



## **The Maine Learning Technology Initiative: An Exploratory Study of the Impact of Ubiquitous Technology on Student Achievement**

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### **Abstract**

The Maine Learning Technology Initiative (MLTI) is the first statewide implementation of ubiquitous computing. Data from the first year of statewide implementation (2002/2003) indicate that engagement and attendance are up and behavior referrals are down, but there was little data on achievement. This study features the 8th grade data from students who took the 2002/2003 Maine Educational Assessments and participated in one of the 9 Exploration Schools that implemented the initiative ahead of the other middle schools. Although in 2000-2001, at the beginning of the initiative, assessment data for the Exploration Sites was not unusual compared with the rest of the state, at the end of 2002-2003, the second year of MLTI at the Exploration Schools, Science Effect Size was positive for the demonstration schools versus the other 214 (for which we had data) at the 8th grade level ( $ES = .44$ ), and the typical MLTI demonstration site 8th grade student scored significantly higher than those from the other 214 schools on science ( $p < .0005$ ), math ( $p < .05$ ) and social studies ( $p < .05$ ). This is credible evidence that MLTI as a total program may be effective in raising test scores for the 9 Exploration Schools and is worthy of further study.

### **Introduction**

Maine is the first state in the nation to take on the task of widespread implementation of one-to-one (ubiquitous) computing through the Maine Learning Technology Initiative (MLTI). MLTI has as its mission to transform teaching and learning in Maine's public schools. It is doing this through its goal to provide a laptop computer to every student and teacher in grades 7 through 12. Schools have had infrastructures installed for wireless, portable Internet access, and wireless computers have been deployed to every 7<sup>th</sup> and 8<sup>th</sup> grade student and teacher in Maine. More than 37,000 laptop computers have been installed in Maine's 239 middle schools. In addition, teachers have been provided professional development opportunities, including two days of initial training, regional content-based workshops, and local offerings.

MLTI started with 9 Exploration Schools, one in each of Maine's 9 Superintendents' Regions, in the spring of 2002. (Maine has numerous school districts. The Superintendents' Regions allow the state to regionalize services to those districts.) The purpose of the Exploration Sites was to pilot the hardware, software, and professional development solutions within the context of Maine's middle schools before scaling up to every school in the state. They also allowed educators, community members, and state legislators to visit and experience the initiative in action. What was learned from the Exploration Sites shaped the implementation as it moved into every 7<sup>th</sup> grade classroom in the fall of 2002.

Seventh grade students from the 2001-2002 Exploration Schools were allowed to take their laptops to the 8<sup>th</sup> grade in the fall of 2002 when all the 239 middle schools received laptops for their 7<sup>th</sup> grade students and teachers. In the fall of 2003, the previous year's 7<sup>th</sup> graders took their laptops into the 8<sup>th</sup> grade and the second group of 7<sup>th</sup> grade laptops were added. Now, all 7<sup>th</sup> and 8<sup>th</sup> grade students and teachers have wireless laptops. Exploration Site students, however, did not take their laptops into the 9<sup>th</sup> grade. Plans are underway to bring the initiative to the high schools beginning in fall of 2004. MLTI's implementation timeframe is summarized in Figure 1.

When?	What?
January 2002	Exploration Sites selected
March 2002	Exploration Site Teachers receive 2-Day introductory training. Exploration Sites receive laptops for 7 <sup>th</sup> grade students and teachers
Summer 2002	All teachers who teach 7 <sup>th</sup> graders at least half time receive laptops. Those teachers receive 2-Day introductory training.
Fall 2002	All 239 middle level schools receive laptops for 7 <sup>th</sup> grade students. Exploration Site students take their laptops into 8 <sup>th</sup> grade.
Summer 2003	8 <sup>th</sup> grade teachers receive 2-Day introductory training
Fall 2003	Last year's 7 <sup>th</sup> graders take laptops into 8 <sup>th</sup> grade. New cohort of 7 <sup>th</sup> grade students receive laptops. Exploration site students are unable to take laptops to high school.
Winter/Spring 2003	DOE & MLTI staff work with State Legislature to find ways to continue MLTI into the high schools.

Figure 1. Maine Learning Technology Initiative Implementation Timeline

The Maine Education Policy Research Institute (Silvernail & Harris, 2003) found that increased engagement, as well as, decreased absenteeism and behavior referrals accompanied the learning with laptop initiative. Not surprisingly, in the early stages of the initiative, there was little data on achievement.

Technology and Achievement. Even though MLTI is the first statewide initiative, one-to-one computing is not new to education. There are over 20 years of research on this topic. *The Impact of Educational Technology on Student Achievement* (Schacter, 1995) reflects the analysis of more than 700 studies and concludes that students who had access to educational technology showed positive gains in academic achievement. According to *Technology in American Schools: Seven Dimensions for Gauging Progress* (Lemke & Coughlin, 1998), while further research studies are needed, emerging trends indicate that under the right conditions technology:

- Accelerates, enriches and deepens basic skills.
- Motivates and engages students in learning.
- Helps relate academics to the practices of today's work force.
- Increases economic viability of tomorrow's workers.
- Strengthens teaching.
- Contributes to change in schools
- Connects schools to the world.

Muir (2001) showed that good learning experiences: create strong relationships; involve hands-on, active work; adjust for differences in learning styles; make learning interesting; allow students to make choices; make connections to previous knowledge, the students lives, and the real world; and put learning into context. Technology can be an asset to curriculum development that respects and reflects these characteristics. Further, technology integration promotes a shift in teaching paradigms from whole class instruction to small group learning environments, as well as a change from passive learning to more engaged learning (Pelgrum & Anderson, 1999; Roblyer & Edwards, 2000; Voogt & Odenthal, 1999). *Computer-Based Technology and Learning: Evolving Uses and Expectations* (NCREL, 2001) concludes, "Technology offers opportunities for learner-control, increased motivation, connections to the real world, and data-driven assessments tied to content standards that, when implemented systemically, enhance student achievement as measured in a variety of ways, including, but not exclusively limited to, standardized achievement tests."

## Methods

The purpose of this exploratory study was to compare and contrast standardized state assessment scores (especially in Math and Science) between the 9 MLTI Exploration Sites and the remaining middle schools throughout Maine before versus after MLTI initiatives took place.

The Maine Educational Assessment (MEA) is administered to 4<sup>th</sup>, 8<sup>th</sup>, and 11<sup>th</sup> graders each year. Students are tested in seven areas: Reading, Writing, Health, Science, Math, Social Studies, and Visual and Performing Arts. In the 2002/2003 school year, the 8<sup>th</sup> graders from the 9 Exploration Sites were the first MLTI students to take the MEAs. At the time, every 7<sup>th</sup> grade student and teacher had laptops, but the only 8<sup>th</sup> graders with laptops were from the Exploration Sites.

Even though there are 239 middle schools involved in MLTI, there were data available on only 223 middle schools, including the 9 Exploration Sites. We accessed school demographic and assessment data from Maine's website (<http://www.maine.gov/portal/education/k12.html>), then examined the MEA data in four areas (Science, Math, Social Studies, Visual & Performing Arts) comparing the 9 Exploration Sites to the remaining 214 middle schools for which we had data.

## Results

As shown in Table 1 and graphically displayed in Figure 1, during 2000-2001, the Exploration Schools collectively were not unusual compared to all of Maine except that perhaps 8th grade MEA math scores in the Exploration Schools were significantly lower (two-tailed  $p < .05$ , see Appendix). At the end of 2002-2003, the second year of MLTI at the Exploration Schools, Science Effect Size was positive for the 9 Exploration Schools versus the other 214 schools at the 8th grade level ( $ES = .44$ ), and the typical MLTI Exploration School 8th grade student scored significantly higher than those from the other 214 schools on science ( $p < .0005$ ), math ( $ES = .24$ ;  $p < .05$ ) and visual/performing arts ( $ES = .24$ ;  $p < .05$ )<sup>1</sup>. This is credible evidence that MLTI as a total program was effective in raising test scores for the 9 Exploration Schools.

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<sup>1</sup> Probability levels were estimated by assigning every child at a given grade level in a school the mean score reported for that school. Analysis of variance between various attributes of Exploration Schools and non-Exploration Schools were carried out. Thus  $n = 988$  for the Exploration School students in 2003 versus 15,724 students in the non-Exploration School category. See Appendix for a complete explanation of the analysis.

Table 1. Trends in MEA Scores for Exploration Schools vs. Other Maine Middle Schools over Three Years.

MEA 2000-2001: Group 1 = 9 Exploration Schools, Group 2 = All Others					
Group Statistics					Effect Size (Cohen's D)
	GROUP	N	Mean	Std. Dev	
Science	1	9	529.11	3.95	0.05
	2	204	528.90	4.25	
SocStud	1	9	531.33	4.39	-0.12
	2	204	531.89	4.54	
Math	1	9	527.78	3.87	0.03
	2	204	527.61	5.03	
VPArts	1	9	531.00	5.59	0.06
	2	204	530.65	5.52	
MEA 2001-2002: Group 1 = 9 Exploration Schools, Group 2 = All Others					
Group Statistics					Effect Size (Cohen's D)
	GROUP	N	Mean	Std. Dev	
Science	1	9	529.56	3.84	0.44
	2	214	527.67	4.27	
SocStud	1	9	529.44	4.36	-0.06
	2	214	529.76	5.20	
Math	1	9	527.78	6.61	0.21
	2	214	526.59	5.72	
VPArts	1	9	530.33	4.72	0.11
	2	213	529.67	6.10	
MEA 2002-2003: Group 1 = 9 Exploration Schools, Group 2 = All Others					
Group Statistics					Effect Size (Cohen's D)
	GROUP	N	Mean	Std. Dev	
Science	1	9	529.00	3.43	0.22
	2	211	528.03	4.52	
SocStud	1	9	531.44	3.32	0.02
	2	211	531.35	5.41	
Math	1	9	528.44	3.88	0.22
	2	211	527.37	4.94	
VPArts	1	9	531.67	4.50	0.22
	2	211	530.37	6.08	

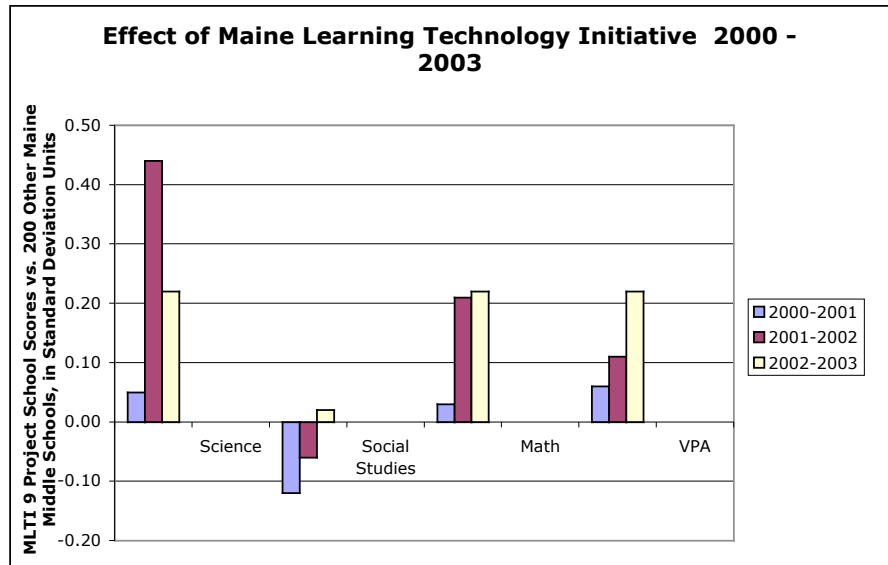


Figure 1. Trends for Maine Learning Technology Initiative (MLTI) eighth grade standard assessment scores across 9 Demonstration school sites (vs. 200 other Maine middle schools representing origin = 0.0).

Note: Total n = approx. 17,367 8th grade students per year.

Note2: Standard assessment = Maine Educational Assessment (MEA) test scores.

## Discussion

One unit of measurement for presenting findings in this report is effect size, an index that places test scores on a common scale (for comparison to others) by presenting them in terms of standard deviation units. For at least three decades researchers have relied on effect size as a standard metric for comparing results across studies (Cohen, 1969). Cohen developed the guidelines still widely used as a rule of thumb for judging the magnitude of effect sizes: .2 is small, .5 is moderate and .8 is large. Using these criteria, one might say that MLTI has had a “moderate” effect on the science standardized achievement scores of Maine 8th grade students in Exploration Site schools, as well as “small” effects on standardized achievement scores in math and visual/performing arts.

Viewed from a slightly different perspective, the North Central Regional Educational Laboratory (NCREL, 2002) has reported that an effect size of 0.1 is equivalent to about one month of learning gain. If this holds true for science, math, and visual/performing arts at the seventh and eighth grade level, then Exploration Site students have gained the equivalent of 4 extra months in science compared to typical Maine middle school students — and 2 extra months in math and visual/performing arts — over the course of two years. Probably most middle school educators would deem such a program a success.

## Conclusions

Three years of standardized achievement data gathered from approximately 1000 students at 9 of 239 middle schools immersed in ubiquitous computing-based teaching/learning activities in Maine have generated credible evidence that this initiative might be effective in increasing the math and science scores of 8<sup>th</sup> grade students. If this favorable outcome can be replicated in the remaining 200+ schools (with 15,000 students) while the scores of the original 9 stay high, then the model may be worthy of replication in many parts of the nation. A unique opportunity exists to study the impact of a massive educational intervention being introduced at the statewide level. Sufficient proof of concept data exists to suggest the project to date a success and worthy of further study. **Researchers should replicate this study**

**with the individual student data and with future data before any definitive conclusions can be drawn.** It also suggests that researchers should study schools where scores increase to try to identify those characteristics and components that will predict improved scores.

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## The Maine Learning with Laptop Study



The Maine Learning with Laptops Study's mission is to conduct a scholarly study of the integration of learning technology into Maine's setting of one-to-one student to computer access. MLLS is a collaborative project of the Maine Center for Meaningful Engaged Learning at the University of Maine at Farmington and the Institute for the Integration of Technology into Teaching and Learning at the University of North Texas.

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## Appendix.

### Summary of Maine Student-Level Test Score Analysis

Individual student score treatment vs. control group differences were estimated by taking the mean value for each school and multiplying it by the number of students who contributed to that value. Thus the statewide analysis shown in Table A1 was based on a weighted average of the mean values for individual schools with the degrees of freedom adjusted to be appropriate for a t-test/f-ratio analysis for individual students:

$$t = \frac{\text{Mean1} - \text{Mean2}}{\sqrt{s_1/N1 + s_2/N2}}$$

As shown in Figures A1 and A2, the treatment vs. control group trends were similar for weighted (Figure A1) and non-weighted (Figure A2) data. By 2003, Exploration Site students were higher on math, science and visual/performing arts (VPA).

Table A1. Descriptive Statistics and t-test results for eighth grade students in 9 Exploration Schools vs. all other Maine Middle Schools, MEA Standardized Achievement Exam

#### 2001

	Data from 204 middle schools	Data from 9 Exploration sites	t-test
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	n	mean	St dev	n	mean	St dev	T value
Sci	15103	529.19	4.26	964	529.20	3.72	.081
SS	15068	532.31	4.56	961	532.16	4.21	1.086
Mth	15024	527.97	5.04	956	527.59	3.65	3.04*
VPA	15031	531.58	5.60	959	531.75	5.32	.965

\*Significant at .01 (one-tailed); at .005 (two-tailed)

#### 2002

	Data from 214 middle schools	Data from 9 Exploration sites	t-test
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	n	mean	St dev	n	mean	St dev	T value
Sci	15695	528.02	4.29	1017	528.60	3.75	4.75**
SS	15683	530.13	5.21	1013	529.88	4.14	1.84*
Mth	15610	527.16	5.75	1013	527.55	6.24	1.94*
VPA	15577	530.26	6.11	1015	530.13	4.45	.878

\*\*Significant at .001 (one-tailed); at .0005 (two-tailed) \*Significant at .05 (one-tailed)

#### 2003

	Data from 211 middle schools	Data from 9 Exploration sites	t-test
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	n	mean	St dev	n	mean	St dev	T value
Sci	15724	528.37	4.53	985	528.58	3.26	.1886
SS	15694	531.60	5.41	988	531.63	3.18	.2729
Mth	15641	527.60	4.94	987	527.97	3.68	2.99*
VPA	15641	530.93	6.10	984	532.46	4.32	10.47**

\*\*Significant at .001 (one-tailed); at .0005 (two-tailed) \*Significant at .01 (one-tailed); at .005 (two-tailed)

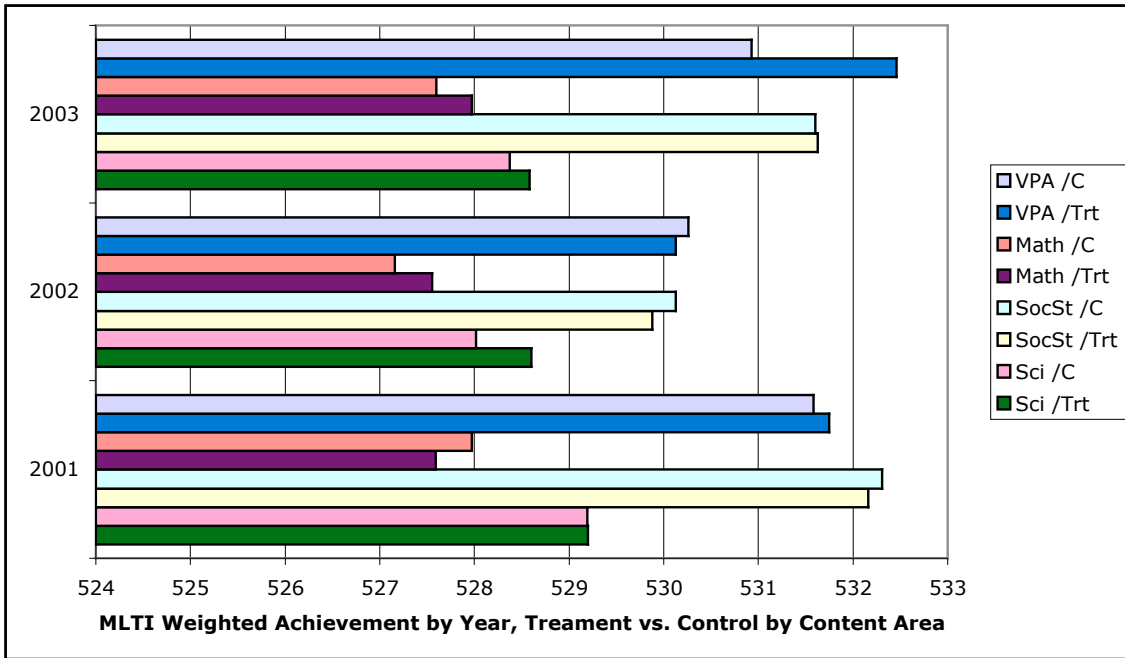


Figure A1. Three year trends in eighth grade MEA weighted average scores for 9 Exploration Schools (Treatment = 988 students) versus 214 other Maine middle schools (Controls = 15,694 students).

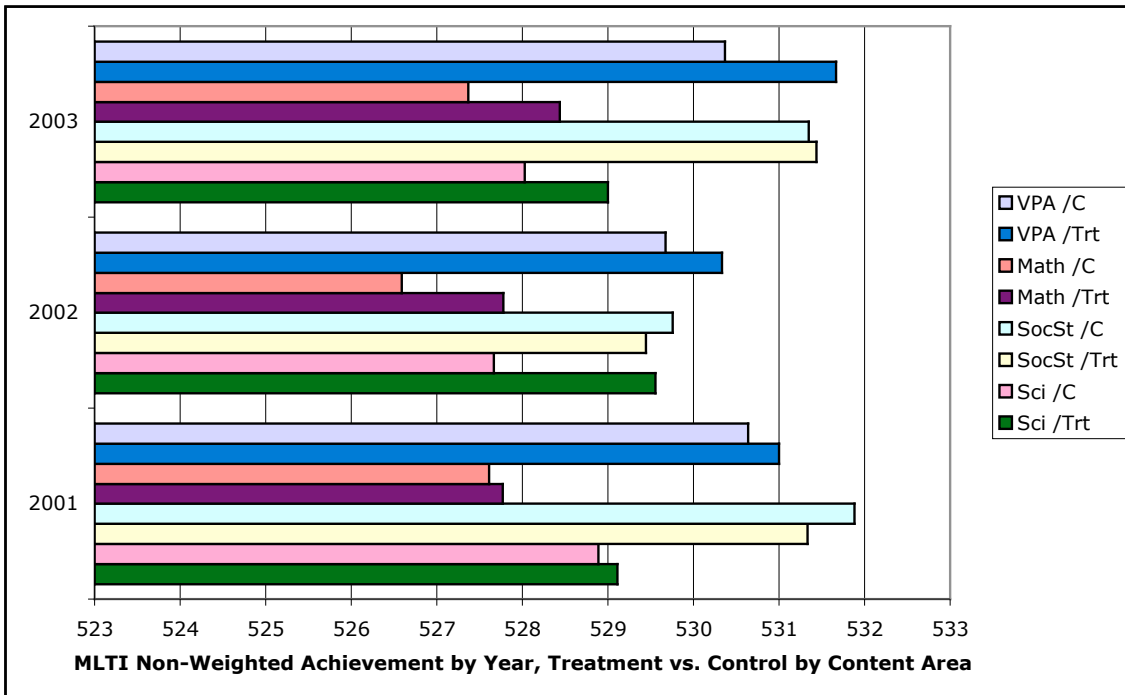
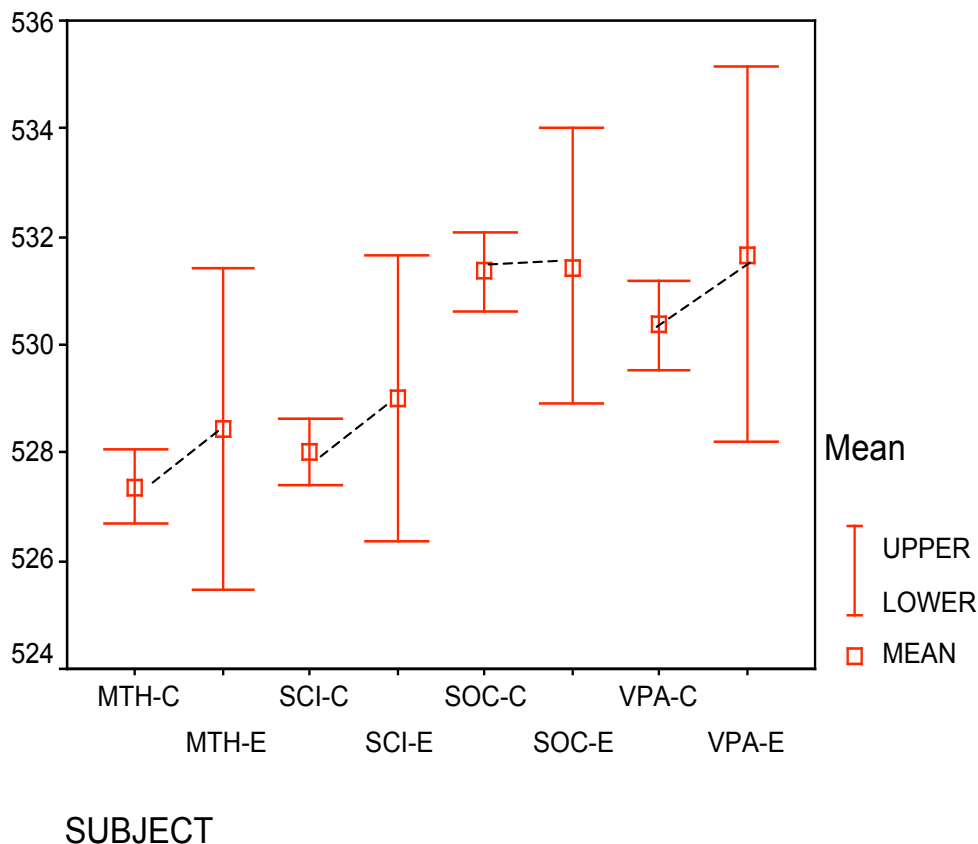


Figure A2. Three year trends in eighth grade MEA non-weighted average scores for 9 Exploration Schools (Trt = treatment) versus 214 other Maine middle schools (C = controls).

Figure A3 shows 95% confidence intervals for 2003 treatment and control group means. Exploration Schools (treatment) have a wide spread due to small n (9 schools). All measures but social studies indicate positive impact due to Maine Learning Technology Initiative.

## 95% Confidence Intervals



SUBJECT	LOWER	UPPER	MEAN	SD
SCI-E	526.37	531.63	529.00	3.43
SCI-C	527.42	528.64	528.03	4.51
MTH-E	525.46	531.42	528.44	3.87
MTH-C	526.70	528.04	527.37	4.94
SOC-E	528.89	534.00	531.44	3.32
SOC-C	530.62	532.08	531.35	5.41
VPA-E	528.21	535.13	531.67	4.50
VPA-C	529.54	531.19	530.37	6.08

Figure A3. 95% Confidence Intervals for the Mean Scores of 9 Exploratory Schools (E) versus 214 Control Schools (C) on Math (Mth), Science (Sci), Social Studies (Soc), and Visual Performing Arts (VPA) for Eighth Grade Students in Maine.