phi Delta Kappan,* September, 9-21.

Connelly, F. M., & Clandinin, D. J. (1988). Teachers as curriculum planners: Narratives of experience. New York, NY: Teachers College Press.

Creswell, J.W. (2007). *Qualitative inquiry & research design (*2nd ed.). Thousand Oaks, CA: Sage.

Creswell, J.W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom.* Cambridge, MA: Harvard University.

Cuban, L. (2006, October 18). Commentary: The laptop revolution has no clothes. *Education Week,* p.29.

Davis, F. D., (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3): 319–340

de Koster, S., Kuipert, E., Volman, M. (2012). Concept-guided development of ICT use in ‘traditional’ and ‘innovative’ primary schools: What types of ICT use do schools develop? *Journal of Computer Assisted Learning,* 28:454-464.

Denzin, N.K. (1978). *The research act: A theoretical introduction to sociological methods (2nd ed.).* New York, NY: McGraw-Hill.

Donovan, L., (2005). Exploring relationships between configurations of laptop use and student off-task behavior. *Unpublished doctoral dissertation, University of Nevada, Las Vegas. Retrieved from ProQuest Dissertations and Thesis A&I (*http://search.proquest.com.ursus-proxy-1.ursus.maine.edu/pqdt/docview/305393590/fulltextPDF/8821F19CABA5405BPQ/1?accountid=8120*), 20 Feb. 2014.*

Donovan, L., Hartley, K., & Strudler, N. (2007). Teacher concerns during initial implementation of a one-to-one laptop initiative at the middle school level. *Journal of Research on Technology in Education, 39(3), 269-283.*

Drayton,B., Falk,J.K., Stroud, R., Hobbs, K., & Hammerman, J. (2010). After installation: Ubiquitous computing and high school science in three experienced, high-technology schools. *Journal of Technology, Learning, and Assessment, 9(3).* Retrieved 10/15/2012 from http://www.jtla.org.

Ertmer, P.A., Gopalakrishnan, S., & Ross, E.M. (2001). Technology-using teachers: Comparing perceptions of exemplary technology use to best practice. *Journal of Research on Computing in Education, 33(5).*

Fern, E.F. 2001. *Advanced Focus Group Research*. Thousand Oaks, CA: Sage.

Frank, K. (2001). Identification with the collective as a quasi-tie: Based on 'The dynamics of social capital'. February, Annual Meeting of the *International Social Networks Association, New Orleans, LA.*

Garthwait, A., & Weller, H.G. (2005). A year in the life: Two seventh grade teachers

implement one-to-one computing. *Journal of Research on Technology in Education,* 37(4), 361-377.]

Gauci, S.A., Dantas, A.M., Williams, D.A., & Kemm, R.E. (2009). Promoting student-centered active learning in lectures with a personal response system. *Advances in Physiology Education,* 33(1), 60-71.

Glaser, B.G., & Strauss, A. (1967). *The discovery of grounded theory.* Chicago, IL: Aldine.

Goos, M. (2009). A sociocultural framework for understanding technology integration in secondary school mathematics. In M. Tzekaki, M. Kaldrimidou, & Sakonidis, C. (Eds.), *Proceedings of the 33rd Conference of the International Group for the Psychology of Mathematics Education, Vol. 3, 113-120. Thessaloniki, Greece: PME.*

Granger, C.A., Morbey, M.L., Lotherington, H., Owston, R.D., & Wideman, H.H. (2002). Factors contributing to teachers' successful implementation of IT. *Journal of Computer Assisted Learning,* 18: 480-488.

Guba, E., & Lincoln, Y. (1981). *Effective evaluations.* San Francisco, CA: Jossey-Bass.

Haelermans, C. (2010). Innovation power of Dutch secondary education. *Innovation: Management, policy & practice, 12(2), 154-165.*

Hall, G.E., (2010). Technology's achilles heel: Achieving high-quality implementation. *Jorunal of Research on Technology in Education, 42(3), 231-253.*

Hall, M., Elliott, K.M. (2003). Diffusion of technology into the teaching process: Strategies to encourage faculty members to embrace the laptop environment. *Journal of Education for Business, July/August, 301-307.*

Hall, G.E., George, A.A., & Uchiyama, K. (2000). Extent of implementation of a standards based approach to teaching mathematics and student outcomes. *Journal of Classroom Interaction, 35(1), 8-25.*

Harris, J.B., Hofer, M.J. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education, 43(3), 211-229.*

Harris, S. (2002). Innovative pedagogical practices using ICT in schools in England. *Journal of Computer Assisted Learning,* 18- 449-458.

Hsu, P.S., & Sharma, P. (2008). A case study of enabling factors in the the technology integration change process. *Educational Technology & Society,* 11(4), 213-228.

Huang, L.Y. (2004). A study about the key factors affecting users to accept Chunghwa Telecom's Multimedia on Demand. *Unpublished Master Thesis, National Sun Yat-Sen University.*

Hung, P. -H., Fen, Y -F., & Hwang, G. -J. (2010). Formative assessment for PDA integrated ecology observation. *Educational Technology & Society, 13(3), 33-42.*

Irving, K.E. (2006). The impact of educational technology on student achievement: Assessment of and for learning. *Science Educator,* 15(1) p.13-20.

Kebritchi, M. (2010). Factors affecting teachers' adoption of educational computer games: A case study. *British Journal of Educational Technology, 41(2), 256-270.*

Koehler, M.J. & Mishra, P. (2008). Introducing TPCK. In AACTE Committee on

Innovation and Technology (Ed), *Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators.* New York, NY: Routledge.

Kottemann, J.E. & Boyer-Wright, K.M., (2009). Human resource development, domains of information technology use, and levels of economic prosperity. *Information Technology for Development, 15(1), 32-42.*

Lee, Y., Hsieh, Y., & Hsu, C. (2011). Adding innovation diffusion theory to the technology acceptance model: Supporting employees' intentions to use e-learning systems. *Educational Technology & Society, 14(4), 124-137.*

Lei, J. & Zhao, Y. (2008). One-to-one computing: What does it bring to schools? *Journal of Educational Computing Research,* 39(2), 97-122.

Levin, T. & Wadmany, R. (2006) Teachers' beliefs and practices in technology-based classrooms: A developmental view. *Journal of Research on Technology in Education, 39, 157-181.*

Li, Q., Ma, X. (2010) A meta-analysis of the effects of computer technology on school students' mathematics learning. *Educational Psychology Review, 22, 215-243.*

Li, S.C. (2010). Social capital, empowerment and educational change: A scenario of permeation of one-to-one technology in school. *Journal of Computer Assisted Learning, 26, 284-295.*

Lincoln, Y.S., & Guba, E. G. (2000). *Naturalistic inquiry*. Thousand Oaks, CA: Sage.

Maine Department of Education, Task Force on the Maine Learning Technology Endowment, Augusta, Maine (2001). *Teaching and learning for tomorrow: A learning technology plan for Maine's future*. Retrieved 10/1/2012 from

http://maine.gov/mlti/resources/history/mlterpt.pdf

Maine Department of Education, (2014). *About MLTI.* Retrieved 3/30/2014 from http://maine.gov/mlti/about/index.shtml.

Manfra, M.M., & Hammond, T.C. (2006). Teachers' instructional choices with student-created digital documentaries: Case studies. *Journal of Research on Technology in Education, (41(2), 223-245.*

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

McCarthy, P., & Breen, Y. (2001). *Teaching and learning for tomorrow: A learning technology plan for Maine's future.* Augusta, ME: Maine State Legislature.

Merrriam, S.B. (2009). *Qualitative research: A guide to design and implementation.* San Francisco, CA: Jossey-Bass.

Mishra, P., & Koehler, M.J. (2006). Technological Pedagogical Content Knowledge: A framework for teacher knowledge. Teachers College Record, 108(6), 1017-1054.

Moore, G. A. (1991). *Crossing the Chasm: Marketing and Selling Technology Products to Mainstream Customers*, Harper Business, New York, New York.

Mouza, C., (2011). Promoting urban teachers' understanding of technology, content, and

pedagogy in the context of case development. *Journal of Research on Technology in Education, 44(1), 1-29.*

Munshi, K. (2004). Social learning in a heterogeneous population: Technology diffusion in the Indian Green Revolution. *Journal of Developmental Economics, 73(1), 185-213.*

Neiss, M.L. (2008). Guiding preservice teachers in developing TPCK. In AACTE Committee on Innovation and Technology (Ed.)*, The handbook of technological pedagogical content knowledge (TPCK) for educators (pp. 223–250).* New York: American Association of Colleges of Teacher Education and Routledge.

Ndubisi, N.O. (2006). Factors of online learning adoption: A comparative juxtaposition of the theory of planned behavior and the Technology Acceptance Model. *International Journal on E-Learning, 5, 571-591.*

Pamuk, S. (2012). Understanding preservice teachers' technology use through TPACK framework. *Journal of Computer Assisted Learning,* 28, 425-439.

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas*. New York, NY: Basic Books.*

Patton, M. (1990). *Qualitative evaluation and research methods (*2nd ed.). Newbury Park, CA: Sage.

Polly, D. (2011). Teachers' learning while constructing technology-based instructional resources. *British Journal of Educational Technology,* 42(6), 950-961.

Quazi, A. & Talukder, M. (2011). Demographic determinants of adoption of technological innovation. Journal of Computer Information Systems ,Fall, 34-41.

Rittel, H. & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4(2), 155-169.*

Sahin, I., (2011). Development of survey of technological pedagogical and content knowledge (TPACK). *The Turkish Online Journal of Educational Tehnology,* 10(1): 98-105.

Sahin, I., & Thompson, A. (2006). Using Rogers' theory to interpret instructional computer use by COE faculty. *Journal of Research on Technology in Education, 39(1): 81-104.*

Schmidt, D.A. & Gurbo, M. (2008). TPCK in K-6 literacy education: It's not that elementary! In AACTE (Eds.), *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators.* New York, NY: Routlege.

Schmidt, D.A., Baran, E., Thompson, A.D., Mishra, P., Koehler, M.J., Shin, T.S. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education.* 42(2): 123-149.

Shinas, V.H., Yilmaz-Ozden, S., Mouza, C., Karchmer-Klein, R., & Glutting, J.J. (2013). Examining domains of technological pedagogical content knowledge using factor analysis. *Journal of Research on Technology in Education*, 45(4): 339-360.

Shulman, L. (1987). Knowledge and teaching: Foundations of a new reform. *Harvard Educational Review,* 57(1): 1-22).

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher,* 15(2): 4-14.

Silvernail, D.L., & the MLTI Research Evaluation Team (2011). *A middle school one-to-one laptop program: The Maine experience.* University of Southern Maine, Gorham, Maine: Maine Education Policy Research Institute.

Silvernail, D.L., Buffington, P.J. (2009). *Improving mathematics performance using laptop technology: The importance of professional development for success.*, Gorham, Maine: Maine Education Policy Research Institute.

Silvernail, D.L., & Gritter, A. (2005). *Maine's middle school laptop program: Creating better writers.* Gorham, Maine: Maine Education Policy Research Institute.

Shapley, K.S., Sheehan, D., Maloney, C. & Caranikas-Walker, F. (2010). Evaluating the implementation fidelity of technology immersion and its relationship with student achievement. *Journal of Technology, Learning, and Assessment,* 9(4). Retrieved 10/15/2012 from http://www.jtla.org.

Simon, H. A. (1956). "Rational Choice and the Structure of the Environment." *Psychological Review* **63** (2): 129–138

Stake, R.E. (2005). Qualitative case studies. In N.K. Denzin & Y.S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed.). Thousand Oaks, CA: Sage.

Staples, A., Pugach, M.C., Himes, Dj. (2005). Rethinking the technology integration challenge: Cases from three urban elementary schools. *Journal of Research on Technology in Education, 37(3), 285-311.*

Straub, E.T., (2009). Understanding technology adoption: Theory and future directions for informal learning. *Review of Educational Research, 79(2), 625-649.*

Suhr, K.A., Hernandez, D.A., Grimes, D., Warshauer, M. (2010). Laptops and fourth-

grade literacy: Assisting the jump over the fourth-grade slump. *Journal of Technology, Learning, and Assessment,* 9(5). Retrieved 10/15/2012 from http://www.jtla.org.

Wang, K.H., Wang, T.H., Wang, W.L., Huang, S.C. (2006). Learning styles and formative assessment strategy: Enhancing student achievement in web-based learning. *Journal of Computer Assisted Learning,* 22, pp.207-217.

Warschauer, M., & Matuchniak, T. (2010). New technology and digital worlds: Analyzing evidence of equity in access, use, and outcomes. *Review of Research in Education, 34(1), 179-225.*

West, R.E., Waddoups, G., Graham, C.R., (2007). Understanding the experiences of instructors as they adopt a course management system. *Educational Technology Research & Development,* 55: 1-26.

Weston, M.E. & Bain, A. (2010). The end of techno-critique: The naked truth about one-to-one laptop initiatives and educational change. *Journal of Technology, Learning, and Assessment,* 9(6). Retrieved on 10/15/2012 from http://jtla.org.

Wong, E.M.L., Li,S.S.C., Choi, T.-H., & Lee, T. N. (2008). Insights into innovative classroom practices with ICT: Identifying the impetus for change. *Educational Technology & Society,* 11(1): 248-265.

Yang, M.M. (2007). An exploratory study on consumers' behavioral intention of usage of

third generation mobile value-added services. *Unpublished Master Thesis, National Cheng Kung University.*

Yin, R.K. (2014). *Case study research: Design and methods* (5th ed.). Thousand Oaks, CA: Sage.

Zelkowski, J., Gleason, J., Cox, D.C., & Bismark, S. (2013). Developing and validating a reliable TPACK instrument for secondary mathematics preservice teachers. *Journal of Research for Technology in Education,* 46(2): 173-206.

Appendix A: Initial Survey

Initial Survey of Teachers

Name

Discipline

Years of experience

Years teaching with MLTI in their classroom

Willingness to be interviewed individually

Adopter Status

After reading the following descriptions, please identify which of these describes your most common response to technological innovations seen in your school's deployment of MLTI. Please place an "X" beside the descriptor that applies most often to you.

________ (1) I am one of the first members of the faculty to try new approaches to technology integration in my classroom. I often am aware of new innovations before others in my school. I often try new innovations even though they are not fully developed and I am comfortable with the knowledge that they may not become a permanent part of my practice.

________ (2) I often adopt a new approach to technology integration before many of my peers. I am often looked to by my peers for advice on the use or implementation of new technology innovations. Although I am very comfortable with trying new

innovations within my own practice, I am judicious about which of these innovations I share with my peers.

________ (3) I often adopt new approaches to technology integration in about the same time frame as most of my peers. I am deliberate in which innovations I choose to use in my practice, neither being the first to try nor the last. I am willing to adopt those innovations that some of my peers have tried and seek their perspectives on the innovation.

________ (4) I often am one of the last to adopt a new approach to technology integration into my practice. I am cautious and skeptical of innovations and wish to see that most faculty have found the innovation to be valuable in their practice before I invest valuable resources into trying the innovation.

________ (5) I often adopt only those new approaches to technology integration that are required of me. I am suspicious of many of the innovations and the advocates of these innovations. The benefits of adopting these innovations rarely outweigh the demands on my resources.

Appendix B: Interview Questions

Interview 1- Teacher

1) Can you give me a short biography of your teaching experience?
2) How do you describe yourself as a teacher?
    1) What is your teaching style? Philosophy?
    2) What do you believe about how students best learn?
3) Could you describe the first year of your experience with one-to-one technology in the classroom?
    1) What were some of your initial successes? Frustrations?
4) How did your use evolve over the first few years?
    1) If it didn't, can you describe why? What prevented you from adopting or using some of the practices your colleagues were using?
5) How did your students' use evolve over the first few years?
6) In those first few years what types of instructional changes did you undertake because of technology? (Can you share some examples?)
    1) How would you describe why you didn't make many changes to your instructional practices with the introduction of one-to-one devices in your classroom?
7) In those few years what types of assessment changes did you undertake because of technology? (Can you share some examples?)
    1) How would you describe why you didn't make many changes to your assessment practices with the introduction of one-to-one devices in your classroom?

8) In those first few years how did your curriculum change because of the presence of technology? (Can you share some examples?)

    1) How would you describe why you didn't make many changes to your curriculum with the introduction of one-to-one devices in your classroom?

9) In those first few years how did your classroom management change? (Can you share some examples?)

    1) Did the introduction of devices make classroom management more or less difficult? Why?

10) Looking at those first few years and where you are at today, how have your instructional, curricular, and assessment approaches changed as you have become more fluent with the use of technology? (Can you share some examples?)

    1) How do describe why you haven't see much use for these devices in your classroom for curricular, instructional, or assessment?

11) Where did you turn for information about effective integration in the first few years?

12) Did you experience any challenges to your teaching style during the first few years of the MLTI deployment?

13) How did you help or were you helped by your peers in the early stages of MLTI's deployment?

    1) Who did you go to for support? Did others come to you for support?

14) Compared to your peers early in the deployment of MLTI were you an early adopter or late adopter of some of the innovations happening in your school?

    1) Can you give me an example of why you say that?

15) In terms of teaching strategies or assessment approaches did you learn anything from the presence of laptops in your classroom?
    1) Can you give me an example?
    2) If not, why do you think that is?
16) What types of support were in place when you first started to teach with laptops in your classroom?
    1) PD? Integration specialists? Leadership?
17) Thinking back to the first few years of the MLTI deployment, what were some of the most valuable changes you saw, experienced, or heard about in your school?
    1) If few, why do you think this is? Is it the technology, your comfort, the level of support?
18) What does assessment look like in your classroom? Can you describe some of the different ways you assess student understanding? (**ASK early in interview)**
19) In your discipline, how do you help students develop understandings over the course of a unit? Can you give me an example? (**ASK early in interview)**
20) What types of teaching approaches do you use in your classroom? Can you give me some examples? (**ASK early in interview)**
21) Do you adapt your approaches to different students? What does that look like (prompt for an example)? (**ASK early in interview)**
22) How do you scaffold student learning for the most difficult topics you cover? (**ASK early in interview)**
23) Do you focus on common student misconceptions for topics in your content area? Can you give me an example? (**ASK early in interview)**

24) How do you use, assess, or build on students' prior knowledge when introducing a new topic? **(ASK early in interview)**

Interview 2 -Teacher

1) Describe the ways you use technology currently in your classroom.
    1) Prompt for instructional, curricular, and assessment uses.
2) How have these uses changed over the past three years?
    1) IF they haven't why not?
3) Describe the example you have brought to share.
    1) What do you find valuable about this artifact?
    2) Where do you use it in your curriculum? How do you use it in your classroom?
    3) How, if possible, would you use accomplish the same outcome if you did not have the technology available in your classroom?
4) Looking at the big picture of technology integration in your classroom, what are the most important supports to your use?
    1) Have those supports changed over time? Do you need different support today than you did in the past?
5) Looking at the big picture, what are the largest barriers or obstacles to your use?
    1) Have those barriers changed over time? Do you encounter different obstacles today than you did in the past?
6) How do new practices (in technology integration) come to your attention?
    1) Prompt for the use of peers, experts, online resources, professional development opportunities, etc.
    2) Has that changed over the course of the MLTI deployment?
    3) What do you need to be in place before you adopt a new practice that has come to your attention, into your teaching and learning?

7) In looking at your and your student's uses of technology in your classroom, where are they unique to your discipline?
    1) Thinking about your peers' uses, outside of your discipline, what practices are unique to their use of technology?
8) When planning curriculum that will depend on or use technology, how do you make the decision about the use of a particular piece of software or hardware? How do you know you have made the correct choice? (Was this different when you first started to use technology in planning curriculum)?
9) When using technology for instruction, how do you make the decision about the use of a particular piece of software or hardware? How do you know you have made the correct choice? (Was this different when you first started to use technology in your instruction)?
10) When using technology for assessment, how do you make the decision about the use of a particular piece of software or hardware? How do you know you have made the correct choice? (Was this different when you first started to use technology in planning assessment)?
11) Can you think of any examples where you adapt the technology to your learning outcomes?
    1) For example, do you use the same software or hardware in different ways depending on your goals for the lesson?
12) How does your teaching style affect the choices you make about what type of technology to use in your classroom?
    1) Does the technology ever shape your teaching style?

13) What does your use of technology look like outside the classroom?

14) When participating in professional development around technology integration, do you see applications to your discipline easily?

    1) For instance, if a science teacher demonstrates a use in their class, do you find yourself thinking about how it might apply to your context?

15) Can you think of examples of where you have used technology to create effective representation of content in your discipline?

    1) If not how do you represent (heuristics) content or understanding in your courses?

16) Do you use technology for differentiation for your students? Can you give me some examples? Has this changed over the years?

    1) If not how do you differentiate for your students? Prompt for examples.

17) Has the use of technology in your classroom required you to develop different classroom management practices?

Interview 3 -Teacher

Many of the questions for this interview will be based on responses to earlier interview questions. Clarifications of, elaborations on, or exploration of unanticipated ideas and meanings will be the focus of this final interview. However, the following questions will be asked of participants to obtain their descriptions of the meaning they ascribe to the MLTI deployment.

1) Do you feel that the technologies that you choose to use enhance what you teach, or how you teach, or what students learn? Can you give me an example(s)?
2) Do you have strategies for combining content, technology, and teaching approaches when designing your curriculum and lesson plans? Is there a framework or approach you take to blending these three areas? (Prompt for examples).
3) How competent do you feel in combining content, technology and pedagogy in your practice? Why?
4) What do you see as the next steps in your integration of technology into your practice?
    1) What are you considering doing differently?
5) MLTI has been in place for a decade, what has it meant to you as a teacher? To your students as learners? To your school as an institution?
6) Education has undergone a tremendous amount of change in the last decade, how does your school's participation in the MLTI deployment compare to the other types of changes/initiatives you have participated in over that same period?

1) Prompt for information on which was more challenging? More rewarding? More valuable? More Stressful?

7) What are your hopes for the future of technology in your classroom?

8) What are your fears about the future of technology in your classroom?

Administrator and Technology Leader Interview Protocol

1. How do you envision using technology to help students learn the basics? Or foundational knowledge?
2. How does your technology deployment support students using knowledge?
    a. How does it contextualize learning and make learning engaging and meaningful?
    b. How does it support creating and creativity or project based learning?
2. How do you use technology to keep track of student learning?

Maintain evidence of mastery?

1. How do you use technology to promote a transparent curriculum?
2. How do you use technology to make learning progressions clear?
3. How does your use of technology help the student do more one their own and need the teacher less?
4. How do you use technology to capture what students know and can do?
5. How do you use technology to help stay better connected to parents?
6. Can your teachers use these devices themselves as their own productivity and learning tool?
7. How do you help teachers manage technology in their classrooms? IE how can teachers insure that students are focused and on task when using technology?
8. How do you help teachers organize technology (or collaborate with students to organize technology) so it works and is available?
9. How do you deliver technology professional development?

10. Do you have a technology vision and strategic plan? Can you walk me through it?
11. How do you model technology use in your role as a building leader?
12. What are your expectations for staff integration of technology into their teaching and learning?

a. How do you communicate those expectations to staff? How do you monitor those with staff?

2. How do you encourage your staff to share their insights and success around technology use with one another?
3. Do teachers in your school give each other feedback on pedagogy whether it involves technology or not?
4. How much time is devoted to various forms of professional development?

a. In what areas?

b. In what manners is this delivered?

2. Who decides the focus for professional development for your building?
3. How do you support the change process in your building?

Appendix C: Informed Consent Form

University of Southern Maine

CONSENT FOR PARTCIPATION IN RESEARCH

Project Title: An examination of teacher understandings of technology integration at the classroom level.

Principal Researcher(s): *Shawn Carlson, 35 Sheepscot Shores Road, Wiscasset, ME, 04578, (207) 350-9647 shawn.carlson@maine.edu*

Introduction:

- Please read this form, you may also request that the form is read to you. The purpose of this form is to provide you with information about this research study, and if you choose to participate, document your decision.
- You are encouraged to ask any questions that you may have about this study, now, during or after the project is complete. You can take as much time as you need to decide whether or not you want to participate. **Your participation is voluntary and you may ask questions at any time.**

Purpose of the Study:

· The purpose of this study is to describe the reflection of teachers on MLTI's impact on their teaching and student learning.

· Participants in this study are 8 classroom teachers who have been teaching within a middle school participating in the MLTI program for at least 3.

What will you be asked to do?

If you choose to participate in this study, you will be asked to:

· Participate in 3 audio-recorded individual interviews lasting 45-60 minutes each. Interviews will be conducted at a mutually convenient time and place.

· Share any relevant artifacts and documents deemed relevant to this work (sanitized to protect staff and student confidentiality).

· Provide feedback on transcripts, themes, or big ideas generated from your interview.

What are the possible risks of taking part in this study?

- Although every possible step will be taken to assure your confidentiality if you participate, the nature of teaching in a small school may allow some to make reasonable guesses about the identity of some participants when reading their words. Your identity may not be associated with your interviews, but some details may allow the readers from your own school to infer the identity of the respondent. You will be given the opportunity to read all materials and may request that anything you share not be used, or you may withdraw from the study at anytime if you are concerned about any issue.

What are the possible benefits of taking part in this study?

· As a participant in this study, you will have the opportunity to engage in a confidential professional reflection about your teaching practice in a school participating in MLTI's program.

· This study will inform the field about teacher perceptions and the overall impact of one-to-one computing in the classroom on teacher practices.

Confidentiality and Privacy of Data:

- The records of this study will be kept confidential to the extent allowed by law.
  - All participants will be given a pseudo name.
  - Audio recording files of each interview will be stored on storage devices at the above address and on a secure server that is password protected.
  - Only those listed as researchers will have access.
  - All audio files will be destroyed upon completion of the project.
  - Any sort of report published will not include any information that will make it possible to identify a participant.
  - Data included in such a report may be replicated in other formats and for future studies but personal information will remain unidentifiable.

o Please note that regulatory agencies and the Institutional Review Board may review the research records.

- A copy of your signed consent form will be maintained by the principal investigator for at least 3 years after the project is complete before it is destroyed. The consent forms will be stored in a secure location that only members of the research team will have access to and will not be affiliated with any data obtained during the project.

Voluntary Participation / Withdrawal:

- Your participation is voluntary. Your decision to participate will have no impact on your current or future relations with the University.
- You may skip or refuse to answer any question for any reason.
- If you choose not to participate there is no penalty to you. You are free to withdraw from this research study at any time, for any reason.

Contacts and Questions:

The researcher conducting this study is Shawn Carlson. For questions or more information concerning this research you may contact him at (207) 350-9647, shawn.carlson@maine.edu. For additional information or questions, you may also contact Catherine Fallona, Dissertation Chair, cfallona@usm.maine.edu, (207) 228-8326.

- If you choose to participate in this research study and believe you may have suffered a research related injury, please contact Shawn Carlson at (207) 350-9647 or Catherine Fallona at (207) 228-8326.

· If you have any questions or concerns about your rights as a research subject, you may call the USM Human Protections Administrator at (207) 228-8434 and/or email usmirb@usm.maine.edu.

Will I receive a copy of this consent form?

- You will be given a copy of this consent form.

Biography of the Author

The author was born in Barkhamsted, CT and attended Northwestern Regional #7 High School. The author attended the University of Maine where he obtained a B.S. in Forest Resources in 1985. The author subsequently earned his M.S. in Wood Science and Technology at the University of California, Berkeley. Later the author earned his M.S. in Educational Leadership from the University of Southern Maine in 2008. A professional educator, the author has held the positions of science teacher, building administrator, technology director and assistant superintendent. He is a candidate for the Doctoral degree in Public Policy from The University of Southern Maine in May, 2016.