A Middle School One-to-One Laptop Program:
The Maine Experience

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Executive Summary

Over eight years ago, Maine embarked on a bold new initiative. Entitled the Maine Learning Technology Initiative (MLTI), this program funded by the State of Maine, provided all 7th and 8th grade students and their teachers with laptop computers, and provided schools and teachers with a wireless internet infrastructure, technical assistance, and professional development for integrating laptop technology into their curriculum and instruction.

The first full implementation of MLTI began in the Fall of the 2002-03 academic year. At the same time the Maine commissioner of education contracted with the Maine Education Policy Research Institute (MEPRI) to conduct the ongoing evaluation of MLTI. MEPRI is a non-partisan research institute funded jointly by the Maine State Legislature and the University of Maine System. Over the past eight years the MEPRI research and evaluation team has used a mixed method approach in the evaluation of the MLTI program; an approach that uses both quantitative and qualitative techniques in collecting and analyzing research and evaluation evidence.

The evidence presented in this report indicates the MLTI program has had a significant impact on curriculum, instruction, and learning in Maine's middle schools. In the areas of curriculum and instruction, the evidence indicates many teachers have reached the tipping point in the adoption and integration of the laptop into their teaching. However, the adoption is uneven for some teachers, and in some content areas. Relatively speaking, mathematics teachers use the laptops less frequently than their colleagues in other core disciplines. Most teachers are not using the laptops as frequently in assessment as one might anticipate, and too few teachers report using the laptop in teaching 21st Century Skills.

Middle school teachers report substantial benefits from the laptop program. Teachers indicated the laptops have helped them teach more, in less time, and with greater depth, and to individualize their curriculum and instruction more. Many teachers reported that their students learned more and in greater depth with the laptops.

There also is some evidence of the direct impact of the laptops on student achievement. Results indicate that students' writing has improved. In mathematics there is evidence that a well-designed and executed professional development resulted in improved student performance in mathematics. A science study also found significant gains in student achievement, both short term and longer term, when students used their laptop to learn science. In addition, two studies demonstrated the impact of students' laptops in learning an important 21st Century Skill, the skills of locating and evaluating information.

In light of these benefits of the laptop program, it is important to also consider the costs of the program. Although much of the evidence in this area must be used cautiously, it appears Maine's one-to-one laptop program costs are in line with the average costs found in other one-to-one laptop programs. Maine's per unit costs were very similar to the average found in four other cost studies, and the incremental costs appear to be moderate. Thus, it appears the MLTI program has been successful in many ways.

A Middle School One-to-One Laptop Program: The Maine Experience

Maine Education Policy Research Institute
University of Southern Maine

Background

Over a decade ago Maine embarked on a bold new initiative, an initiative designed to:

> *…transform Maine into the premier state for utilizing technology in kindergarten to grade 12 education in order to prepare students for a future economy that will rely heavily on technology and innovation.* (Task Force on Maine's Learning Technology Endowment, 2001, p. vi)

The Maine Learning Technology Initiative (MLTI) has provided all 7th and 8th grade students and their teachers with laptop computers, created a wireless internet infrastructure in all of Maine's middle schools, and provided teachers and staff technical assistance and professional development for integrating laptop technology into their curriculum and instruction.

The concept of the Maine Learning Technology Initiative (MLTI) began with a vision of former Governor Angus King. He believed that if Maine wanted to prepare Maine's students for a rapidly changing world, and wanted to gain a competitive edge over other states, it would require a sharp departure in action from what Maine had done in the past.

In late 1999 a one-time State surplus of general funds provided Governor King the opportunity to act upon his beliefs. He proposed that all middle school students and teachers in Maine be provided laptop computers. In the summer of 2000 the Legislature and Governor King convened a Joint Task Force on the Maine Learning Technology Endowment and charged the task force with conducting an in-depth examination of the issues surrounding Governor King's proposal, and to recommend the best course for Maine to follow.

The task force concluded:

> *We live in a world that is increasingly complex and where change is increasingly rampant. Driving much of this complexity and change are new concepts and a new economy based on powerful, ubiquitous computer technology linked to the Internet.*
>
> *Our schools are challenged to prepare young people to navigate and prosper in this world, with technology as an ally rather than an obstacle. The challenge is familiar, but the imperative is new: we must prepare young people to thrive in a world that doesn't exist yet, to grapple with problems and construct new knowledge which is barely visible to us today. It is no longer adequate to prepare some of our young people to high levels of learning and technological*

> *literacy; we must prepare all for the demands of a world in which workers and citizens will be required to use and create knowledge, and embrace technology as a powerful tool to do so.*
>
> *If technology is a challenge for our educational system, it is also part of the solution. To move all students to high levels of learning and technological literacy, all students will need access to technology when and where it can be most effectively incorporated into learning.* (Task Force on Maine's Learning Technology Endowment, 2001, p. i).

In the Fall of the 2002-2003 academic year, the first full implementation phase of the MLTI began. In this first phase, over 17,000 seventh graders and their teachers in over 240 middle schools across the state of Maine received laptop computers. The following year all eighth graders and their teachers also received laptops, and each subsequent year thereafter, all seventh and eighth graders and their teachers have received laptop computers, paid for by the State of Maine.

Concurrently, with the first deployment of the laptops, the Maine Department of Education initiated a professional development program to assist teachers in integrating the laptops into their curriculum and instruction. Teacher training through professional development was believed to be paramount for the successful implementation of the laptop program. In each of the State's middle schools, both a Teacher Leader and a Technology Coordinator were selected and trained to serve as leaders within their schools for the MLTI. These teacher leaders and technology coordinators now serve as contact and support personnel for the classroom teachers in the buildings where they teach. Subsequently new roles were created and added to the MLTI professional development network. These positions were created to facilitate greater integration of curriculum and technology and as support for the transformation of teaching and learning in Maine's classrooms.

This report describes some of the major impacts of the Maine middle school laptop program. It presents evidence on both the use and impacts of the laptop technology with teachers and students, evidence of the impacts of the program on student achievement, and a cost analysis of the program.

Documenting the Maine Experience

In June 2002, the Maine commissioner of education, J. Duke Albanese, contracted with the Maine Education Policy Research Institute (MEPRI) to conduct the ongoing research and evaluation of MLTI. MEPRI is a non-partisan research institute funded jointly by the Maine

State Legislature and the University of Maine System. The institute conducts education policy research for the Legislature, and under grants and contracts, conducts a variety of studies and evaluations for various state agencies.

Over the past eight years the MEPRI research and evaluation team has used a mixed method approach in the examination of the MLTI program. Evidence has been collected with online surveys, site visits and observations, and research studies. *This report describes the survey evidence and the results from a number of targeted research studies.*

The evidence contained in this report is organized into six sections. The first two sections of this report describe the most recent evidence on how the laptops are being used in Maine middle schools and classrooms, and some factors which appear to be related to use levels. The third section describes benefits of the laptop program as reported by teachers and students. These sections are followed by one reporting achievement impacts of the program, and one reporting program costs. The final section summarizes the impacts of the MLTI program, and identifies areas for future research.

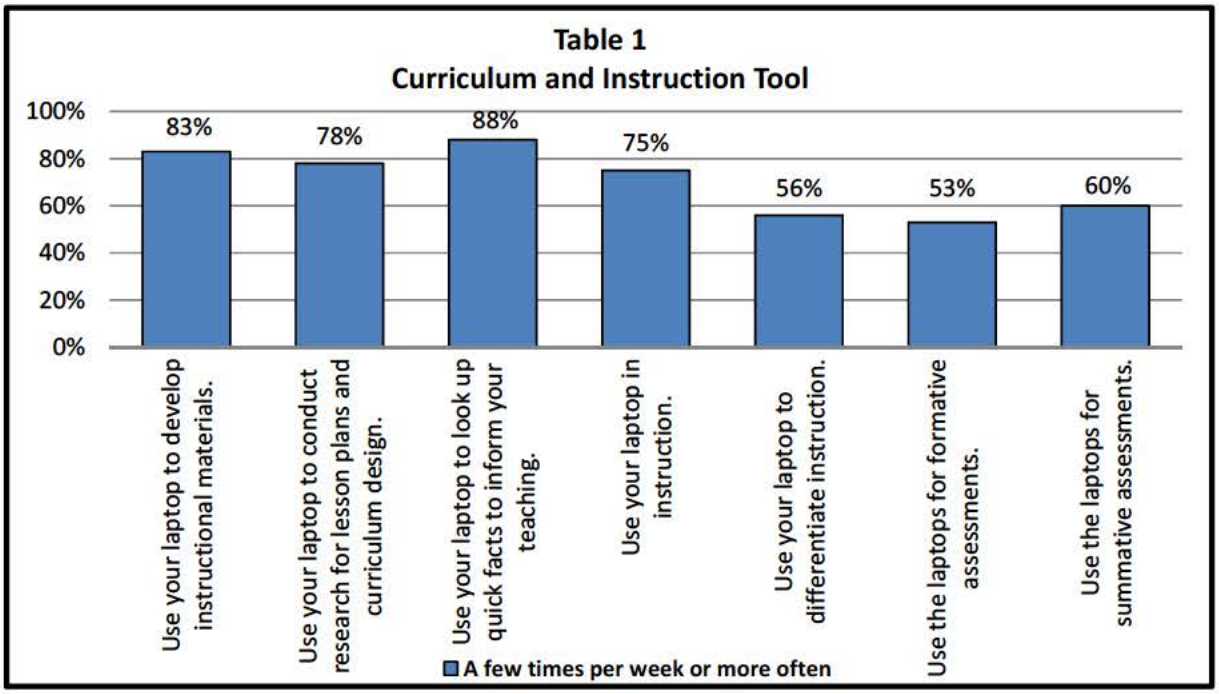
Section 1: Evidence on Laptop Uses

Given eight years of implementation of the laptop program in Maine’s middle schools, one may ask how frequently are the laptops being used in classroom instruction, and how are they being used? Are use levels as high as one might expect? To explore these questions, surveys were used to collect evidence from teachers and students.

Teachers report using the laptops in a variety of ways, and with different levels of frequency. Tables 1 and 2 on subsequent pages describe two broad categories of use, as reported by over 1,690 middle school teachers in Spring 2010. These teachers represent approximately 38% of all middle school teachers, and an analysis of the demographic of the respondents indicated these teachers were fairly representative of all of Maine’s middle school teachers.

Table 1 presents frequency use for a series of activities which may be classified as related to curriculum development and instruction. The survey items asked teachers how frequently they used their laptops to perform certain activities. Teachers could respond by marking one of six categories: (1) Never; (2) Less than once per week; (3) Once per week; (4) A few times per week; (5) Once daily; or (6) Often during the day. *For purposes of this report, the top three most frequent use levels (#4-#6) were aggregated and this is the evidence presented in the tables* *which follow. Thus, the tables included in this section report frequency levels for use of the laptops as "<u>A Few Times Per Week or More Often</u>."*

The evidence in Table 1 indicates that approximately 80-90% of the teachers reported using their laptops a few times a week or more frequently to develop instructional materials, and

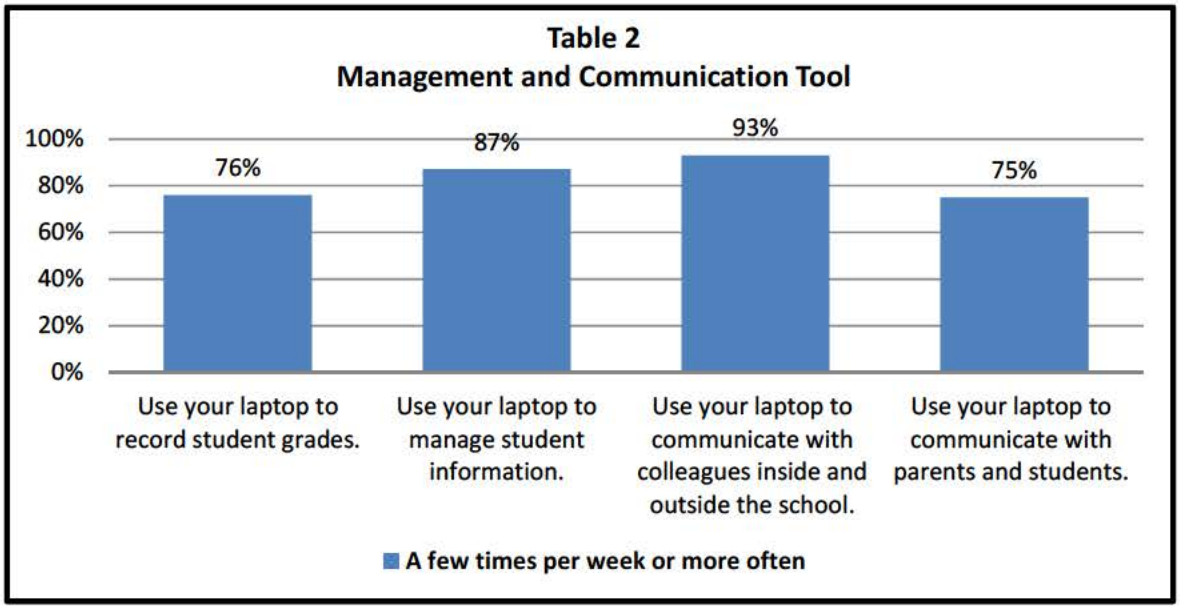


conduct research for lesson development. And three-quarters of the teachers (75%) report using the laptop just as frequently in providing instruction.

However, while a large majority of teachers report frequently using the laptop in developing lessons and in providing classroom instruction, only a little over half the teachers reported using the laptops to provide differentiated instruction. Why this is not higher was not discernable from the survey evidence.

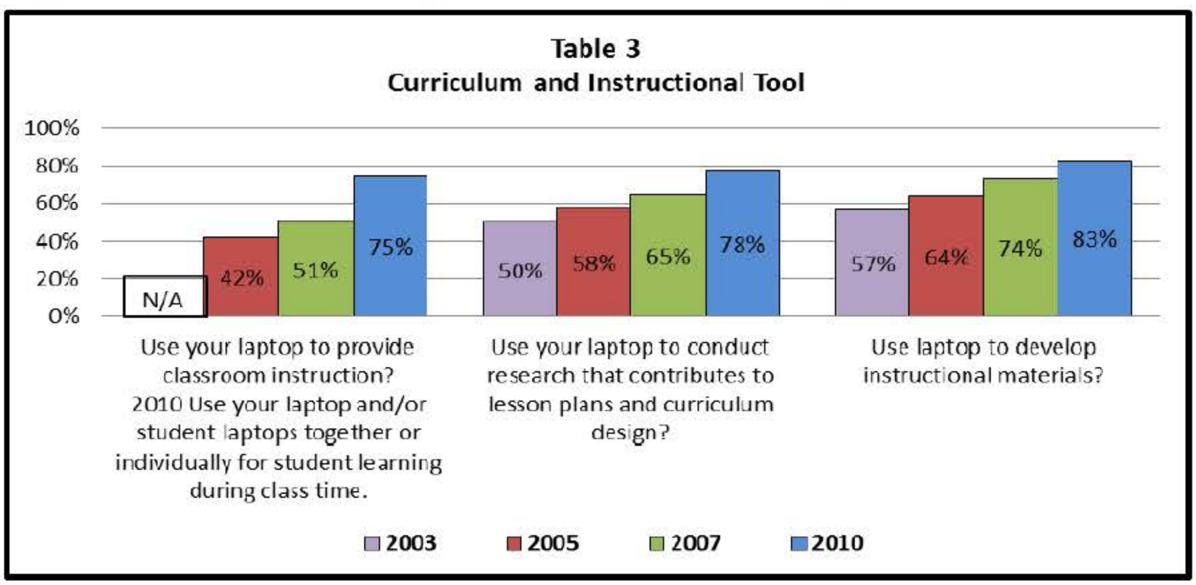
The same may be said in the case of using the laptops for assessment. Three out of five teachers reported using the laptops for summative assessments, but only about one-half report using them for conducting formative assessments. Given the potential of the laptop technology to differentiate instruction, and assess learning easily, quickly, and frequently, further research in these areas is warranted.

Table 2 reports activities that suggest the laptops are also being used as a management and communication tool. Approximately 75-90% of the teachers use the laptops a few times a week or more frequently to record and manage student information. Over 90% of the teachers

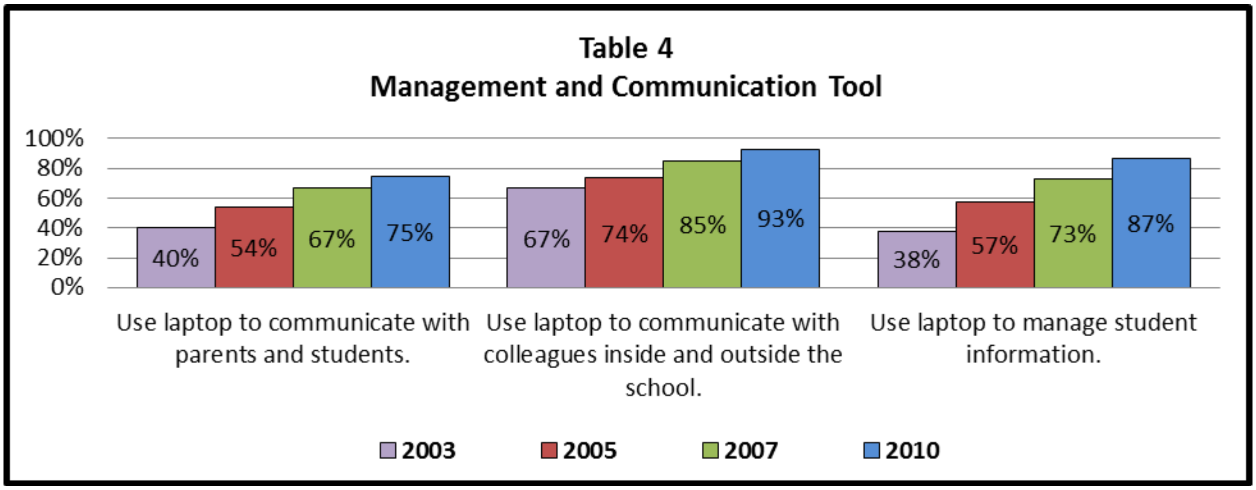


use their laptop for communicating with colleagues and 3 out of 4 teachers report using their laptops to communicate with parents and students.

Have use levels changed over time? Tables 3 and 4 report changes in use levels over the past eight years. In the case of using the laptops as a curriculum and instructional tool, Table 3 reports teacher use levels for four different time periods: (1) 2003, at the end of the first full year of implementation, (2) Year 3 of implementation; (3) Year 5 of implementation; and (4) for



2010, eight years after the initial deployment of the laptops in all middle schools. As the data shows, there has been a consistent increase in the use of the laptops in developing curriculum and in providing instruction. The same is true in the case of using the laptops as management and communication tools (Table 4). The greatest increase in this case has been the frequent use of the laptop to manage student information, an increase from 38% to 87%. And particularly noteworthy is the increased use of the laptops for communicating with parents and



students. Whereas, by the end of the first year of deployment of the laptops, 4 out of 10 teachers reported using their laptops to communicate with parents and students a few times a week or more frequently, eight years after the initial deployment, 75% of the teachers indicated they were communicating frequently with parents and students using their laptops.

Are these use levels eight years into the project at the desired levels? Are they at a level one might expect to find after eight years? These questions are difficult to answer for several reasons. First, what constitutes the "desired level?" As described earlier, for this report the top three most frequent use levels have been combined to define "Frequent Use." But, one may ask, is use "A Few Times a Week or More Often" the appropriate benchmark? Should there be a different benchmark depending upon the type of activity (e.g., preparing lessons vs. providing instruction vs. assessment)? Might frequency level depend upon the discipline, content, time of year, or class schedule (e.g., daily or block schedule)? Given these questions, determining the appropriate standard is not an easy task.

Setting aside for the moment this set of questions, one might consider using a comparative standard for judging those use levels. That is to say, are the use levels found in Maine comparable to levels found in other one-to-one laptop programs. Unfortunately, a review of the extant literature provides very little guidance here. In fact, in general there is a dearth of information documenting laptop use by teachers in their curriculum and instruction, and what evidence that does exist, consists of reports using a variety of different metrics for measuring use (e.g., hours per day, days per week, more or less than without laptops, etc.) Thus, a comparative standard for use levels is difficult.

Another potential way of examining use levels is in terms of what is known about innovation and diffusion. Roger (1995) describes how new ideas or innovations are adopted by individuals and become diffused throughout the organization, how they reach what Gladwell (2000) and others before him called the "tipping point," the point where something that began as *unique* becomes *common*.

Rogers identifies five types of adopters: (1) innovators; (2) early adopters; (3) early majority adopters; (4) late majority adopters; and (5) laggards. The first four groups account for approximately 84% of all adopters, with laggards accounting for the last 16%. Reaching Roger's 100% adoption level is theoretically possible, but empirical evidence suggests that achieving 100% may be unrealistic. Laggards may never become adopters.

How might this research be applicable in Maine's case? Table 5 reports frequent use levels measured against the 84% bar (e.g., less Laggards). Given that the teachers who

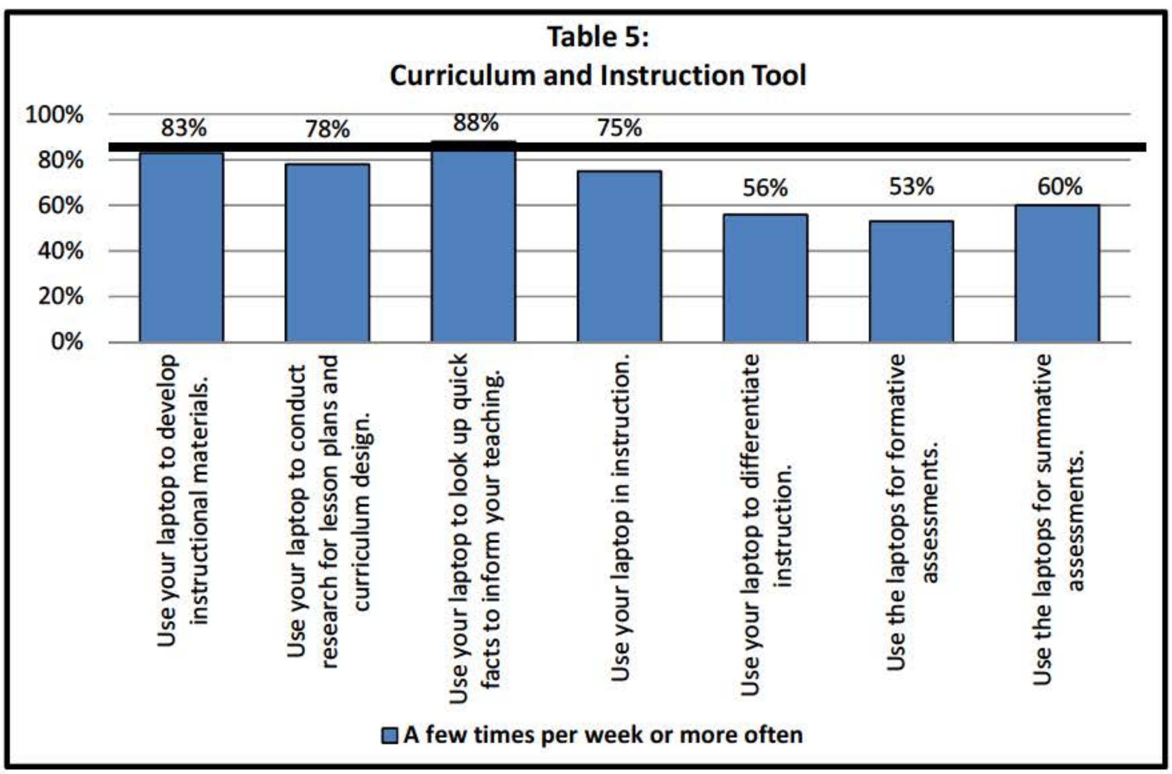
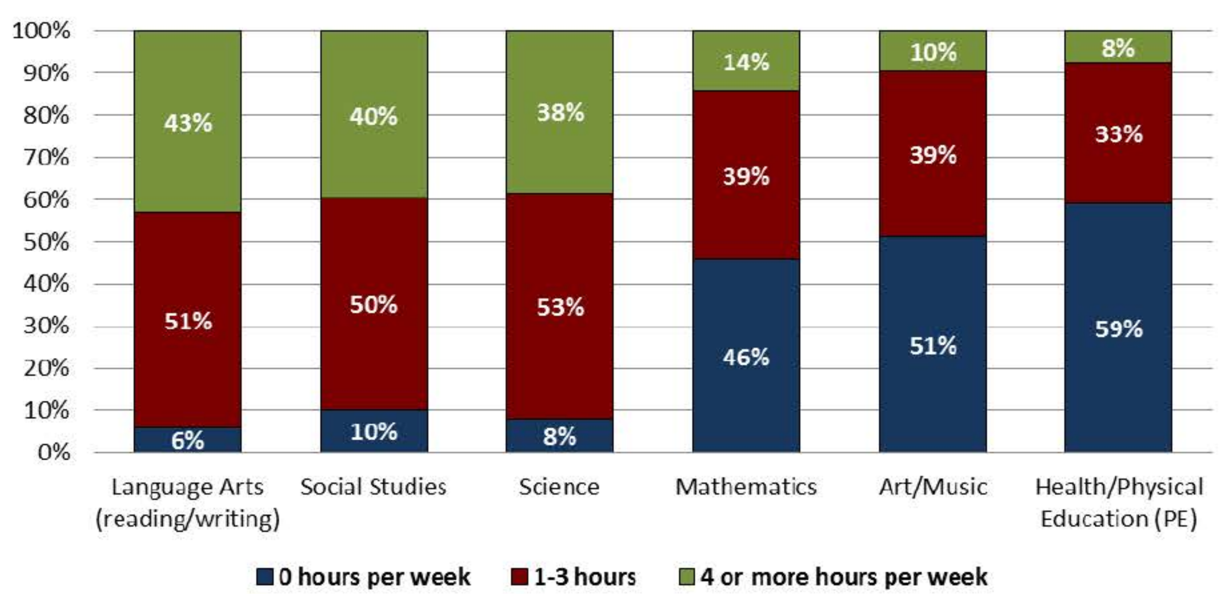


Table 5: Curriculum and Instruction Tool

completed the 2010 survey were fairly representative of the population of Maine's middle school teachers, as was noted earlier, these findings suggest that use levels are approaching the tipping point in several areas, but not in others. Eight years after the initial deployment of the laptops, most teachers completing the survey who may become adopters have done so in the areas related to developing and providing curriculum and instruction. Using the laptops in differentiating instruction and assessment has not reached the tipping point. However, as mentioned earlier it is unclear if using laptops "a few times a week or more frequently" is the appropriate benchmark. Possibly it takes longer for adoption to reach critical levels in these areas. But taking all the evidence into consideration in Table 5, it appears that for many Maine teachers the critical tipping point has been reached for integrating the laptops into some core curriculum and instruction activities. It is important to note that not all teachers report high use levels, but for many, frequent use appears to be commonplace.

Turning to student use levels, Table 6 reports how often students in a recent survey reported using their laptops in different subject areas. Students reported using their laptops most frequently in Language Arts, Social Studies, and Science. In these three areas, approximately 40% of the students indicated they use their laptops four hours or more each week. The same may not be said for other subject areas. In the case of Art/Music and Health/Physical Education the less frequent use may, at least in part, be attributed to the fact that classes in these areas are

Table 6
Student Reported Laptop Use in Classes



often held less often during a school week. But this is not true for Mathematics where only 14% of students report using their laptops for four hours or more, and almost one-half report never using their laptops in mathematics classes. Given the importance of this subject area, further research is needed to determine why, in light of the availability of many interactive programs in mathematics, use levels are still so low.

Tables 7 and 8 report survey results about how students use their laptops in classes and in completing homework. As indicated in Table 7, approximately 7 out of 10 students report using their laptops to conduct research a few times or more during the school week. But similar use levels are not as high for other tasks. For example, one-half or more of the students report using their laptops once a week or less to prepare written papers, and take notes, and over 80% report less use with spreadsheets.

Table 7
Percent of Student Indicating How Often They Use their Laptop

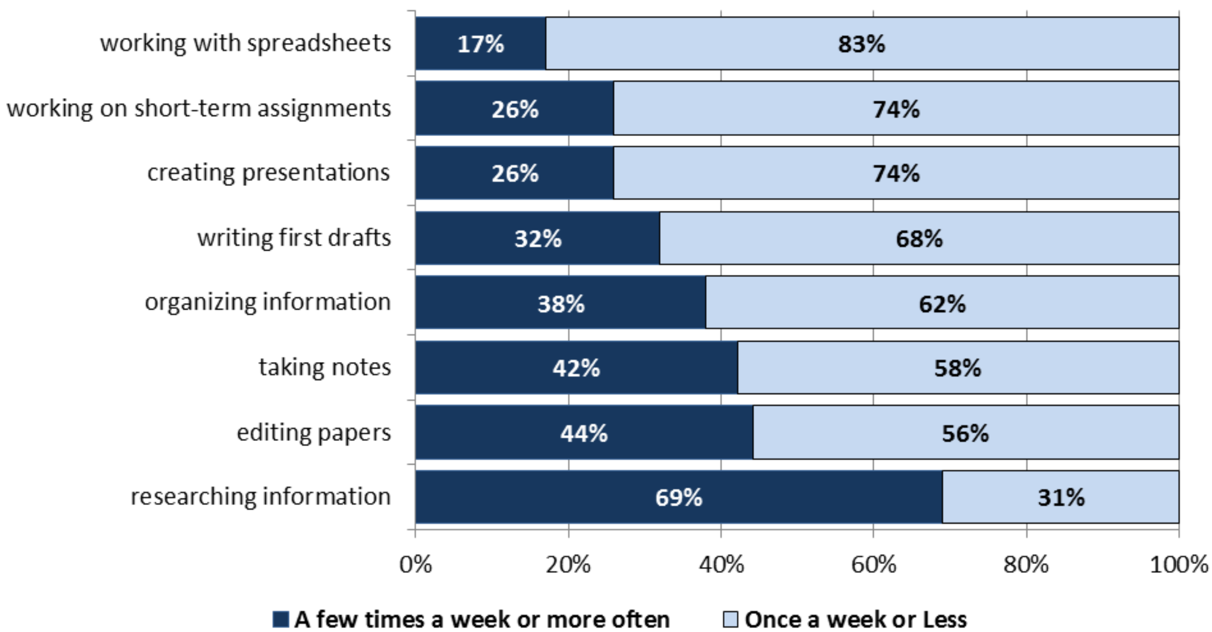
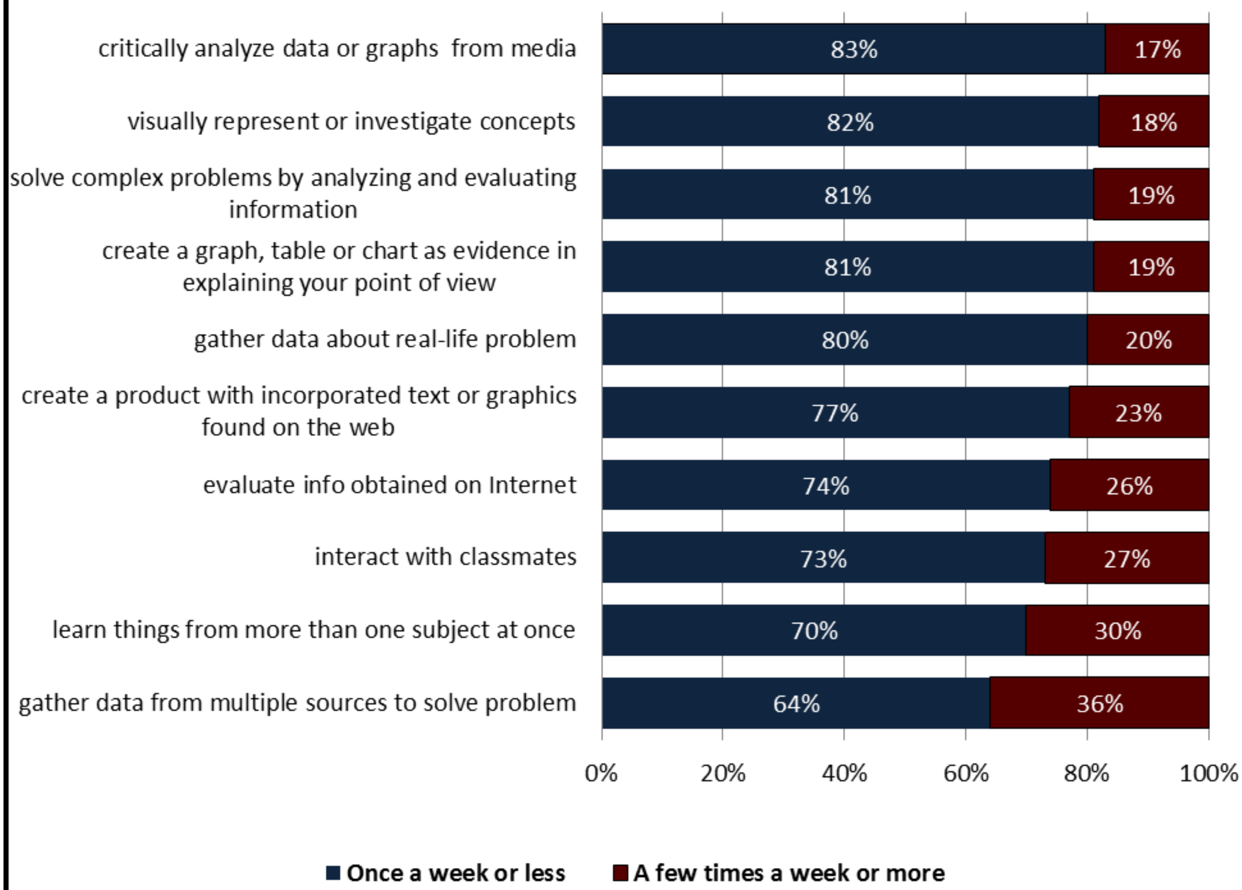


Table 8 on the next page reports student use of the laptops in other areas. In this case, the ten use areas represent what many experts believe to be skills needed in the 21st Century. Unfortunately, as may be seen from the student responses, it appears students are being asked infrequently to use their laptops in developing and practicing their skills. For instance, in only four of the ten areas do a quarter or more of the students report using their laptop a few times a week or more to perform these tasks. And less than one in five report frequent use in

Table 8
Percent of students indicating how often they use their laptop to do the following:



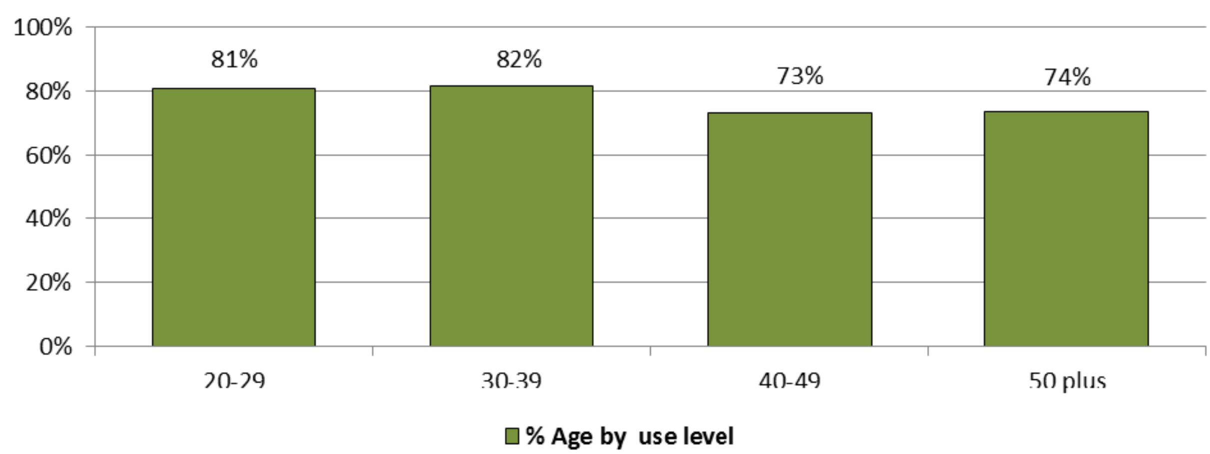
gathering information about a real-life problem, creating a graph, table or chart, or using their laptops to analyze or evaluate information. Thus, it appears the laptops are not being used with a high degree of frequency in developing these 21st Century skills. What is unclear from the survey results is if this infrequent use, relatively speaking, is because teachers are not teaching these skills, regardless of the instructional mode, or because teachers lack skills to effectively develop activities that use the laptops to teach these skills.

Section 2: Factors Relating to Use Levels

Turning to an examination of the factors which may influence teacher use of the laptops, the evidence above reveals that while most teachers report frequent use of their laptops, it is not true for all teachers. What accounts for these differences? One reason has already been discussed above; that is, differences in adoption levels. But are there other factors which may explain the differences? More specifically, are there teacher characteristics or school characteristics which may influence use levels?

Over the course of several years attempts have been made by the research and evaluation team to explore the possible relationships between use levels and teacher characteristics. The evidence has revealed some distinguishing characteristics and a few which appear to be unrelated or only modestly related to use levels. The unrelated ones include teacher gender and teacher education level. That is to say, use levels have not differed significantly by gender nor by how much education teachers have acquired. And in a couple additional characteristics the differences are small. Tables 9 and 10 provide evidence related to two such factors, age and years of teaching experience. As is the case for all the tables in this section of the report, use levels reported are in terms of the benchmark used in Section 1; that is, "A Few Times Each Week or More Often." In the case of teacher age, the evidence in Table 9 indicates frequent use levels are high and do not vary among teachers younger than 40 years of age. For those over 40 years old, overall frequency of use falls off some, but does not differ among older teachers.

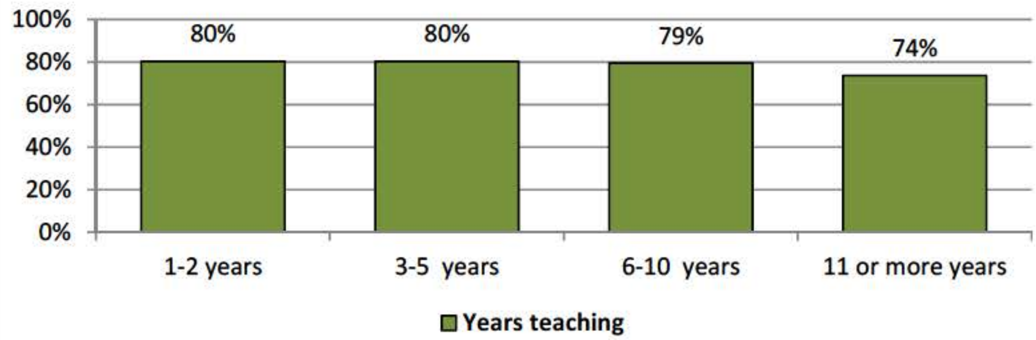
Table 9
Teacher Age and Use of their Laptop in Instruction



In the case of years of teaching experience, and as may be seen in Table 10, it appears that frequent use levels are generally also unrelated to years of experience. For teachers relatively new to the teaching profession (i.e., 1-2 years), approximately 8 out of 10 reported

Table 10

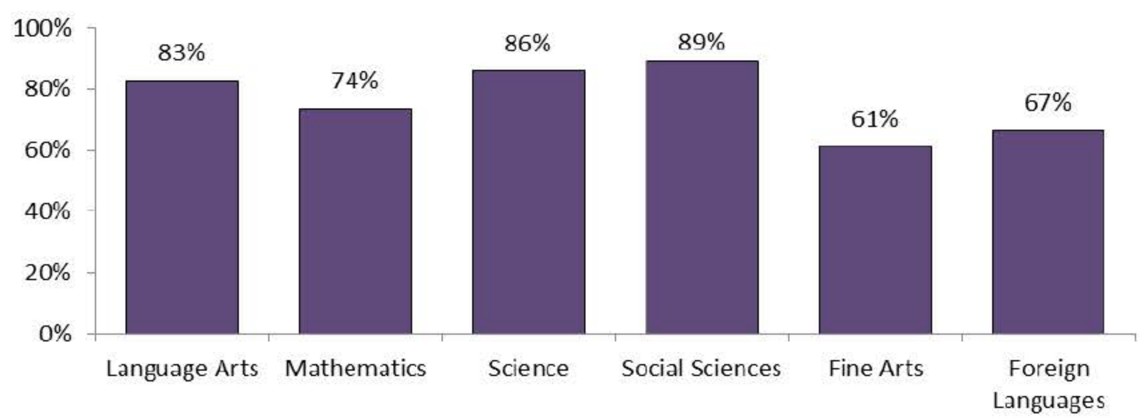
Years Teaching Experience and Percentage Use of Their Laptops in Instructio



using their laptops frequently in providing classroom instruction. And this ratio of frequent users is the same for teachers with up to ten years of experience. It is somewhat less for teachers who have been teaching for more than ten years, but frequent use is still relatively high (e.g. 74%).

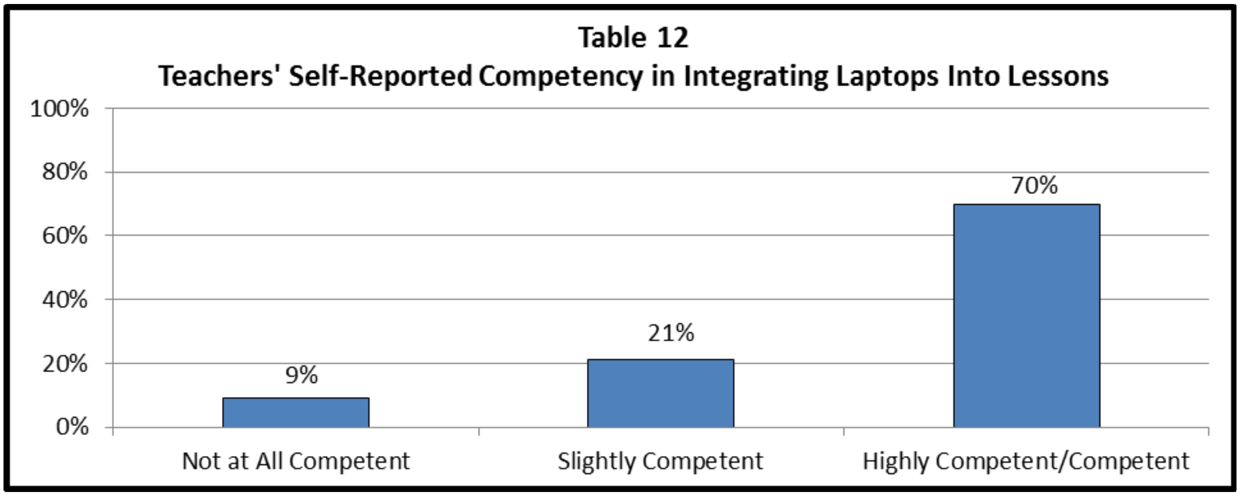
In the area of disciplines, Table 11 does reveal some differences in frequent use levels depending upon what subject the teachers teach, results which parallel those reported by students in Table 6. Between 80 – 90% of teachers who teach Language Arts, Science, and Social

Table 11
Discipline Teachers Teach and Percentage Use of Their Laptops in Instruction



Sciences report using their laptops in classroom instruction a few times a week or more frequently. Relatively speaking, Mathematics teachers use the laptops less frequently, as do Foreign Language teachers. Fine Arts teachers report even less frequent use; however, some of this phenomena may be due to the fact that fine arts classes, in many middle schools, do not meet as often as other disciplines (e.g., three times a week versus every day).

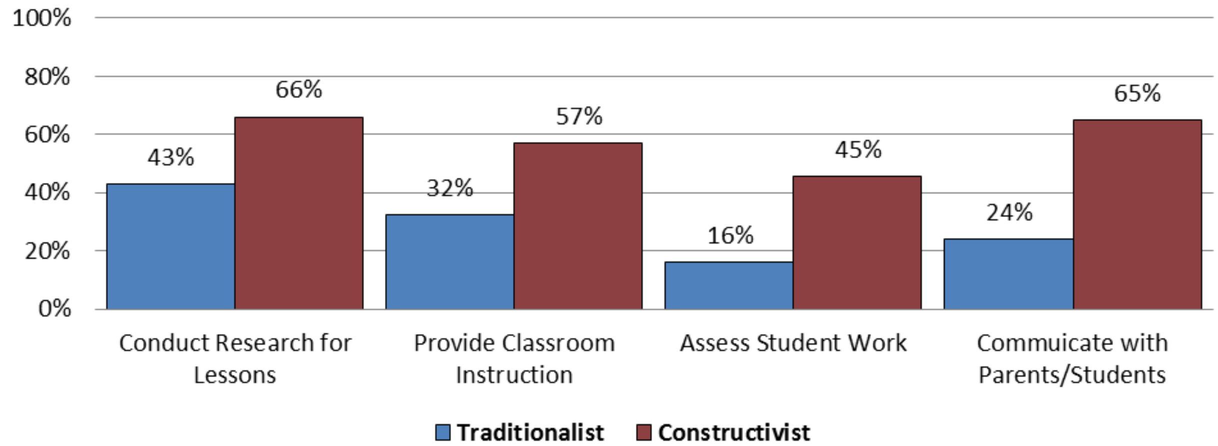
In the case of technology competency, and as may be seen in Table 12, teachers who feel they are competent in their ability to integrate the laptops in their instruction are three times more likely to use the laptops in providing instruction than the teachers who felt less competent. (60% vs 20%). This is not very surprising, but the difference appears to be quite dramatic.



Turning to other factors which may be related to use levels, teaching philosophy also appears to be somewhat related to teacher use levels. Teachers' philosophy on teaching and learning is often characterized as being somewhere on a continuum from Traditionalist to Constructivist. So-called Traditionalist teachers maintain more teacher-directed classrooms. Teachers tend to be very much in control of the teaching and learning environment. They most often decide what is taught, how it is taught, and at what speed students will learn. Constructivist teachers, on-the-other hand, are described as more facilitators and guides of learning than their counterparts, and believe students should play a larger role in directing more of their own learning. In reality, teaching philosophy is much more situational than absolute. Most teachers adopt different aspects of these two philosophies in different situations, but still maintain an underlying teaching philosophy that is more reflective of one or the other philosophy.

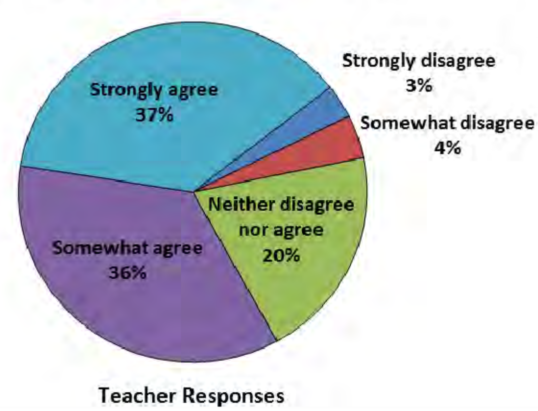
Are these two teaching philosophies related to use levels? Table 13 presents some insight into this question. Teaching philosophy and frequency of use appear to be related when it comes to using the laptop in classroom instruction. Approximately 57% of the teachers classified as Constructivist, as defined by their responses to teaching philosophy survey items, report using their laptops frequently in providing instruction. In contrast, frequent use levels by more Traditionalist teachers is only approximately 32%. Similar differences in frequent use levels are also apparent in other areas, as shown in the table.

Table 13
Teacher Philosophy and Use of Laptops in Instruction

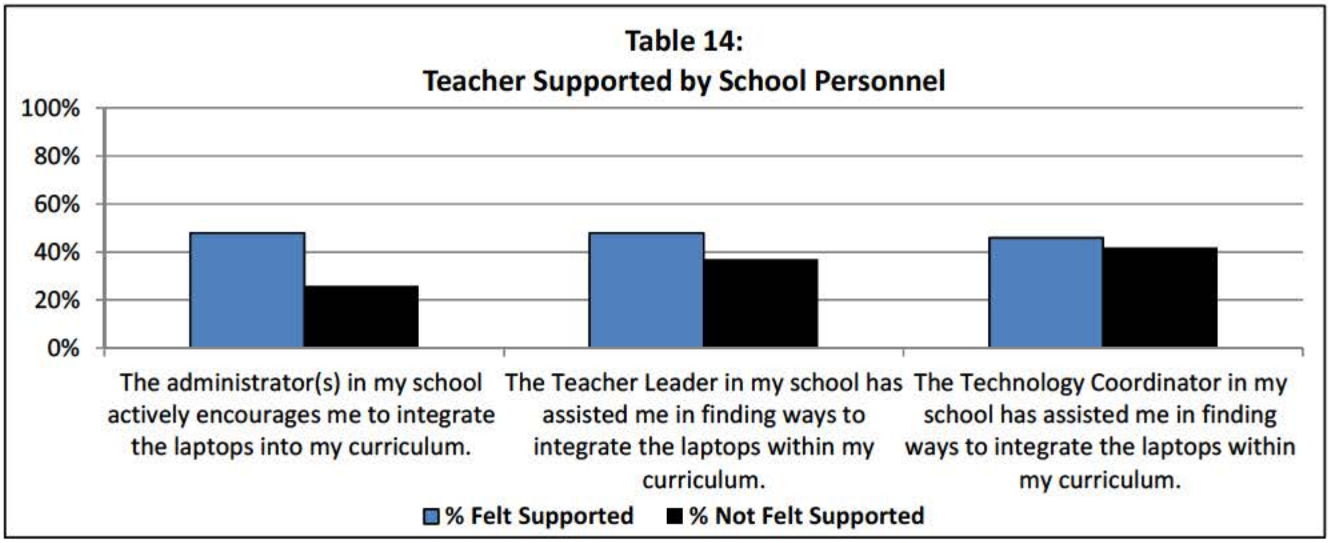


An interesting finding is that use of the laptops appears to have helped some teachers shift their teaching philosophy. Figure 1 reports teachers' belief about becoming more student-centered (i.e., more Constructivist). Almost 75% of the teachers who completed the MLTI evaluation survey in 2010 reported that the availability of the laptops have helped them to be more student-centered. What is unclear is what and why this happened. How did using the laptops help shift their teaching approach? And who shifted? These questions would benefit from further exploration.

Figure 1: Availability of the laptops has helped me shift my teaching from being more teacher-centered to being more student-centered.



The last major factor that has been explored in an attempt to identify factors related to use levels is actually a three part factor. Teachers were asked if they felt supported by three different types of personnel in the integration of technology into their curriculum. The evidence in Table 14 reveals that some teachers do feel more supported than others, and those support levels appear to be related to frequent use levels. Teachers who feel supported by their building administrators are almost twice-as-likely to be more frequent users than teachers who do not feel supported.



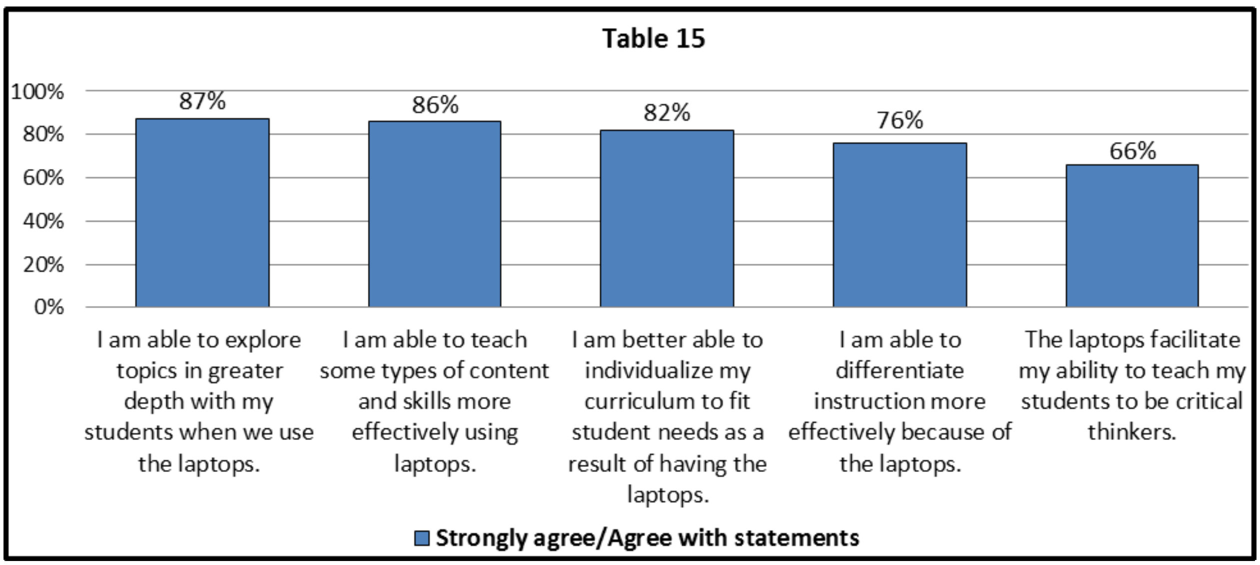
There is also a difference depending upon how helpful teachers feel their teacher leaders are of their work in integrating the laptops in their classrooms, but not much of a difference in the case of technology coordinator support. These findings suggest that while all school level supports are important, support by building level administrators is particularly important. This has significant implications for the provision of professional development, both for pre-service and in-service school principals and school leaders.

In summary the results suggest some links between teacher and school characteristics and use levels. Characteristics like age, gender, teaching experience, and education level appear not to be very significantly linked, but teaching philosophy, technology competence, and school supports do appear to be linked to use levels. However, a cautionary note must be made. The evidence suggests a link between some characteristics and use levels. But causal relationships cannot be determined with descriptive data. Just because two variables are related does not reveal which is the cause and which is the effect, or even if there is not another variable which explains the causal relationship. This caveat must be kept in mind as one explores links between variables; in this case, the link between teacher and school characteristics and use levels.

Section 3: Benefits of the Laptop Program

Section 1 of this report described the types of uses, and the frequency of uses of the laptops by teachers and students. Given these use levels and types, and the evidence of increase of use levels over time, what do the teachers and students see as the benefits of the MLTI program. In the documentation of the Maine experience, benefits have been examined in terms of self-reports by teachers and students, and in impacts on achievement. This section will describe the self-reported benefits to teaching and learning.

Table 15 reports teachers' perceived benefits of the laptops in helping them teach. On the MLTI evaluation surveys teachers were given a list of potential benefits and asked to indicate

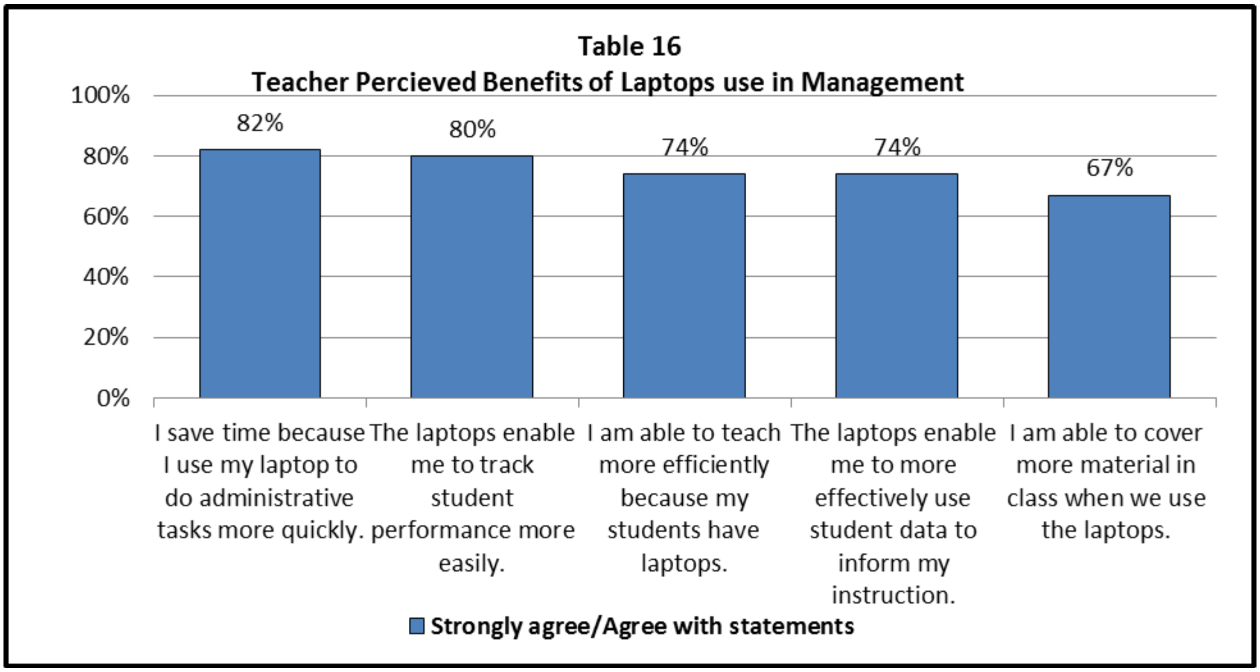


their level of agreement for each benefit. Responses could range from "Strongly Disagree" to "Strongly Agree", and only the top two categories (Strongly Agree and Agree) are reported in Table 15 and the subsequent tables in this section of the report.

It is clear many teachers perceive that the laptops help them in providing classroom instruction. Not all teachers agree, but over 80% report that the laptops help them explore and teach in greater depth and to teach a wider variety of content. Over 3 out of 4 teachers believe the laptops help them to differentiate instruction more (although the evidence reported earlier may call this into question) and help them do a better job of individualizing the curriculum to meet the different needs of different students. And two-thirds of the teachers believe the laptops help them to better teach their students critical thinking skills.

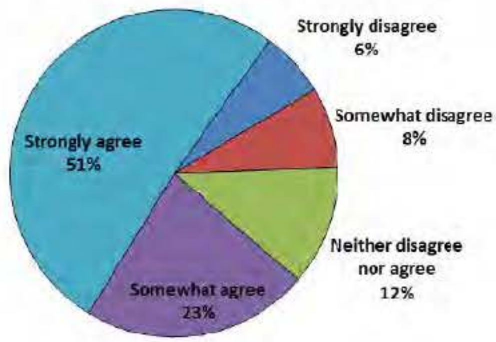
The teachers also report benefits from using the laptops to manage their curriculum, to use student data, and to track student performance (Table 16). A majority of the teachers report that because of the laptops they can cover more material (67%), teach more efficiently (74%), and use student data to guide their instruction (74%). And over 8 out of 10 teachers believe the laptops help them to track student progress, and perform other administrative duties.

Thus, it is apparent that many teachers believe that having the laptops benefits them, both in teaching and managing curriculum. In fact, when asked how important the laptops were to



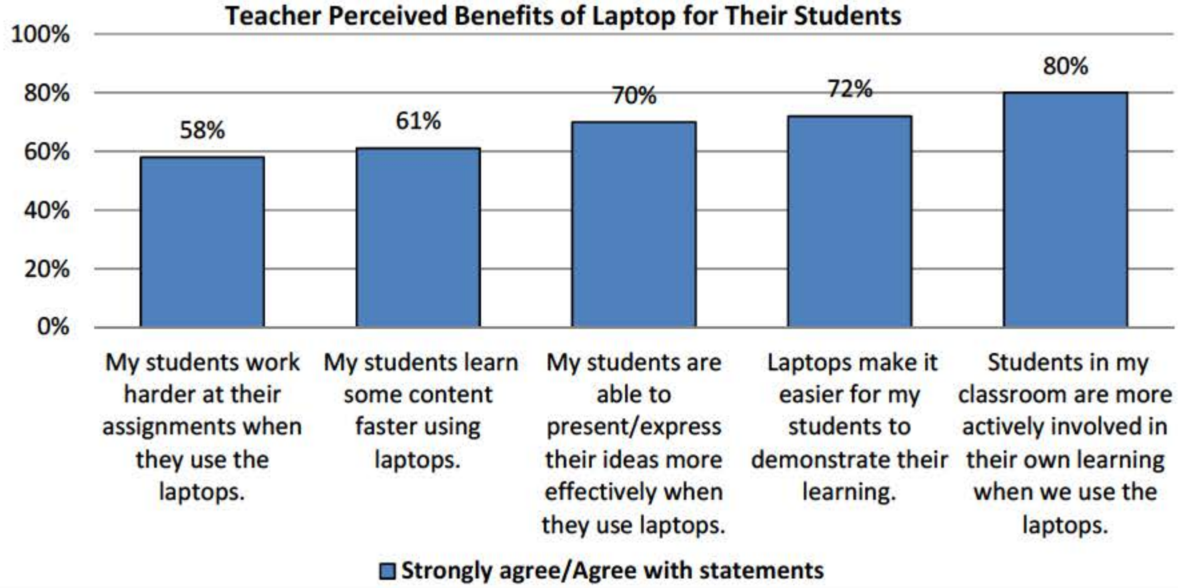
their teaching, a large majority reported they were of considerable importance. More specifically, many indicated they could not imagine teaching without their laptops. Figure 2 reports this evidence. Almost three-quarters of the teachers report that their laptops are an important teaching tool.

Figure 2: The laptops have become such an important tool in my teaching that I cannot imagine teaching without them.



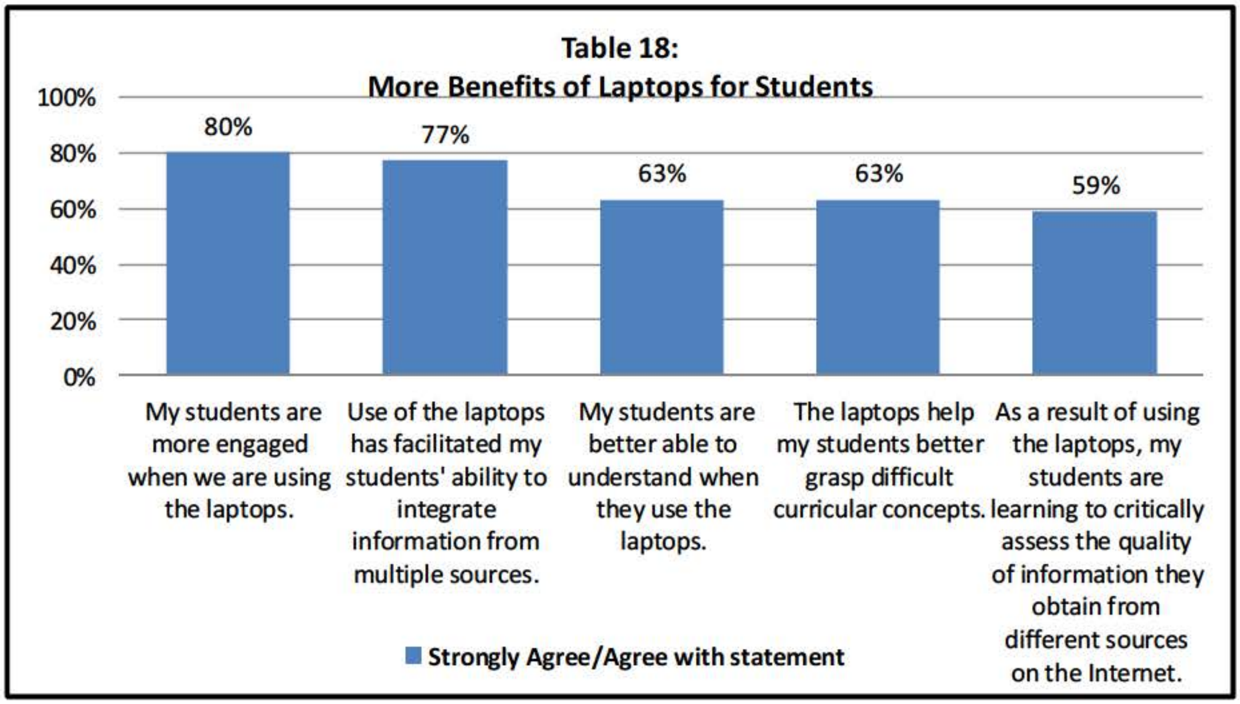
Teachers also believe the laptops are beneficial for their students. As shown in Table 17, 8 out of 10 teachers believe the laptops keep their students more engaged and more actively

Table 17
Teacher Perceived Benefits of Laptop for Their Students



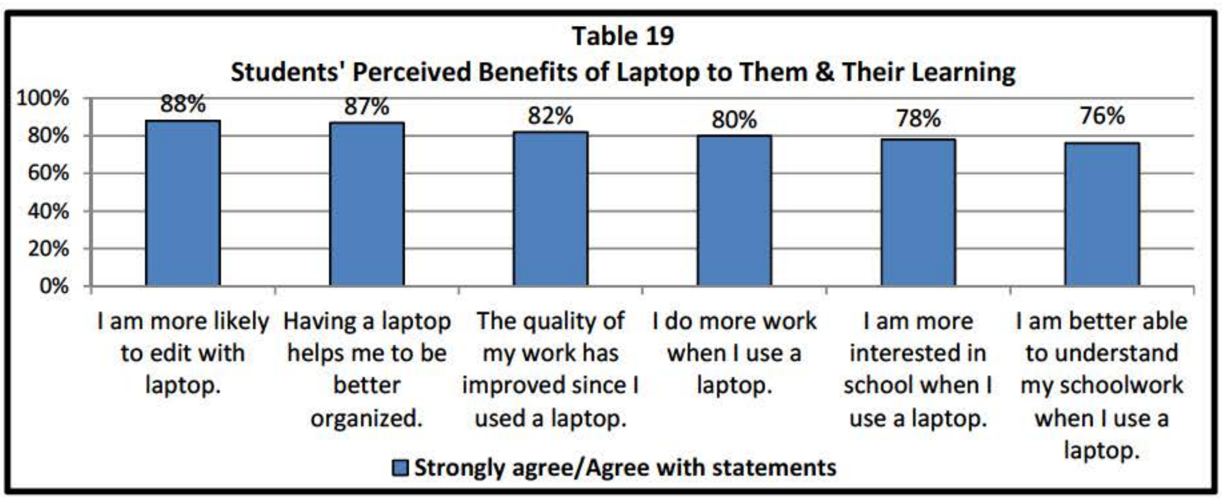
involved in their learning. Additionally, approximately 6 out of 10 teachers report that the laptops benefit their students by helping them learn content quicker, and that students work harder on assignments when they use their laptops.

Table 18 reports other benefits many teachers believe their students receive from having



laptops. Seven out of 10 teachers report that the laptops help their students express their thinking better, and demonstrate their learning. Even more teachers think the laptops help students better access and integrate information from multiple sources, and approximately 60% believe laptops help students to learn how to critically evaluate information obtained from the Internet.

In many areas students agree with their teachers' assessments of the benefits of the laptops. As shown in Table 19, approximately 80% of the students report that the laptops help



them do more work, to improve the quality of work, and to be more interested in school. And almost 9 out of 10 students report that the laptops help them edit their work more, and to be better organized. Finally three-fourths of the students believe having and using their laptops help them to better understand what they are learning in school.

Thus, in terms of self-reports, both teachers and students believe there are many benefits in having and using the laptops. Many teachers believe they can provide better instruction, and more individualized instruction with the laptops. They believe the laptops help their students become better learners, and their students agree.

Section 4: Impacts on Student Learning: A Summary of Findings

Is there achievement evidence which supports the self-reported benefits described in Section 3? Does the availability and use of laptops by teachers and students translate into higher achievement? The answer is that it depends. The evidence indicates that if teachers specifically target content and/or skills and integrate the use of laptops in teaching these, the evidence indicates greater achievement. If the integration is less targeted, the results are less clear.

An underlying premise of the laptop program has been that the State of Maine will make the laptops available to all middle school students and their teacher, but that individual schools and teachers will decide how they are used. Consequently, use levels vary, as reported in Section 1 of this report, and types of use also vary across classrooms and schools. A further consequence of this underlying premise is that there is little consistent statewide evidence of the impacts of the laptops on student achievement, (except in the area of writing). But there is some evidence of the positive impacts of the laptops on achievement in cases where use of the laptops is specifically targeted to improve achievement.

The research team has conducted several small and large scale research studies designed to assess the impacts of the laptop program on student achievement. To date research has been completed in the areas of mathematics, writing, and science. Additionally, two research projects have been completed to determine what impact the introduction of ubiquitous computing may have on students' ability to evaluate sources, specifically sources found on the Internet. This section of the report provides summaries of these studies. Full reports of each of the studies summarized here are available at www.usm.maine.edu/cepare/publications.htm.

Report 1: MISTM: Maine's Impact Study of Technology in Mathematics

The first study was designed to investigate the impact of a sustained technology-infused teacher professional development program on student mathematics achievement. As mentioned earlier, the ongoing overall evaluation of MLTI has provided evidence that, indeed, the introduction of the laptops in Maine's middle schools has impacted teaching and learning in many ways. But the laptops are not being used with the same frequency level in all disciplines. One discipline with less frequent use is mathematics.

The fundamental premise of this study was that changes are needed in both teachers' content knowledge and pedagogical practices to improve students' mathematical knowledge and understanding. Thus the logic underpinning of this study was that a robust professional development intervention would result in changes in teachers' mathematical content and pedagogical knowledge and skills, classroom practices, beliefs about teaching, and their use of technology in instruction. These changes would in turn have a positive impact on students' mathematics achievement.

A randomized control trial (RCT) research design, the so-called gold star of research designs, was used in this study. A total of 56 schools were randomly assigned to one of the two study groups (Experimental and Control). The goals of the experimental professional development intervention in this study were fourfold:

- Content – deepen teachers' mathematical content knowledge in the areas of *Numbers and Operations* and *Patterns* in Maine's statewide learning standards.
- Pedagogy – improve teachers' pedagogical practice in technology infused mathematics classrooms.
- Technology Integration – develop and apply strategies that support the integration of technology for the teaching, learning, and assessment of mathematics.
- Professional Learning Community – engage teachers in meaningful interaction and dialogue about mathematics through face-to-face and online environments.

The experimental intervention consisted of four interrelated professional development components. These were: (1) face-to-face workshops; (2) online workshops; (3) peer coaching and mentoring; and (4) site visits.

Two separate achievement tests were developed for assessing student learning in two core mathematics areas. One focused on Numbers and Operations, and the second focused on Patterns and Relationships. Teacher assessments were designed to assess teachers' content and pedagogical knowledge in the same two content areas. Pedagogical knowledge was also assessed and included understanding students' mathematical thinking, as well as understanding how to effectively build upon and develop mathematical thinking.

Table 20 reports the student achievement scores at the beginning and end of the two year intervention. As the results indicate, the experimental group classroom students and control group classroom students did differ in prior achievement levels at the beginning of the study. But an analysis of covariance (ANCOVA) for group effects indicated overall test score results were also significantly different at the end of the two year intervention, in favor of the experimental group students. Overall, the experimental group students gained more over the two years in which their teachers participated in the sustained technology-infused professional development program. That is to say, it appears if a teacher actively participated in the intervention activities for 20 months or more, increased their own content knowledge, and implemented classroom technology use practices, then student achievement improved. And these improvements in achievement were also found in the statewide mathematics tests. Students in the experimental group out scored their peers in the control group on sections of the state test that measured the content in this study.

Table 20
Student Total Test Score Results After Two Year Intervention

Mathematics Test Total Score	Experimental (n=281)	Control (n=692)	t=	p=	Effect Size
Fall 2004	32.1%	27.8%	3.80	<.01	0.29
Spring 2005	54.6%	47.9%	3.62	<.01	0.39

Report 2: Maine's Middle School Laptop Program: Creating Better Writers

The purpose of a second research study was to determine the impact that Maine' laptop program was having on students' writing ability. Student test scores on the Maine Educational Assessment (MEA), the annual statewide test, were examined by researchers for two separate years. The primary examination looked at student test scores for the years 2000 and 2005 in order to determine if there was a difference in scores at two points in time: before the laptop program was implemented in any schools (2000) and after the program had been implemented for several years (2005).

Table 21 reports the MEA Writing Scale Scores for 2000 and 2005. The writing portion of the MEA at that time consisted of a writing prompt that was double scored. Scale scores could range from 500-580. As may be seen in the table, in 2005 the average writing scale score was 3.44 points higher than in 2000. Analysis of these average scale scores indicated that, in fact, there was a statistically significant difference in writing scores between the two time

Table 21
MEA Writing Scale Scores 2000 and 2005

Year	Number of Students	Average Scale Score	Standard Deviation	Effect Size
2000	16,557	534.11	10.61	0.32
2005	16,251	537.55	9.17	

periods ($t= 31.51$; $df = 32806$; $p<.001$). The results indicated writing performance had improved. Undoubtedly other factors beyond implementation of the laptop program may have contributed to improved writing performance over the course of five years (implementation of new writing programs in schools, more teacher professional development, etc.), but since these other interventions did not occur in all Maine middle schools, and the results are based on the total population of all 8th graders and all Maine middle schools, the results from this study suggest that improvements in writing performance may be attributed, at least in part, to the laptop program.

A secondary analysis of the 2005 scale scores revealed an additional key finding. How the laptops were being used in the writing process influenced writing performance. As shown in Table 22, writing scale scores are related to how, and to what extent students used their laptop

Table 22
Type of Laptop Use in Writing

Survey Question		Number of Students	Scale Score	
Stem	Responses		Average	Standard Deviation
How do you use your laptop for writing?	Drafts and Final copy	11593	538.8	8.97
	Final copy only	3413	537.7	8.89
	Drafts only	233	533.0	9.74
	Not at all	642	532.0	9.63

to produce writing. Students who reported not using their laptop in writing (No Use Group) had the lowest scale score, whereas students who reported using their laptops in all phases of the writing process (Best Use Group) had the highest scale score. Analysis of variance revealed a significant difference between the groups (F=123.67; df=3, 15,877; p<.001), and post hoc analysis indicated significant differences between all four groups shown in the table. In essence the findings revealed greater levels of use of the laptop in the writing process as a writing development tool (e.g., drafts, edits, final copy) was related statistically to writing scores.

However, one may ask if the laptops helped students to become better writers in general or just better writers when using the laptops? To answer this third key research question, the way in which students produced their MEA writing sample was examined. In 2005, some Maine students completed the MEA writing assessment online, while many others produced their writing sample in longhand. Table 23 reports the average writing scale scores for students who produced their writing sample online and those who were developing their writing sample in the traditional paper and pencil fashion. As shown in the table, the scale scores are almost identical. In fact, an analysis of these scores using an independent sample t-test statistic indicated no

Table 23
MEA 2005 Writing Scale Scores by Mode of Writing (Assessment)

Writing Sample	Number of Students	Average Scale Score	Standard Deviation
Online	3,251	537.68	10.52
Longhand	13,000	537.52	8.80

statistically significant difference between the scale scores of the two groups (t= .810; df=16249; p>.05). In other words, writing improved regardless of the writing test medium.

Thus, the evidence indicated that implementation of Maine's one-to-one ubiquitous laptop program was related positively to middle school students' writing. Five years after the initial implementation of the laptop program, students' writing scores on Maine's statewide test had significantly improved. Furthermore, students scored better the more extensively they used their laptops in developing and producing their writing. And finally, the evidence indicated that using their laptops in this fashion helped them to become better writers in general, not just better writers using laptops.

Report 3: Using Middle School Laptops to Facilitate Middle School Science Learning: The Results of Hard Fun

The primary goal of a third research project was to examine how the MLTI program might impact the academic achievement and general engagement of students within a science classroom. This action research study was designed to answer the following research question:

> *Is the use of the laptops to create narrated animations more effective than having students create traditional paper diagrams and reports in helping students learn the concepts related to Earth's axis angle?*

The research team for this project consisted primarily of researchers from the Maine Education Policy Research Institute, and one classroom teacher and his two 8th grade science classes at a school in Midcoast Maine. The basic design of the study was that both classes were taught the same information in the same way, but that the students had to *demonstrate* their learning differently; one group used computer-generated animation while the other group used a traditional poster/paper approach. The teacher with whom the research team worked introduced the concept of Earth's axis angle and the cause for the seasons, to both of his eighth grade science classes. One of his classes (Control Group) was taught in the traditional manner and was asked to complete a traditional paper diagram and report as a final project. The other class (Experimental Group) was also taught the material in the traditional manner; however, they had access to interactive, educational websites for their final project and were asked to turn in a narrated animation podcast.

In order to examine how the technology impacted academic achievement and general classroom engagement, a number of measures were used in the study. A pre-assessment was administered to all of the students in order to establish a baseline comprehension level of axis angle concepts. This pre-assessment measured comprehension, as well as attitudes about science, comfort-level and skill-level with regard to making animations, and 21st Century skills. A post-assessment measured student comprehension and contained several opinion questions, which asked students to explain what they liked and disliked about completing their science projects. A retention assessment was also administered roughly a month after the teacher had completed the unit in order to measure the students' retention of learning.

Table 24 provides a comparison between the experimental and control groups performance. The evidence indicates that the students in the experimental group answered more questions correctly than the students in the control group on the post-assessment. In fact, the average of the students' scores in the experimental group increased from 42.36% to 90.97%, while the student's scores in the control group increased from 52.38% to only 81.25%. In addition, the Effect Size on the post-assessment was .61, indicating that the experimental

Table 24
Pre- and Post-Assessment Results

Group	Pre-Assessment		Post-Assessment		
	Average of Student Scores	Standard Deviation	Average of Student Scores	Standard Deviation	Post-Assessment Effect Size
Control Group	52.38%	20.52	81.25%	15.94	.61
Experimental Group	42.36%	19.93	90.97%	12.03	

group students scored approximately 2/3 of a standard deviation above the control group students. Thus, academic achievement of the students in the experimental group was greater in comparison to the students in the control group.

In terms of retention, the information in Table 25 provides a comparison between the two groups on an achievement retention assessment. The students in the experimental group

Table 25
Retention Assessment Results

Group	Retention Assessment		
	Mean	Standard Deviation	Effect Size
Control	63.08%	17.02	1.42
Experimental	87.27%	9.04	

answered more of the questions correctly, in comparison to the students in the control group. The results of the pre- and post-assessment, as well as the retention assessment, indicated that the students in the experimental group had a higher level of comprehension and exhibited a higher level of retention of learning. As one student in the experimental group remarked, "It took more effort, but it was more fun."

Report 4: Using Technology in Helping Student Achieve 21st Century Skills: A Pilot Study

The primary goal of this pilot research study, involving teachers from a Maine school district and researchers from MEPRI, was to create a model to help students in 7th-9th grades learn how to evaluate electronic/digital resources within the context of authentic learning activities. Technology integrationists within a school district and the research team developed materials to help teachers more effectively help students learn how to evaluate electronic/digital resources. A set of guidelines detailing what to teach was given to each of the teachers and they were asked to incorporate the information into their curriculum. Students were pre- and post-tested before and after receiving the intervening material to determine what, if any, knowledge they had gained about how to evaluate electronic/digital media over a short intervention period.

The intervention focused on enabling students to gain skills in answering three key questions: Does the content of the website appear to be useful? What is the apparent purpose of the website? How reliable is the information contained on the website? The amount of time teachers spent providing the intervention to their students was determined by the teachers themselves and varied among teachers and grade levels. No guidelines for *how* to teach the material were specified by the project team, and teachers were encouraged to use the materials in whatever content area they deemed appropriate. The experimental classroom teachers reported spending a total of 30 minutes of instruction in 7^{th} & 8^{th} grades and two hours of instruction in 9^{th} grade.

As reported in Table 26, the analysis of the pre- and post-assessment scores indicated that the scores of students who received the intervention were significantly higher on the post-assessment than scores of students who did not receive the intervention. Further, the

Table 26
Pre-Post Test Differences – Experimental vs. Control Groups

7^{th} - 9^{th} Grades		Average	Standard Deviation	Effect Size
Pretest	Experimental	14.55	4.49	0.19
	Control	15.52	5.11	
7^{th} - 9^{th} Grades		**Average**	**Standard Deviation**	**Effect Size**
Posttest	Experimental	16.47	5.50?	0.41
	Control	14.19	5.58	

experimental group students outperformed their control group cohorts. Analysis of the data for different grade levels indicated that the intervention was most effective with 8th graders, and somewhat mixed for the other grade levels. In summary, this <u>pilot</u> study demonstrated the potential impact of interventions specifically designed to address 21^{st} Century Skills.

Report 5: 21st Century Teaching and Learning: An Assessment of Student Website Evaluation Skills

This study was undertaken by the science department at a Maine junior high school and MEPRI research and evaluation team. The primary goal of this project was to expand upon the pilot study described above, and to help students learn how to evaluate Internet resources in a systematic way, thus enhancing their ability to evaluate websites.

Teachers and researchers worked together to create benchmarks that would outline the concepts that 7th and 8th grade students at the middle school would need to learn in order to evaluate electronic/digital resources within the context of authentic learning activities, specifically, science classrooms. In addition, project leaders and researchers worked together to help participating teachers effectively implement the benchmarks in their curriculum. Using the agreed-upon benchmarks, each teacher was asked to adapt or construct materials/concepts, and implement materials/concepts into their curriculums based on their own curricula agenda.

The intervention was implemented by the science teachers over approximately five months. The method of implementing the intervention generally followed one of two types of formats. The first format was in conjunction with an existing lesson. This involved all students looking at the same web page and discussing as a class the factors that contributed to it being identified, according to the benchmarks, as a "good or bad" website. Instruction usually revolved around dissecting the site to reveal differences for research purposes. The second format was conducted as a research project. This consisted of the teacher assigning students a research project or topic and the students identifying and explaining the webpage layout in relation to the benchmarks.

The pre- and post-assessments completed by the students were scored by MEPRI project staff and two science teachers (project leaders). As shown in Table 27, results for the middle school revealed that the students performed well on the post-assessment in June when compared to the pre-assessment taken in December. The students' average scores on the post- assessment were above the pre assessment (17.8 vs. 15.0). In fact, statistical analysis of these results revealed there was a statistically significant improvement in student performance. Furthermore, analysis of the average scores, using Effect Size procedures, indicated students as a group

Table 27 Pre and Post Assessment 7th & 8th Grade Student Results						
	Pre Assessment			Post Assessment		
	n	average	Standard Deviation	n	average	Standard Deviation
Students	297	15.01	4.58	347	17.80	5.59

improved their scores by 2/3 of a standard deviation. Thus, this study demonstrated the potential impact of interventions specifically designed to address 21st Century Skills. Furthermore, the project demonstrated the importance and feasibility of developing individual curriculum interventions tailored to specific content areas.

Section 5: Costs of the Laptop Program

The previous sections of this report have focused on describing how the laptops are being used in Maine's middle schools, and the impacts the laptop program is having on teaching, knowledge, and student achievement. Many teachers believe the laptops have provided benefits to them and their students. But one may ask if the benefits are commensurate with the costs? In effect, one may ask if the MLTI program is cost-effective.

This is not an easy question to answer. There is a considerable body of literature on determining cost-effectiveness and how to conduct a cost-benefit analysis. But it is always more difficult to apply these business-type analyses to fields such as human services and education. For one, it is virtually impossible to objectively quantify all of the benefits in the human services and education arenas. Second, most cost-benefit type analyses are premised on the availability of an alternative solution or program to calculate costs; to provide a comparison between an existing program and a new program. But in the case of the MLTI program this was not possible. Schools were using technology before the implementation of the one-to-one laptop program, but there was no documentation of the specific costs of this earlier technology use. In addition, at the time of the implementation of the one-to-one laptop program, no alternative use of resources was proposed to compare with the MLTI program.

This is not to suggest that cost analyses are impossible to conduct with programs such as MLTI. It just means one has to be more careful in tying costs with benefits. In fact, they cannot, in actuality, be tied directly to one another. The best one can do is document each, and rely on one's judgment to reach cost and benefit conclusions.

Given these limitations, what can be documented about the costs of the MLTI program? First, it is important to recognize that there are two major cost components: (1) State costs; and (2) local school district costs. Second, identifying costs for each component requires different methodologies. And third, these methodologies impact the quality of evidence one may obtain.

Beginning with annual State costs, there are costs associated with the laptops and accompanying software, network costs, and state level personnel costs. In Maine's middle school laptop program the State pays the costs associated with the laptops and technology infrastructure in each school, and provides some professional development programs at no cost to the schools. The lease-purchase cost of each laptop for the State and accompanying software is $242 per year for four years. A second State cost is for Networks. Each school is provided a network infrastructure that provides both wired and wireless bandwidth and storage capacity. It includes servers, data storage devices, routers, switches and fire walls and built-in redundancy for this equipment as well as the cooling and power systems in the data centers where the equipment is stored in order to ensure uptime. Apple, Inc., the contractor, provides personnel and equipment to ensure performance of the network. The annual cost of each network in each of the 225 middle schools is $7,817 per school.

A third State cost is for the MLTI staff. Currently the staff consists of ten full-time and part-time professional personnel responsible for managing the technical component of the MLTI program and providing professional development for school personnel statewide.

Table 28 provides a summary of the State costs for 2009-10. The total yearly cost is

Table 28
2009-10 State MLTI Costs

Item	Units	Cost
1. Middle School Student	29,570 @ $242 per unit	$7,155,940
2. Middle School Staff	4,468 @ $242 per unit	$1,081,256
3. Network Fee per School	225 @ $7,817 per unit	$1,758,825
4. MLTI Staff	Ten full and part-time staff	$471,905
	Total Costs	**$10,467,926**
	Cost per Unit	**$308 per Unit**

approximately $10.5 million, for a per-unit yearly cost of **$308** ($10,467,926 / 34,038 laptop units).

In the case of calculating local district costs, determining costs are more difficult. Local school districts do not report the middle school laptop costs separately from other technology costs. Accordingly, in order to determine these costs, a cost survey was distributed to all public school districts (n=155) that had deployed MLTI laptops to all their 7th and 8th grade students and staff. The return rate for the surveys from the school districts was low. Only 28 school districts returned useable surveys, for a useable return rate of 18%. But those 28 districts represent approximately 31% of all middle school students, and useable surveys were returned from a variety of small, medium, and large school district. Thus, for purposes of this report, the evidence on local school district costs of the MLTI program should be viewed as preliminary, and not definitive. This is an important caveat, and caution must be exercised in interpreting these cost results.

Notwithstanding this caveat, what can be determined about local school district costs for the laptop program? What is very apparent from an analysis of the surveys is that the districts vary considerably in how much they spend locally per pupil. These differences are very apparent when the districts are clustered by school size. Table 29 displays this information. The evidence in the table indicates that the average for all these districts is approximately $283 per laptop. The range among the 28 school districts is from a low of $24 per laptop per year in one of the small middle schools, to a high of $976 per laptop per year in one of the medium size middle schools. An additional analysis revealed that the largest expenditure categories are for salaries and

Table 29
2009-10 Local School District MLTI Cost

Local District	No of Laptops	Ave Cost Per Laptop	Range in Cost Per Laptop	
			Low	High
Small school districts (0-149 pupils)	1247	$215	$24	$333
Medium school districts (150-399 pupils)	3062	$342	$39	$976
Larger school districts (400-2000 pupils)	5113	$288	$146	$412
All Districts (n=28)	9422	$283	$24	$976

benefits for (a) technology integrationists/mentors; and/or (b) technical support personnel. Not all school districts had expenditures for these categories and it does not appear to be related to school size. That is, some small, medium, and larger schools funded these personnel positions while others did not. In fact, this is true for all the categories of expenditures. Thus, while the average local MLTI expenditures in 2009-10 for these 28 school districts was approximately

$283 per laptop, expenditures vary greatly among the districts. This suggests different school districts are making different choices on what they will expend local level funds on in support of their middle school laptop programs.

Given these state and local cost analyses, what is the total average yearly cost per laptop of Maine's middle school program? If one combines the two average cost figures (State and local school district) it appears that on average, Maine's yearly cost per laptop is approximately **$591** (State average cost of $308 and local district cost of $283 = $591). How are these costs to be interpreted? Are they low, average, or high? Do they match benefits? As discussed earlier, these are questions which are difficult, if not impossible, to answer directly or definitively. However, to provide some context for interpreting these cost figures, two approaches were taken. First, how do these costs compare to other costs the State and local school districts incur in providing K-12 education in Maine? An analysis of average per pupil expenditures for K-12 education in Maine for 2009-10 indicated that the average costs for the middle school laptop program is approximately 5.4% of the total K-12 per pupil expenditures ($591/$11,039 = 5.4%). The average of $591 is about one-third of what was spent on special education, and this average amount is similar to what was spent in 2009-10 for each of the areas of school level administration and transportation.

Second, how does the cost of Maine's one-to-one laptop program compare to costs of other laptop programs? Surprisingly, few systematic attempts have been made throughout the country or internationally to document costs. A review of the literature surfaced scant evidence of program costs. What was uncovered was a limited study by one national K-12 computing association. Beginning in 2003, the consortium on School Networking (CoSN), in collaboration with Gartner, an information technology research firm, developed a tool and protocol for calculating what was called Total Cost of Ownership (TCO). Using the protocol CoSN conducted cost studies of three school districts in which costs before and after implementation of one-to-one programs were calculated. In addition, one other cost analysis was uncovered by the MLTI team, a cost analysis conducted by another school district which used the CoSN protocol for analyzing their costs.

Table 30 reports the cost figures for the four school districts and for the Maine program. The protocols used in the four studies were slightly different than the protocol used for the Maine study, but they were similar enough to provide some comparisons, albeit cautious ones.

As shown in the table, the cost per unit in the 1-to-1 programs ranged from a low of $516

Table 30 Average Cost per Laptop Unit			
District\State	No. of Units	Cost per Unit Pre 1-to-1	Cost per Unit Post 1-to-1
District 1	4401	$262	$780
District 2	850	$577	$541
District 3	1079	$603	$516
District 4	540	N/A	$748
Non-Maine 1-to-1 Program Cost Average		$481	$646
State of Maine	34,038	N/A	$591

per unit (District 3) to a high of $780 per unit (District 1). Maine's cost per unit of approximately $591 places it in the middle of the five programs, and approximately $55 below the average of the other four programs. And although Maine does not have any evidence of pre 1-to-1 laptop program costs, if the pre 1-to-1 per unit costs in the three other programs are used as surrogate evidence, the incremental or marginal cost of Maine's implementation of the middle school laptop program would be approximately $110.

To summarize, one has to exercise considerable caution in interpreting costs of Maine's middle school program. Costs at the State level are fairly clear cut, but not so in the case of local district costs. The evidence that is available indicates that for 2009-10, the average costs of the laptop program, including both State and local costs, was approximately $591 per laptop unit per year. This amount represents approximately 5% of average K-12 per pupil expenditures in Maine. The $591 average costs is lower than the reported costs of other 1-to-1 laptop programs, and may represent an incremental cost of approximately $110 over other non-1-to-1 laptop/computer programs.

Section 6: Summary and Future Research

The evidence presented in this report, indicates that the MLTI program has had a significant impact on curriculum, instruction, and learning in Maine's middle schools. In the areas of curriculum and instruction, the evidence indicates many teachers have reached the tipping point in the adoption and integration of the laptop into their teaching.

Middle school teachers report substantial benefits from the laptop program. Teachers indicated the laptops helped them teach more, in less time, and with greater depth. For their students, many teachers reported that their students learned more and with greater depth and understanding.

There is some evidence of the direct impact of the laptops on student achievement. Results indicate that students' writing has improved. In mathematics there is evidence that a well-designed and executed professional development resulted in improved student performance in mathematics. A science study also found significant gains in student achievement and retention when students used their laptop to demonstrate science learning. In addition, two studies demonstrated the power of students' laptops in learning an important 21st Century Skill; the skills of locating and evaluating information.

In light of these benefits of the laptop program, it is important to also consider the costs of the program. Although much of the evidence in this area must be used cautiously, it appears Maine's one-to-one laptop program costs are in line with the average costs found in other laptop programs. That is to say, Maine's per unit costs were very similar to the average found in four other cost studies, and the incremental costs appear to be moderate.

Thus, it appears the MLTI program has been successful in many ways. In addition, this review has also identified some areas which warrant further research. The evidence in the Use section suggests some areas for further exploration. For instance, teachers report lower use levels, relatively speaking, of the laptops in differentiating instruction and conducting formative assessments. It is unclear why this is the case. Technology, like the laptops, if used appropriately, should increase teachers opportunities to differentiate instruction to meet more diverse learner needs, and to collect, analyze, and provide formative feedback to not only adjust instruction, but help learners better understand their own learning. Thus, further research is needed to understand why the laptops are not being used more in these areas, and to identify what strategies and supports are most effective in helping teachers acquire skills in differentiating instruction and conducting more formative assessment in their classrooms.

Another area needing research is why students report using their laptops very infrequently in learning 21st Century skills. Is it because teachers are not asking students to use their laptops in acquiring and practicing these skills, or because teachers lack skills in using the laptops to teach these skills? Or is the problem more fundamental? Possibly teachers do not even include these skills in their curriculum. Finding answers to these questions is important because technologies like laptops may be very useful and effective in helping students learn 21st Century skills.

A third major area of further research is the perceived shift to more student centered instruction. A majority of the teachers report they have become more student centered because of the availability of the laptops. How has this happened? To what degree has it happened? And for whom? Finding answers to these questions is important for identifying strategies for further promotion of this shift for more teachers.

Pursuing research in these and related areas should provide a greater understanding of the impacts of a one-to-one laptop program. And this information should prove useful to others as they strive to integrate technologies into instruction and learning.

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