# Facilitating Technology Integration:
## Results from an Evaluation of West Virginia's Enhancing Education Through Technology (EETT) Model School Project

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## ABSTRACT

This paper discusses the results of a comprehensive, federally-funded study of a statewide approach to facilitating technology integration. Specifically, the West Virginia Department of Education was awarded a federal grant to study the Technology Model Schools (TMS) initiative; a program whereby technology integration specialists (TIS) were placed in schools on a full-time or part-time basis to work directly with teachers on technology integration. As a whole, the evidence suggests that the TMS program was a success. In general, the data indicate that: (1) any version of the TIS service was preferable to none; (2) two years of help was better than one; and (3) the TIS changed their services to become more effective in the second year than in the first.


## INTRODUCTION

Despite the fact that “technology integration” is a widely accepted term of art that is not well-defined in the worlds of educational research or practice, there are plenty of empirically-based efforts to document or measure levels of technology integration (Sandholtz, Ringstaff & Dwyer, 1997; O’Dwyer, Russell & Bebell, 2004; Hughes, 2005). Furthermore, there is plenty of very good research into the (positive and negative) predictors of variance in technology integration

(Norris, Sullivan, Poirot, & Soloway, 2003; Zhao & Frank, 2003; Ertmer, 2005). There is even an increasing body of research on the benefits of technology integration (Wenglinksky, 1998; Mann, Shakeshaft, Becker, and Kottkamp, 1999; Martindale, Pearson, Curda, and Pilcher, 2005; O'Dwyer, Russell, Bebell, and Tucker-Seeley, 2005;). Yet, assuming arguendo that there is a need to increase levels of technology integration into teaching and learning, there is very little by way of empirical evidence or guidance on how to best facilitate technology integration. That void is a problem for school leaders looking to move the teaching and learning process into the 21st Century as well as those who teach and work with sitting and aspiring school leaders.

Our empirical understanding of effective professional development, generally speaking, is reasonably well informed (NSDC, 2001; Garet et al., 2001; Guskey, 2003). However, professional development or any kind of change revolving around technology in education presents a unique set of challenges.

> Technophobes would argue that the mere inclusion of technology makes our discussion a horse of a different color, that is, that it is incommensurable with discussions of…change in other arenas. Technology supporters, surprisingly, might agree with them, arguing that networked technology creates environments that are qualitatively different from non-networked environments and thus comparisons of…change across the two dimensions would be incommensurable (Davidson, 2003, p. 747).

In other words, pedagogical change is difficult to achieve; facilitating technology integration is a particularly complicated enterprise. It is a leadership challenge that could use a comprehensive research base.

Partly to that end, this paper discusses the results of a comprehensive, federally-funded effort to study a single statewide approach to facilitating technology integration within schools. Specifically, the Office of Technology and Information Systems of the West Virginia Department of Education was awarded a grant under the federal “Evaluating State Education Technology Programs” (ESETP) to study the Technology Model Schools (TMS) initiative; a program whereby technology integration specialists (TIS) were placed in schools on a full-time or part-time basis to work directly with teachers on technology integration.

Conceptually, then, this study was situated in Davidson’s (2003) notion of the role of the educational technologist in school reform.

> … in general, ETs are those individuals responsible within or across schools in a district for integrating technology into instruction at the classroom level. ETs are distinct from classroom teachers (responsible for one or more classes of students), computer lab teachers (responsible for teaching computer skills per se), computer technicians (with sole responsibility for the maintenance of machines), or curriculum specialists (holding district-wide responsibilities for the implementation of curriculum in specific disciplinary areas). The ET position often combines parts of each of these roles, if not several more as well (Davidson, 2003, p. 703).

The technology integration specialists (TIS) placed in the schools of West Virginia by virtue of Title II, Part D funds took on the role of education technologists, and they were the “intervention” under investigation here. Furthermore, the ESETP request for proposals asked applicants "…to determine whether the program implemented produces meaningful effects on student achievement or teacher performance…" (*Competitive Preference Priority*, p 35127). The grant was awarded to West Virginia based on a proposal to search for student achievement outcomes associated with the TMS program, but to initially focus on the “teacher performance” aspect. That is, the initial goal was to concentrate on documenting the intermediate, teacher and instructionally related gains that are intrinsically worthwhile---especially technology integration. The secondary goal was to explore the effects of the TMS program on student achievement. Hence, the goal of the study was to answer two fundamental questions of national educational policy:

- Does sustained, in-house professional development (i.e. the presence of a school-based technology integration specialist) impact teacher attitudes and behaviors with respect to technology?
- To what degree does sustained, in-house professional development (i.e. the presence of a school-based technology integration specialist) account for variance in student achievement?

# RESEARCH METHODS

From a research design perspective, this was a quasi-experimental evaluation research design applied to schools implementing a federally funded program and to comparable control schools. The study took place primarily over two academic years, and was focused on teachers and students in grades three through five. Furthermore, in addition to the typical pre-post, self-report questionnaires, two technology-based methods of documenting technology integration were used: the installation of metering software on classroom computers and random-interval web-based surveys triggered by the activation of pagers; a modified version of the Experience Sampling Method (ESM) (Hektner, Schmidt & Csikszentmihalyi, 2006; Csikszentmihalyi & Hunter, 2003).

## Data Collection Methods

### The Modified Experience Sampling Method

The Experience Sampling Method (ESM), originally developed to "detect variations in emotional states over time," (Csikszentmihalyi & Hunter, 2003, p. 186) has since been expanded and used in educational research to study, among other areas, student stress (Verma, Sharma & Larson, 2002), teacher motivation and job satisfaction (Bishay, 1996), and student affective experiences of studying (Asakawa & Csikszentmihalyi, 1998). ESM involves asking participants to answer questions at multiple random moments over time whenever an electronic timing device (e.g. a pager, a watch, a personal digital assistant, etc.) prompts a response.

In this study, the ESM was modified a bit.  Teachers were equipped with pagers that were activated once or twice a day at random times every other week.  When the pagers were activated, teachers were to complete a short web-based questionnaire at their earliest convenience.  Additionally, one randomly selected student was to complete a different, even shorter web-based survey.  The web-based questionnaires were designed and tested with reasonably parallel items for teachers and students.  Specifically, using SNAP Survey software and the hosting capabilities of a cooperating university, two questionnaires (teacher and student) were developed for use in the study.  The questionnaires were comprised of 3-5 questions, including straightforward inquiries about whether teachers and/or students were using computers at the time the pagers were activated.

This form of data collection was notably successful.  In the first year of the study, 109 teachers (61 teachers in treatment schools and 48 teachers in control schools) were equipped with pagers.  From November 15, 2004 through April 15, 2005, the pagers were activated 41 times.  In the end, 1,598 usable[1] pager-triggered web survey responses were received from teachers.  Those 1,598 responses came from 109 different teachers (i.e. every teacher responded at least once).  The range in the number of responses from individual teachers was one to 41 (i.e. a couple of teachers responded once, and one teacher responded

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[1] "Usable" means a few things:  first, the response came on a day a response was expected; some teachers responded on a day during a week when no pages were scheduled.  Second, the response came at a time close to when it was expected.  If a response came well before 9 a.m. or well after 2:00 p.m., data were deleted since pagers were set to go off between 9 and 2 only.  Finally, there were some instances when the same teacher submitted two or more responses nearly simultaneously with the exact same responses.  In those instances, it was assumed that the teacher clicked "submit" at the end of the survey more than once; all but one of the responses were deleted in those cases.

to all 41 pages). Students sent 1,311[2] usable pager-triggered web survey responses. Those 1,311 responses came from 102 different classrooms. The range in the number of responses from individual classrooms was one to 34 (i.e. a couple of teachers only once asked a student to respond, and one teacher had students respond 34 different times).

For the second year of the study, this form of data collection was limited to certain teachers and other teachers refused to continue to participate in this form of data collection for a second year. Thus, significantly fewer teachers were equipped with pagers in the second year of the study than in the first year. Fifty-one teachers were paged 40 times from December 2005 through March 2006. Over the course of that time, 33 different teachers sent 319 usable random-interval, pager-triggered web survey responses. The range in the number of responses from individual teachers was one to 32. In addition to teacher surveys, 297 usable pager-triggered web survey responses arrived from students. Those 297 responses came from 33 different classrooms. The range in the number of responses from individual classrooms was one to 31 (i.e. a few teachers only once asked a student to respond, and one teacher had students respond 31 different times).

**Monitoring File Activity on Classroom Computers**

In addition to the modified ESM, file activity on individual computer workstations was documented through metering software. TrueActive Monitor

[2] There are a couple of reasons why this number is smaller than the number of teacher responses. First, because of a necessary change in the Web-survey for the students, the student web-survey data start with December 1, 2004 (compared to November 15, 2004 for teachers). Second, seven teachers never had any students respond to the web-survey.

(TAM) version 5.0 has the capacity to capture an extraordinary amount of finely-grained data about the functioning of any computer workstation. TAM was installed on every possible classroom computer in all 4th and 5th grade classrooms in treatment and control schools. Only file activity on classroom computers was monitored.

Throughout the study, it was necessary to troubleshoot the use of data on computer file activity captured automatically and unobtrusively by TAM. As one example, the TAM developers had to revise the TAM 5.0 system to run on Windows 98 computers; the functionality of TAM 5.0 could never be supported by Windows 95. Classrooms where Windows 95 computers were being used were encouraged to upgrade the operating system if possible. Additionally, the stealth e-mail function which sends the data automatically to the researchers had to be reprogrammed to allow the data to be sent every seven days. As originally developed, the longest possible time span between e-mails was 60 hours. While the software was reprogrammed to allow for the data to be sent every seven days, upon initial implementation, many of the computers were sending data every seven minutes. This was slowing down the workstations and bombarding the researchers with data.

Eventually, the data from the metering software arrived, and in bunches. Between October 1, 2004 and April 1, 2005, TAM was installed on approximately 287 computers. Over the course of the two years of the study, data was ultimately received at one point or another from 184 computers in 25 schools. In each of the two years of the study, almost 35,000 e-mails with a data file attached were forwarded to the researchers.

## Naturalistic Inquiry

In addition to the hordes of electronically-captured data, lots of qualitative data were collected through field-based methods. In each year of the study, treatment schools were visited and data were collected through observations and interviews with technology integration specialists, teachers and administrators. Additionally, WVDE staff members charged with supporting the TMS program were consulted regularly.

### Sampling Framework

This was a quasi-experimental research design since all of the schools participating in the TMS program were involved in the study. For each of the original TMS schools, a matched control school was chosen. In 20 of the 28 instances, control schools were chosen from within the same county/district as the treatment school. Schools were matched based on geography, school size, student demographics and *NCLB* accountability measures. In four instances, it was not possible to find a reasonably matched school that would participate or the school originally slotted into the framework withdrew from the study. In general, the control schools were good matches for the treatment schools.

After the first year of the study, a series of judgments by local educators seeking to improve schooling compromised the quasi-experimental design. The "turnkey assumption" was that after a year of specialized assistance, the TISs would move on, the "key would turn" and the faculty would be sufficiently confident and competent to (1) persist in what they had been shown during the TIS year and (2) train their colleagues. From the methods point of view, the treatment would end after the first year of the study and, in the second year of the study, the researchers would measure how much they continued to use the technology after the TMS services had moved to another school and how much the originally trained teachers would train their colleagues. Instead, some schools in the original treatment group extended the services of their TIS either through a second round of EETT funds or through locally generated funds. Additionally, prior to the second year of the study, some schools in the original control group applied for and received EETT funds to implement the TMS program.

**Additional Threat to Validity: Treatment Variability**

The compromising of the turnkey assumption was not the only design challenge. From an experimental standpoint, the singular treatment under study was simply the presence of a TIS in the school buildings. A major part of the statewide TMS program was professional development for the TISs. The goal was for the TISs to take their own professional development and turn it around (in the turnkey mode) in their role as TISs with the teachers. In addition to traditional forms of professional development, WVDE facilitated a series of collaborative exchanges (CE) in which the host TIS was to demonstrate a particularly useful or successful way to help teachers integrate technology into the curriculum. Each TIS had to host at least 2 CEs during the school year. Those elements of the TMS program were consistent across the state.

However, the lived reality in schools dictated that, in a few important ways, the TMS program was implemented differently across counties and between schools. First, baseline data indicated that there were significant differences in the experience and competencies that the TISs brought to their respective schools. Of the 18 TISs that were studied in the first year, three had served in that same capacity in the preceding year though in different schools. The other fifteen held varying positions before become a TIS, ranging from classroom teachers to Title I specialists to full-time media specialists.

The second treatment variation involved the mode and delivery of services. In their work turning around their own learning, the most common forms of professional development offered by the TISs were one-on-one technology training during school time and small group training during school time. Field notes and conversations with the TISs informed the conclusion that one-on-one training took several forms, ranging from troubleshooting specific problems to finding relevant and appropriate websites for teachers. The greatest variation among TISs came with respect to full-faculty trainings. One-half of the TISs reported doing full-faculty training during school time on no more than 2 occasions; the other half reported doing such training occasionally or regularly. Full-faculty trainings would also occasionally occur on county-wide professional development days.

Finally, and perhaps most importantly, there were significant differences in the way the TIS position was structured across the counties and schools. Only five of the18 TISs were contracted to work full-time (designated as at least 35 hours per week) in a single school. The other TISs were all part-time in one or more schools. The range of arrangements was significant. For example, one TIS worked 20 hours per week in one elementary school whereas another worked four hours per week in two elementary schools and seven hours per week in a third school. Most of the TISs who worked less than full-time as a TIS worked in another capacity within one of the schools they served as a TIS. For example, one TIS was a ½ time TIS and ½ time librarian in the same school. Another TIS was a ½ time TIS and ½ time secondary-level subject teacher in a K-12 school.

This treatment variability can be seen as a threat to validity, and therefore a limitation of the study. However, the variability was also embraced as context for the findings and factors in to conclusions and implications  Ultimately, to accommodate those world-of-practice circumstances and to stay as close to the original research design as possible, a decision was made to report the study schools across four groups:

1. The one-year treatment/turnkey group: a TIS in year 1 but not in year 2
2. The two-year treatment group: TISs in both years
3. The control and treatment group: no TIS in year 1 but a TIS in year 2
4. The control group: no TIS in either year

The policy decisions by WVDE and the county school systems certainly complicated the analysis. But, they also allowed for answers to policy relevant questions such as, "Is two years of TMS service better than one?" and, "Do the effects of the TMS services differ between the first and second years?"

## FINDINGS

Over the two years of this study, lots of data were collected, analyzed and reported. This paper highlights the major findings and is organized according to the logic of the TMS program. That is to say, the premise of the TMS program was that the TISs would work with teachers to improve their attitudes toward and work with technology. Those teacher-level changes would, in turn, lead to increased and improved student use of computers. Finally, the work of the TISs with the teachers would yield benefits in learning as measured by state-level achievement tests. This section of the paper, organized according to the logic of the program theory, offers evidence that, generally, the program worked according to plan.

### Teacher Attitudes Toward Technology

Each of the three times that teachers were surveyed (prior to the first year, after the first year, and at the end of the second year), they were asked to self-report their attitudes toward technology. Those questions were based on a previously validated scale composed of six Likert-scale items to which teachers were asked to indicate their level of agreement. Scores on this scale were computed by taking the mean response across all six items. Thus, the range of scores was from one (best attitude) to four (worst attitude). The results are displayed in Table 1 below. The teachers that worked with a TIS for both years of the study reported the most drastic improvements in attitudes. Teachers who had any assistance from a TIS developed more positive attitudes, and teachers that never worked with a TIS showed no change in attitudes.

| Table 1. Teacher Technology Attitudes<br>[NOTE: lower score means more positive attitude] | | | |
|---|---|---|---|
| | **Pre** | **Post (Year 1)** | **Post (Year 2)** |
| No TIS year 1, No TIS year 2 (the "control" group) (n=10) | 2.73 | 2.70 | 2.78 |
| TIS year 1, No TIS year 2 (the one-year "treatment/turnkey" group) (n=44) | 2.27 | 2.34 | 2.12 |
| TIS year 1, TIS year 2 (the "two-year treatment" group) (n=7) | 2.50 | 2.48 | 1.71 |
| No TIS year 1, TIS year 2 (the "control and treatment" group) (n=6) | 2.64 | 2.47 | 2.39 |

Furthermore, repeated measures analyses of variance show that there are different growth trajectories across two of the groups (the control group and the one-year treatment/turnkey group); there are statistically significant differences in the growth in positive attitudes between those two groups (F=3.721, p=.016).

On the final survey, at the end of the second year, teachers were asked to report on the degree to which they were more confident in their ability to use technology moving forward and their confidence in doing so independently. As demonstrated in Table 2, the most confident group was the teachers with TIS services for two succeeding years, followed by those who had TIS services during the second year only. As with the technology attitudes scale, scores ranged from one (strongly agree) to four (strongly disagree).

For both the future (F=8.029, p <.01) and independent (F=6.729, p<.01) uses of technology, an analysis of variance showed significant differences in group means. Furthermore, post-hoc analyses demonstrated that teachers who never had TIS help reported much less confidence in their future and independent uses of technology than each of the other three groups of teachers. That is to say, having worked with a TIS at any point during the study period was associated with higher levels of confidence in future independent uses of technology.

| Table 2. Teacher self-reported confidence and independence [NOTE: lower score means more positive attitude] | | |
|---|---|---|
| | **Next September, I will be better able to use technology in my classroom than I was last September.** | **Next September, when I use technology in my classroom, I will be able to do so on my own (i.e. without the aid of colleagues or a TIS).** |
| TIS year 1, TIS year 2 (the “two-year treatment” group) (n=14) | 1.64 | 2.20 |
| No TIS year 1, TIS year 2 (the “control and treatment” group) (n=17) | 1.94 | 2.36 |
| TIS year 1, No TIS year 2 (the one-year “treatment/turnkey” group) (n=49) | 2.12 | 2.41 |
| No TIS year 1, No TIS year 2 (the “control” group) (n=13) | 2.85 | 3.15 |



**Teacher Computer Use**

Teachers often apply increased technological fluency on their own before they are able to transfer that learning into pedagogical change. Furthermore, since for the purposes of this study “technology integration” was not considered solely student computer use, data on teacher use of computers for their own work were collected. Self-report data were collected on the surveys, but teacher technology use was best measured by the modified Experience Sampling

Method (ESM). On the short web-based questionnaire to which teachers responded when the pagers were activated, teachers were asked if they were using computers for their own work (at the moment when the pagers were activated). For these analyses, data were aggregated to the teacher level and then weighted by the number of times any particular teacher responded.

Across the first year of the study, on the 933 instances when teachers in TMS schools responded to the question, they responded “Yes” 22% of the time. Teachers in control school classrooms only responded “Yes” in 9% of the 630 instances when they responded to the question. That difference is statistically significant ($p < .001$).

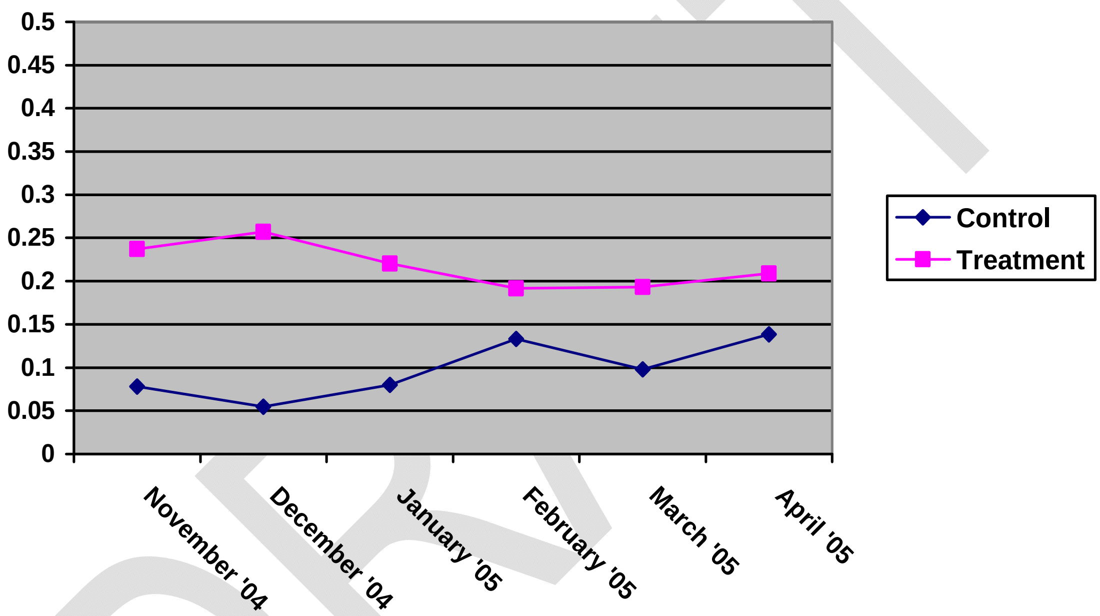
Those responses were also analyzed by month, as evidenced by Table 3 and Figure 1.

**Table 3. Teacher Computer Use by Month by Study Condition**

| MONTH | TMS/Control | N | % “Yes” Responses |
|---|---|---|---|
| November '04 | TMS | 194 | .2371 |
| | Control | 77 | .0779 |
| December '04 | TMS | 175 | .2571 |
| | Control | 128 | .0547 |
| January '05 | TMS | 218 | .2202 |
| | Control | 163 | .0798 |
| February '05 | TMS | 141 | .1915 |
| | Control | 105 | .1333 |
| March '05 | TMS | 114 | .1930 |
| | Control | 92 | .0978 |
| April '05 | TMS | 91 | .2088 |
| | Control | 65 | .1385 |

Figure 1 depicts the differences in teacher computer use over the course of the first year of the study. The teachers in the treatment schools began working with a TIS at the beginning of the school year, and by November they were significantly more likely to report using computers than their control school counterparts.  That gap narrowed a bit over the course of the year, but the TMS teachers were always more likely to report self-use than their control school teachers.

**Figure 1. Teacher Computer Use by Month by Study Condition (% "Yes" responses)**




The differences in the likelihood of teacher computer use grew after the first year of the study.  While the likelihood that teachers reported using computers for their own work in the control group schools plummeted from 9% of the instances to 1% of the instances between the first and second years of this study, for the TMS teachers, the likelihood remained constant.  That is, over the course of the second year of the study, the TMS teachers reported using computers for their own work 22% of the time just as they had during the first year of the study.

### Student Computer Use

#### Teacher Reports

Student computer use was documented in the same ways as teacher computer use. That is, in addition to being asked about their own work with computers, when the pagers were activated, the Web-based questionnaire asked teachers if any of their students were using a computer (when the pager was activated). Looking at the data from the first year again, TMS teachers were more likely to respond in the affirmative (25% of the time) than were the control school teachers (21% of the time).

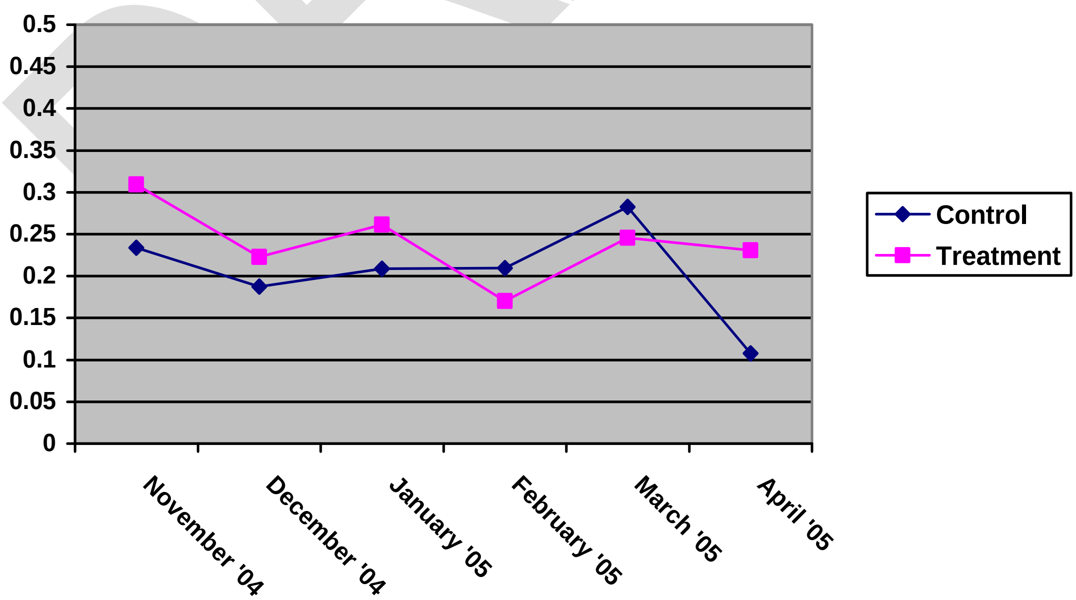
The following table shows the uses by months of the school year between the Model Schools and other teachers.

**Table 4. Student Computer Use (Teacher Reports) by Month by Study Condition**

| MONTH | TMS/Control | N | % "Yes" Responses |
|---|---|---|---|
| November '04 | TMS | 194 | .3093 |
| | Control | 77 | .2338 |
| December '04 | TMS | 175 | .2229 |
| | Control | 128 | .1875 |
| January '05 | TMS | 218 | .2615 |
| | Control | 163 | .2086 |
| February '05 | TMS | 141 | .1702 |
| | Control | 105 | .2095 |
| March '05 | TMS | 114 | .2456 |
| | Control | 92 | .2826 |
| April '05 | TMS | 91 | .2308 |
| | Control | 65 | .1077 |

Figure 2 depicts the differences in student computer use over the course of the first year of the study. The reports of student computer use were more likely in the TMS schools than in control schools in the middle months of the school year. While the control schools overtook the TMS school students in February and March, between March and April, there was a dramatic decrease in likelihood of teacher-reported student computer use in the control schools and not in the TMS schools. That difference is likely explained by the proximity to statewide testing. A common phenomenon across the country is for teachers to discontinue technology integration when it comes time to prepare most heavily for high-stakes tests. A point of emphasis in the TMS schools, however, was that technology can be integrated so as to advance student learning and performance on achievement tests.

**Figure 2. Student Computer Use (Teacher Reports) by Month by Study Condition (% "Yes" responses)**



### Student Reports

When the teachers' pagers were activated, they asked a randomly-designated student to fill out a parallel web-survey. The first question that students saw was, "Before you started this survey, were *YOU* OR *ANY OTHER STUDENTS IN YOUR CLASS* using a computer?" Over the first year of the study, students in TMS schools were more likely to report that they were using computers than students in the comparison group schools. On the 642 instances when students in TMS schools responded to the question, they responded "Yes" 31% of the time. Students in control school classrooms only responded "Yes" in 25% of the 620 instances when they responded to the question. That difference is statistically significant ($p < .01$).

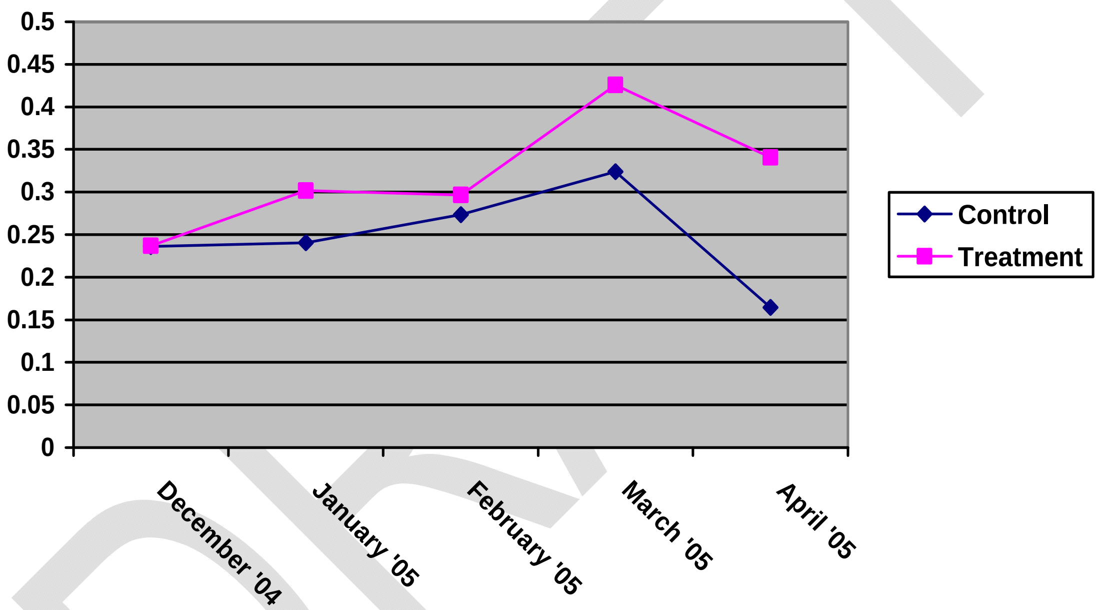
Those responses were also analyzed by month and are reported in Table 5.

**Table 5. Student Computer Use (Student Reports) by Month by Study Condition**

| MONTH | TMS/Control | N | % "Yes" Responses |
|---|---|---|---|
| December '04 | TMS | 152 | .2368 |
| | Control | 127 | .2362 |
| January '05 | TMS | 179 | .3017 |
| | Control | 187 | .2406 |
| February '05 | TMS | 118 | .2966 |
| | Control | 128 | .2734 |
| March '05 | TMS | 101 | .4257 |
| | Control | 105 | .3238 |
| April '05 | TMS | 91 | .3407 |
| | Control | 73 | .1644 |

Like the teacher reports of student computer use, in the middle of the school year, the likelihood of student reports of computer use did not differ much between TMS schools and control schools, though reports of student computer use were a bit more likely in TMS schools.  Also similar to the teacher reports, the likelihood of reported student computer use seriously decreased in the control schools between March and April.

**Figure 3.  Student Computer Use (Student Reports) by Month by Study Condition (% “Yes” responses)**




Between the first and second years of the study, the likelihood of reported student computer use increased in the TMS schools and decreased in the control schools.  In fact, over the second year of the study, students in TMS schools were twice as likely to report that they were using computers compared to students in the control group schools.  On the 195 instances when students in TMS schools responded to the question, they responded, “Yes” 35% of the time.

Students in control school classrooms only responded, “Yes” in 18% of the 77 instances their teachers were paged.

**Student Achievement**

Thus, the data indicated differences in teacher attitudes and teacher and student computer use between schools with a TIS and control schools. Furthermore, consistently, those differences were in favor of teachers and students in schools with a TIS. The final inquiry, then, involves an exploration of student achievement differences.

WVDE officials and the researchers worked hard to identify schools that would match the student achievement characteristics of the TMS schools as closely as possible at baseline (Spring 2004). However, despite their best efforts, at baseline, the groups were not equivalent with respect to student achievement---the schools originally identified as control schools began with higher achievement in Reading/Language Arts and Mathematics. For the cohort of students for whom two years of achievement data were available (students who were 3rd grade students in Spring 2004 and 4th grade students during the first year of the study), the difference between the mean Reading/Language Arts score for the control group students (631.78) and the TMS school students (627.25) was statistically significant ($t$=2.722, $p$ = .007). The difference between the mean Mathematics score for the control group students (620.36) and the TMS school students (615.98) was also statistically significant ($t$=3.080, $p$ = .002).

To account for the different starting points between the two groups, analysis of covariance (ANCOVA) was used in examining student achievement. That is, posttest scores were analyzed while controlling for pretest scores (i.e. holding pretest scores constant). Essentially, this approach computes estimated posttest scores (while holding pretest scores constant) and tests for differences between the groups on those estimated marginal mean (posttest) scores.

**Table 6. Mathematics Achievement: Tests of Between-Subjects Effects**
Dependent Variable: Scaled Score Math (2006)

| Cohort | Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|---|
| **Cohort 2 -** 3rd Grade (2004) to 5th Grade (2006) | Corrected Model | 1178601.879(a) | 16 | 73662.617 | 183.395 | .000 | .631 |
| | Intercept | 208672.145 | 1 | 208672.145 | 519.523 | .000 | .232 |
| | Scaled Score Math (2004) | 1091078.686 | 1 | 1091078.686 | 2716.419 | .000 | .613 |
| | Sex | 1193.010 | 1 | 1193.010 | 2.970 | .085 | .002 |
| | Title I | 41.082 | 1 | 41.082 | .102 | .749 | .000 |
| | TMS Duration[3] | 3990.832 | 3 | 1330.277 | 3.312 | .019 | .006 |
| | Sex x Title I | 125.836 | 1 | 125.836 | .313 | .576 | .000 |
| | Sex x TMS Duration | 143.197 | 3 | 47.732 | .119 | .949 | .000 |
| | Title I x TMS Duration | 4405.497 | 3 | 1468.499 | 3.656 | .012 | .006 |
| | Sex x Title I x TMS Duration | 1636.793 | 3 | 545.598 | 1.358 | .254 | .002 |
| | Error | 689249.738 | 1716 | 401.661 | | | |
| | Total | 785293736.000 | 1733 | | | | |
| | Corrected Total | 1867851.617 | 1732 | | | | |

a. R Squared = .631 (Adjusted R Squared = .628)

[3] "TMS duration" is the name of the variable that groups students into the four possible study conditions: the one-year treatment/turnkey group (a TIS in year 1 but not in year 2); the two-year treatment group (TISs in both years); the control and treatment group (no TIS in year 1 but a TIS in year 2), and the control group (no TIS in either year).

The math achievement data are presented first. In addition to controlling for baseline achievement, data on sex and Title I eligibility were included in the models to hold those standard predictors of student achievement constant.

The tests of between-subjects effects indicate that there were differences between the estimated marginal mean Math posttest scores by condition (i.e. across the four groups defined by service delivery). There were no significant differences by sex or by Title I eligibility status.

**Table 7. Mathematics Achievement: Estimated Marginal Means**
Dependent Variable: Scaled Score Math (2006)

| | | | | 95% Confidence Interval | |
|---|---|---|---|---|---|
| Cohort | Condition | Mean | Std. Error | Lower Bound | Upper Bound |
| 3rd Grade (2004) to 5th Grade (2006) | Control | 669.831(a) | .929 | 668.008 | 671.654 |
| | One-Year Treatment/Turnkey | 671.712(a) | .924 | 669.900 | 673.525 |
| | Two-Year Treatment | 674.238(a) | 2.004 | 670.307 | 678.168 |
| | Control and Treatment | 674.088(a) | 1.150 | 671.832 | 676.344 |

a. Covariates appearing in the model are evaluated at the following values: SS Math (2004) = 618.3619.

Post-hoc pairwise comparisons revealed that the estimate for the two-year treatment group (TIS both years) and the control and treatment group (TIS 2nd year only) were higher than for the control group (no TIS either year). Also, there was a significant interaction effect between Title I eligibility and TMS duration. That is, the TMS “treatment” had differential effects for Title I-eligible students. It is hard to determine exactly what those effects were, but the table below shows the estimated marginal means for the eight possible groups of students. Students eligible for Title I services had higher estimated marginal means in math achievement in both the one-year and the two-year TMS schools than their Title I-eligible counterparts in the control schools.

| Table 8. Mathematics Achievement: Estimated Marginal Means<br>Dependent Variable: Scaled Score Math (2006) | | | | | |
|---|---|---|---|---|---|
| | | | | 95% Confidence Interval | |
| Title I | Condition | Mean | Std. Error | Lower Bound | Upper Bound |
| Not Eligible | Control | 672.192(a) | 1.311 | 669.621 | 674.763 |
| | One-Year Treatment/Turnkey | 673.080(a) | 1.610 | 669.921 | 676.238 |
| | Two-Year Treatment | 671.228(a) | 3.836 | 663.706 | 678.751 |
| | Control and Treatment | 672.516(a) | 1.632 | 669.315 | 675.716 |
| Eligible | Control | 667.470(a) | 1.326 | 664.869 | 670.072 |
| | One-Year Treatment/Turnkey | 670.345(a) | .926 | 668.529 | 672.162 |
| | Two-Year Treatment | 677.247(a) | 1.160 | 674.972 | 679.522 |
| | Control and Treatment | 675.661(a) | 1.622 | 672.479 | 678.842 |

a Covariates appearing in the model are evaluated at the following values: SS Math (2004) = 618.2660.

Similar results were discovered for Reading/Language Arts scores. The tests of between-subjects effects indicate that there were differences between the estimated marginal mean Reading/Language Arts posttest scores by condition (i.e. across the four groups). There are no significant differences by sex or by Title I eligibility status.

Post-hoc pairwise comparisons revealed that the estimate for the one-year treatment/turnkey group (TIS in the first year only) and the control and treatment group (TIS 2$^{nd}$ year only) were higher than for the control group (no TIS either year). Also, there was a significant interaction effect between Title I eligibility and TMS duration, i.e., the TMS “treatment” has differential effects for Title I-eligible students.

**Table 9. Reading/Language Arts Achievement: Tests of Between-Subjects Effects**
Dependent Variable: Scaled Score Reading/Language Arts (2006)

| Cohort | Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|---|
| 3rd Grade (2004) to 5th Grade (2006) | Corrected Model | 1321464.722(a) | 16 | 82591.545 | 212.821 | .000 | .665 |
| | Intercept | 305077.586 | 1 | 305077.586 | 786.119 | .000 | .314 |
| | Scaled Score Reading (2004) | 1239810.161 | 1 | 1239810.161 | 3194.723 | .000 | .651 |
| | Sex | 80.727 | 1 | 80.727 | .208 | .648 | .000 |
| | Title I | 330.790 | 1 | 330.790 | .852 | .356 | .000 |
| | TMS Duration | 4306.514 | 3 | 1435.505 | 3.699 | .011 | .006 |
| | Sex x Title I | 29.480 | 1 | 29.480 | .076 | .783 | .000 |
| | Sex x TMS Duration | 2343.841 | 3 | 781.280 | 2.013 | .110 | .004 |
| | Title I x TMS Duration | 4514.152 | 3 | 1504.717 | 3.877 | .009 | .007 |
| | Sex x Title I x TMS Duration | 311.648 | 3 | 103.883 | .268 | .849 | .000 |
| | Error | 665946.408 | 1716 | 388.081 | | | |
| | Total | 755850324.000 | 1733 | | | | |
| | Corrected Total | 1987411.130 | 1732 | | | | |

a. R Squared = .665 (Adjusted R Squared = .662)

**Table 10. Reading/Language Arts Achievement: Estimated Marginal Means**
Dependent Variable: Scaled Score Reading/Language Arts (2006)

| Cohort | Condition | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| 3rd Grade (2004) to 5th Grade (2006) | Control | 657.625(a) | .913 | 655.834 | 659.416 |
| | One-Year Treatment/Turnkey | 661.384(a) | .903 | 659.613 | 663.154 |
| | Two-Year Treatment | 659.795(a) | 1.970 | 655.931 | 663.658 |
| | Control and Treatment | 661.587(a) | 1.133 | 659.366 | 663.809 |

a Covariates appearing in the model are evaluated at the following values: SS Reading/Language (2004) = 629.6555.

Table 11 shows the estimated marginal means for the eight possible groups of students. Within the one-year treatment/turnkey schools, students not eligible for Title I services did better than those who were eligible. That is unsurprising since Title I eligibility is a proxy for families with low income: those not eligible for Title I assistance are presumed to have achievement advantages.

| **Table 11. Reading/Language Arts Achievement: Estimated Marginal Means**<br>Dependent Variable: Scaled Score Reading/Language Arts (2006) | | | | | |
|---|---|---|---|---|---|
| | | | | 95% Confidence Interval | |
| Title I | Condition | Mean | Std. Error | Lower Bound | Upper Bound |
| Not Eligible | Control | 657.443(a) | 1.286 | 654.919 | 659.966 |
| | One-Year Treatment/Turnkey | 664.910(a) | 1.564 | 661.842 | 667.979 |
| | Two-Year Treatment | 659.276(a) | 3.771 | 651.879 | 666.673 |
| | Control and Treatment | 661.185(a) | 1.609 | 658.030 | 664.340 |
| Eligible | Control | 657.808(a) | 1.301 | 655.256 | 660.360 |
| | One-Year Treatment/Turnkey | 657.857(a) | .910 | 656.073 | 659.642 |
| | Two-Year Treatment | 660.314(a) | 1.142 | 658.075 | 662.553 |
| | Control and Treatment | 661.990(a) | 1.595 | 658.861 | 665.119 |

a Covariates appearing in the model are evaluated at the following values: SS Reading/Language (2004) = 629.6555.



## DISCUSSION AND POLICY IMPLICATIONS

If we accept that one of the roles of schools is to prepare students so that they may lead successful and productive adult lives, then the institution of public schooling must become innovative, particularly in the use and integration of technology, if they are to help their students meet the demands of globalization. Much research has been done on the effects of technology integration in schools (Becker, 2000; O'Dwyer, Russell, & Bebell, 2004; Wenglinsky, 1998), but there has been little to no research on how technology integration is best facilitated. That is an open empirical question, and a very important question of educational leadership and policy.

On the evidence reported herein, West Virginia's Technology Model Schools (TMS) Program was a successful and replicable model of facilitating technology integration.  The results were not overwhelming, but the data indicate that:

- Teacher attitudes toward technology increased from year to year among teachers who worked with a TIS at any point over the study period, but not among the control group teachers.
- By the end of the two year study period, the teachers who were most confident in their ability to integrate technology into their teaching independently were also those who had worked with a TIS at any point.
- In either year of the study, the likelihood that teachers were using computers for their own at any given time was greater in the TMS schools than in the control schools.
- In either year of the study, and especially in the second year, the likelihood that students were using computers at any given time was greater in the TMS schools than in the control schools.
- In general, the achievement of students whose teachers worked with a TIS at any point during the study period was higher than students in classes without the program.  And, in general, two years of TMS help is associated with higher achievement than one year or no years of TMS help.

That final conclusion can be broadened to say that, overall, the most consistent finding is that for a technology integration specialist to be effective, she or he needs more than one year in the position.  Achievement data notwithstanding, the data that best support the decision to extend the TIS position beyond just one year are those about teacher computer use in the first year and student computer use in the second year. After the first study year, there were significant differences between the TMS and the control schools in teacher computer use for their own work. Any differences in student computer use were not as significant during the first year. However, that changed during the second year. Teachers in the TMS schools continued to use computers for their own work at a similar rate (whereas control school teachers were less likely to report working with computers on their own) and teacher and student reports of student computer use became significantly more likely in the TMS schools. This begs a singular explanation. In the first year, the TMS was able to show teachers how to do a few things and teachers were able to try them out. In the second year, though, those teachers began to apply their learning and the TMSs were better able to facilitate the true integration of the technology.

That the teachers who had worked with a TIS for two years reported the most confidence in their ability to integrate technology independently at the end of the second year of the study is further support for the conclusion that the technology integration specialist is best conceived of as more than a one year position. And, the issue of 'independence' is particularly important because it signals mature use. Teachers have their own incentives to stay dependent on 'experts'---teachers believe themselves to be notoriously busy so recruiting someone else to "do technology" helps (that includes delegating to the computer lab). However, for true professional development to occur, help has to shift from technical assistance (doing something for someone) to capacity-building (teaching them to do things for themselves); the TISs had to learn to work from dependence to independence even it means they were working themselves out of a job. One TIS described that transfer of learning as the difference between finding useful and relevant websites for teachers to teaching them how to find those same sites.

There are a couple of explanations and, therefore, policy-relevant implications of this major finding. First, as interview data and observations confirmed, the technology integration specialists spent much of the first year learning their new position. Many of them had spent a decade or more in a classroom working directly and exclusively with elementary and/or secondary school students. A number of them were tapped or recommended for the TIS position as a result of the progressive work they had done integrating technology into the teaching and learning process. One TIS stated that she believed she was recommended for the TIS position because she was seen spending a lot of time around the printers. However, facilitating learning with technology for teenagers is a very different proposition than working with professional peers or colleagues to advance their pedagogy. Thus, it took the first year to accept that proposition and to adjust accordingly.

Another reason for structuring the TIS position as more than a one year proposition is that it takes a considerable amount of time for the TIS to establish her or his role within the school. Davidson studied what she referred to as the education technologist from a role function perspective. In that case study, Davidson wrote about the reflexive process of the development of the education technologist position. “As ETs entered the schools, they needed to define not only who they were but also who they were not. Conversely, those with whom they worked, such as teachers and principals, also had to undertake a similar process” (Davidson, 2003, p. 736). That process was evident in the TMS schools as well with the added dimension that most of the TISs were in the same school they had worked in the year before. Thus, they were suddenly thrust into a role that put them in a different place with respect to their former colleagues (and, in many cases, friends).

One TIS was the full-time media specialist before becoming a ½ time TIS, ½ time media specialist in the same school. Given her proclivity for and fluency with technology, before the TMS program, she was the person on whom teachers relied to solve technical problems and to troubleshoot technological glitches. However, as a TIS, her role was to conduct proactive training and staff development; the TISs were specifically instructed that they were not to be troubleshooters or technical specialists. So, this TIS had to figure out how to re-direct her colleagues for certain forms of support she could no longer provide.

The TMS program was initially designed as a “one and done,” turnkey program where the TIS would serve a school for a year, transfer their own learning to the teachers and then potentially move on to another school the next year. However, after reflecting on the first year, teachers and administrators in a number of the counties decided that the TIS position was not a one year proposition. Those decisions are clearly supported by the data from this study.

In addition to taking a longer-term perspective on the role of the TIS, a few other policy recommendations surface from this study. First, education agencies considering the facilitation of technology integration by establishing a TIS-like position should carefully consider who is best suited to such a position. For one thing, an educator with extensive technical knowledge may have a limited understanding of pedagogy. A network specialist, for example, is not likely to be an effective facilitator of technology integration. Furthermore, teaching adults is much different than teaching children. Relatedly, then, those selected or assigned to such a position should be taught or at least directed to literature on adult learning theory. The National Staff Development Council's Standards for Staff Development (2001) indicate that effective staff development "[r]equires resources to support adult learning and collaboration" and "[a]pplies knowledge about human learning and change." Finally, as Davidson (2003) emphasizes, . "…the ET points the way to a new kind of educator role, one that integrates leadership and instruction and exists interdependently with school colleagues" (p. 747). Thus, schools that are notoriously hierarchical and where teachers are historically isolated within their classrooms must embrace the unique qualities of the role of the technology integration specialist for the effective facilitation of technology integration to occur.

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