PLANNING FOR TECHNOLOGY INTEGRATION: IS THE IT AGENDA OVERRATED OR UNDERAPPRECIATED?[1]

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ABSTRACT

Review of relevant literature and findings from an evaluation of one school's technology integration project raise troubling questions about the place of instructional technology in US schools. Major arguments supporting technology integration are varied, and some of them rest on fundamentally incompatible premises. But despite these arguments, technology integration in general has been neither thoroughgoing nor instructionally effective. Turning first to the relevant literature, this study identifies researchers' explanations for inadequate technology integration in US schools. Then it examines these explanations in light of data generated through the evaluation of one rural school's project to integrate computer-based technologies into instruction in core academic subjects. Findings suggest that technical, ideological, cultural, and systemic circumstances—impediments also identified in the prior literature—did indeed compromise technology integration in the school project evaluated by these researchers.

BACKGROUND

In response to the marketing of home computers in the early 1980s, some educators began to advocate widespread use of technology in K-12 classrooms (e.g., Clay, 1982). Early articles and textbooks on technology integration presented hopeful visions of educational transformations resulting from classroom technology use. Despite the enthusiasm of advocates, teachers were slow to incorporate computer applications in meaningful ways (e.g., Cuban, 2001). At present, following more than 20 years of advocacy and teacher training, advocates continue to extol the instructional benefits of computers and related technologies; yet a majority of teachers continue to eschew or even actively resist technology integration (Becker, 2000; Cuban, 2001). These teachers' perspectives and practices seem not to be associated with the numbers of computers and related technologies available to them in schools. Schools all over the United States have been purchasing hardware and instructional software since the early 1980s, and now, according to the U.S. Department of Education (2005) among other sources (e.g., Becker, 2000), computers and related technologies are available in the vast majority of US schools. Nevertheless, ample evidence suggests that the promises of technology integration have not been fully realized.

Whereas scholars offer various explanations for this disappointing outcome, interactions with practicing teachers tend to support certain of these explanations and cast doubt on others. In this paper, we examine the explanations set forth in the published literature in light of evidence grounded in the world of classroom practice. Such an examination provides important insights to guide educational planning efforts. Notably, it speaks to the question of whether or not technology planning—which in almost all cases represents a variant of rational planning—actually is likely to succeed.

Despite increasing agreement among educational planners that rational planning has distinct limits, technology planners continue to advocate the rational model (e.g., Anderson, 2001; Bennett & Everhart, 2003). Nevertheless, the evidence from empirical investigations of school projects to integrate technology suggests that technology planners ought to be attentive to the limits of rationality resulting from complexity, power dynamics, and cultural norms. Such limits have, in fact, been discussed by theorists of planning for more than 50 years (e.g., Cohen, March, & Olsen, 1972; Mintzberg, 1993; Simon, 1955).

METHOD

The analysis reported in this paper uses data from a program evaluation to interrogate the explanations for the pattern of incomplete and ineffective technology integration exhibited in classrooms in the United States. The first step in conducting the analysis was, therefore, to review literature on the extent and quality of technology integration in K-12 schools. In addition to establishing a context for the study, the literature

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review also yielded a list of possible explanations for the current state of affairs. The literature used for these purposes included empirical studies and critical analyses published in the ten-year period between 1997 and 2007.

In an effort to explore the salience of the various explanations presented in the literature, the second part of the analysis drew on data from an evaluation of technology integration at a rural middle school. In effect, this part of the investigation answered the research question: “To what extent did educators’ experiences at TMS fit in with each of the popular explanations for limited technology integration in US schools?” This approach might be seen as a way to challenge the generalizabilty of each of the explanations, but doing so was not its major intent. Rather, because technology *planning* was the domain of interest, the primary aim was to derive insights about the influence of systemic characteristics (across the classroom, school, district, and state levels of a school system) on the rhetoric and practice of technology integration.

Attending to this aim and considering that (a) the school represented just one example and (b) the number of participating teachers was small, the interpretation avoided making direct generalizations. Instead it focused on the way particular dynamics in one school fit with generalizations brought forward in previous literature. As such, the study might properly be said to elucidate theory rather than either to propose or test it.

FINDINGS

This section of the paper first presents researchers’ explanations of the incomplete and uninventive uses of technology so often seen in US classrooms. Then it describes the school whose integration of technology is the case-in-point used in the present analysis. Finally, it investigates the extent to which circumstances at the school did or did not fit with the explanations offered in the literature.

The Empirical Literature

As Whitworth and Berson (2003, p. 483) suggested, the classroom computer is relegated to the status of “an appendage. . .[and] continues to serve the primary function of facilitating students’ access to content.” Cuban (2001) offered a similar assessment, reporting that approximately half of today’s teachers integrate computers into classroom lessons but primarily as a way to give students access to word-processing and resources on the internet. These authors and many others speculated about the reasons for such limited and unimaginative integration of computers and related technologies, and some (e.g., ChanLin, Hong, Horng Chang, & Chu, 2006) found it useful to categorize these explanations. Using this approach but a different organizational scheme than that used by ChanLin and associates (2006), the current review organizes the explanations in four categories, each defining in a different way the conditions facing schools: (a) technical explanations, (b) explanations relating to organizational capacity, (c) explanations focusing on ideology, and (d) systemic and ecological explanations.

Technical explanations. Even though computers can now be found in most schools in the United States (e.g., Becker, 2000), technical problems still keep them from being used effectively. For example, many teachers reported that they have insufficient access to computers (Fabry & Higgs, 1997; Redmann & Kotrlik, 2004; Shayo, Olfman, & Guthrie, 2001; Smerdon, Cronen, Lanahan, Anderson, Jannotti, & Angeles, 2000; Styron & Disher, 2003) and appropriate software (Zhao, 2007), or that they lack adequate Internet access (Fabry & Higgs, 1997; Zhao, 2007). Problems with hardware, software, and internet connectivity call for technical support, which is limited or totally lacking in some school districts (Redmann & Kotrlik, 2004; Shayo, Olfman, & Guthrie, 2001).

The technical and access problems that face many schools may result from more extensive difficulties in garnering necessary resources and organizational supports of other types. In a sense, then, explanations for inadequate integration of technology that focus on the technology itself may form a subset of more widespread capacity issues such as those described in the next section.

Explanations relating to organizational capacity. Researchers have identified a range of capacity limitations that seem to interfere with teachers’ effective integration of technology. In some studies, educators reported that they lacked funds to initiate and sustain technology integration (Fabry & Higgs, 1997; George, 2000; MacNeil & Delafield, 1998). In some, the major focus was on time (Fabry & Higgs, 1997; Franklin, 2007; George, 2000; Zhao, 2007).

Limited time, moreover, seems to keep schools from supporting the types of activities needed for the expansion of organizational capacity. Some researchers investigated this constraint from the vantage of principals, who reported that there was inadequate time for professional development (MacNeil & Delafield, 1998). Others captured teachers' perceptions that they lacked sufficient time to learn how to integrate computers into instruction (Smerdon, Cronen, Lanahan, Anderson, Jannotti, & Angeles, 2000) or lacked adequate instructional planning time in which to develop lessons that incorporated technology (Redmann & Kotrlik, 2004; Zhao, 2007). In some studies, teachers also indicated that there was inadequate time in the school day to allow students to use computers (Smerdon et al., 2000).

Although certain other studies also reported constraints upon organizational capacity, they did not necessarily attribute these constraints to lack of funds or insufficient time. Several research teams noted, for example, that teachers simply did not have adequate expertise (George, 2000) or experience in using technology for instructional purposes (Zhao, 2007). Some researchers cited lack of appropriate training (Budin, 1999; Fabry & Higgs, 1997; US Department of Education, 2005; Zhao, 2007) or sufficient administrative support (Shayo, Olfman, & Guthrie, 2001; Styron & Disher, 2003) as major impediments.

Several studies focused on the role that school leadership plays in technology integration (Baylor & Ritchie, 2002; Stegal, 1998). Key functions that leaders perform—planning, providing resources, arranging for professional development of teachers, maintaining an open and productive organizational climate—appeared to foster technology integration (Brockmeier, Sermon, & Hope, 2005; Hunt & Lockard, 1998; Staples, Pugach, & Himes, 2005). And evidently these functions tend to be performed to greater and lesser degrees in different schools and districts (Brockmeier et al., 2005). According to some researchers, principals often lacked knowledge about how to support technology integration and, like the teachers whom they were trying to assist, needed to expand their knowledge and skills (e.g., Brockmeier et al., 2005).

Explanations relating to ideology. In a sense, because they concentrate on the connection between organizational means and ends, both types of explanations examined thus far have a technical focus. These explanations assume that, once appropriate solutions are deployed, desired changes will ensue. For example, explanations targeting resources embed the assumption that technology integration will improve once resources are increased.

Another set of explanations identify the primary source of limited technology integration as educators' preexisting beliefs and attitudes. From this perspective, teachers either have a general tendency to resist change (Fabry & Higgs, 1997) or hold particular beliefs about teaching and learning that militate against technology integration (Kanaya, Light, & Culp, 2005; Palak, Walls, & Wells, 2006; Zhao, 2007). These two conditions, of course, are not mutually exclusive: teachers may resist change precisely because of the beliefs they maintain about teaching and learning.

Moreover, resilient beliefs about teaching and learning tend to promote a "teacher-centered" approach—what Freire (1970) called the "banking model of education"—whether teachers choose to deploy technology for instructional delivery or not (Cuban, 2001). This explanation seems to account for some teachers' resistance to technology integration as well as for others' unimaginative applications of instructional technology (e.g.., using technology solely to deliver content).

Systemic or ecological explanations. Although explanations that focus on technical insufficiencies and those that focus on teachers' resilient beliefs appear to have face validity, neither accounts for everything that seems to be going on. Furthermore, the two explanations are disconnected. Another type of explanation—one focusing on schools as systems—seems more inclusive and more parsimonious, and it seems capable of subsuming both of the other types of explanation. Li (2007), for example, offered a systemic description of functional technology integration:

> A technology-enhanced environment, therefore, can be viewed as a system that emerges from the interaction of its components. These components are the critical stakeholders and include students, teachers, and administrators. These stakeholder groups interact with each other and carry out certain tasks that enable the environment to function. For example, students' and teachers' beliefs about technology may affect their adoption of the tools which directly contributes to the establishment of a technology-enhanced environment. Further, administrators' understanding of technology-related issues may affect school policies. This, in turn, may influence the integration of technology in

schools and reshape the environment. (p. 378)

From Li's perspective, attitudes and beliefs influence practices, which, of course, then double back to influence attitudes and beliefs. What he portrayed in the passage quoted above is a more positive version of the systemic influences on the integration of instructional technology than most studies actually have revealed. These studies have tended to highlight the systemic dysfunctions that conspires *against* technology integration: (a) traditional beliefs about pedagogy (e.g., Cognition and Technology Group at Vanderbilt, 1997; Cuban, 2001), (b) emphasis on high-stakes testing (Franklin, 2007), (c) propensity to avoid planning (Budin, 1999; ChanLin, 2007), (d) limited collegiality (Wiske, Sick, & Wirsig, 2001), (e) inadequate leadership, and (f) insufficient resources. Added together these circumstances sustain a durable system that all but disables reform. Building on this explanation—what he called the "history-and-context" explanation—Cuban (2001, p.180) outlined the types of solutions that would be required if school ecologies were to change in ways supportive of technology integration:

- "fundamental changes in how elementary and secondary schools are organized, time is allocated, and teachers are prepared" (p. 180);
- development of "software and equipment specifically designed for teachers and students" (p. 181);
- improvement of product testing, reliability, and support (p. 181); and,
- "sustained attention to the links between the economic, social, housing, and political structures of [urban and low-income] neighborhood[s] and the quality of schooling." (p. 181)

Cuban, however, did not propose that all of these changes be made *on behalf of* technology integration but rather that these and other critical changes be made to restore democratic purposes to the enterprise of schooling. From Cuban's vantage, economic and corporate purposes, so often invoked in calls to increase the integration of instructional technology, diminish schools' capacity to offer meaningful instruction through whatever channels; attention to the inadequacy of technology integration simply obscures this larger, far more important issue, in his view.

The School and Community

> T Middle School is located in the small town of R in a county in the central portion of West Virginia. Though T is the second largest town in the county, it is nevertheless located 25 miles away from the closest juncture with a US highway, the only four-lane highway in the county. The county is slightly more rural than the state as a whole. Currently, its population is estimated to be about 26,446, or about 40 people per square mile, compared to the West Virginia average of 75 people per square mile (US Census Bureau, 2007a). The 2000 census found the population to be 26,562, and the current estimate reflects a slight downward trend (US Census Bureau, 2007b). Not surprisingly, much of this downward trend results from the exodus of younger people who are leaving to find work. The unemployment rate is over eight percent. The county's economy is similar to that of many counties in West Virginia, where extractive industries have, in large part, determined the nature of community economic development and devolution.

The county school system includes 11 elementary schools, two middle school/junior highs, and two high schools. Three of the elementary schools, a middle school, and a high school are located in T. In 2005-2006, the county school system served approximately 4,159 students. That same year, the average class size for the county was 18.7. The attendance rate was high, 97.2 percent, and the drop-out rate fairly low at 3.3 percent.

Although resources available to T Middle School are limited, the school has a library and computer lab that teachers use with their classes. Most of the classrooms also have a few (i.e., typically one to four) computers. Despite the adverse economic circumstances, the atmosphere of the school and its classrooms is pleasant, and students who attend the school seem to feel safe and comfortable. The school building is divided into sixth, seventh, and eighth grade sections each housed along one the three major hallways in the building.

In 2005-2006, the T Middle School students did fairly well on the state's competency test. Table 1 shows the percentages of middle-school students scoring at the proficient level or higher in Math and

Reading at each grade level (WVDE, 2006).

Table 1:

Percentages of T Middle School Students at the Proficient Level, School Year 2005-2006

Students/Scores	Math	Reading
6th graders	82	90
7th graders	82	85
8th graders	70	80

Comparisons between the school's composite proficiency rates and those of the county and the state suggested that overall the school's performance is about average. Even though some of these comparisons (i.e., between the school and the county overall and between the school and the state overall) may achieve statistical significance, practically speaking they do not seem consequential. It is important to note that average performance in a community facing serious economic challenges is often viewed as a positive outcome.[2]

Perhaps contributing to this outcome, the teachers at T Middle are generally well-qualified and experienced. Over 55% of them hold a master's degree plus 45 hours; more than 77% hold the master's degree.

The Program Evaluation

In this section, the paper presents the story of technology integration at T Middle School. Doing so, it sets the stage for an examination of the particularities of the story in consideration of the major findings of prior literature, namely that technical problems, organizational capacity limitations, ideological perspectives, and systemic features of school districts tend to impose serious constraints nationwide on schools' efforts to integrate technology fully and effectively into their programs of instruction.

The story comes from an evaluation of a one-year technology-integration project funded by the state education agency through a competitive grant program. The project aimed to improve the school's technological resources and core teachers' meaningful integration of instructional technology. The activities directed toward the accomplishment of these broad goals were:

- purchase of laptop computers, peripherals, and software intended to increase teachers' and students' access to and effective use of various technological applications;
- delivery of professional development to core teachers; and
- classroom support for technology integration including technical assistance, modeling of technology integration, and co-teaching.

To accomplish these activities, the district used grant monies to employ one of the school's teachers as a Technology Integration Specialist (TIS). For the duration of the project, her role and responsibilities changed completely from those associated with teaching to those associated with project leadership. In short, the TIS temporarily abandoned a role she understood well for one that was new to her, and she did so with little support from district or building leaders and with inadequate technical resources.

The Technology Integration Specialist (TIS) kept weekly activity reports covering the period September

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2 It is also important to acknowledge that, although the R students do as well, in general, as other West Virginia students, they may lag behind students in the US as a whole. Eighth graders in West Virginia scored lower than the national average on the National Assessment of Educational Progress (NAEP) writing assessment (National Center for Education Statistics [NCES], 2002). In 2007, they scored lower than the national average on the NAEP in mathematics and reading, but in 2005, they scored at the national average in science (NCES, 2005).

18, 2006 to June 8, 2007. These reports demonstrated the work she accomplished, which included:

- 164 sessions in which she provided coaching to fellow teachers,
- 60 lessons that she co-taught with one of the school's other teachers, and
- 242 other incidents, including efforts (with and without the help of the district's Technology Specialist) to solve significant problems with the school's network, computers, and peripherals.

Fine-grained analysis of the entries in the log revealed that the coaching provided by the TIS focused mostly on technical matters: helping teachers set up and use equipment (LCD projectors, whiteboards) or software (logging on to and using the network; searching the web; accessing and using email; using varied instructional software packages and so forth). Moreover, the software that the TIS made available on the school's network and then helped teachers learn to use was the sort that either offered practice of skills assessed on the state's accountability tests or provided assistance to teachers with routine tasks such as grading, scheduling, and submitting lesson plans.

Entries in the activity reports and also interviews with the TIS revealed that the installation of the "mobile lab" of laptop computers took place early in the school year, but that continuing network and connectivity problems posed serious challenges to the use of this resource up through the end of the year. In February 2007, the TIS offered this observation in the weekly report pertinent to teachers' developing willingness to use the mobile lab:

> This is the first time this teacher and her student teacher have conducted an Internet lesson without me in the building/classroom. I was thrilled that they were able to cope when faced with Internet problems and able to seek alternatives to help keep the lesson up and running. They are not comfortable with using the laptops with the 6th grade students. Therefore, this was a great success.

Of note in this entry is the fact that the TIS defined "success" primarily in terms of keeping the on-line lesson "up and running." Observations conducted in May 2007 included two class sessions in which the laptops were being used by students. Despite on-going difficulties, teachers did make some use of the new resource.

Teachers' knowledge. An important assumption underlying the project was that TMS teachers lacked knowledge about computer technology and its instructional uses. An explicit aim of the project, therefore, was to increase teachers' knowledge about technology and its various instructional applications. Drawing on the National Education Technology Standards, the evaluators and the TIS agreed to examine teachers' knowledge of: (a) technology operations and concepts, (b) the planning and design of learning experiences and environments using technology, (c) uses of technology to support curriculum and instruction, (d) uses of technology to support assessment, (e) issues of ethics and social justice that relate to instructional technology, and (f) uses of technology to increase professional productivity. The evaluation team constructed a self-report inventory to assess knowledge in these domains and asked teachers to complete the inventory close to the outset of the Project and then again at its conclusion. Information about the technical properties of the instrument is provided in Appendix A, and the instrument itself is included in Appendix B.

The evaluators used paired-sample t-tests to compare teachers' pre- and post-Project responses to items comprising the six scales of the inventory. As shown in Table 2, they found no statistically significant differences in responses on any of the six scales.

Table 2:

Paired Samples T-tests of Pre and Post-Project Self-Inventory

Scale	Mean: Post[a]	Mean: Pre[a]	N	Significance Level[b] (difference)	Effect Size[c]
Operations	3.70 (0.74)	3.30 (1.09)	8	.45 (NS)	+.29 (.40/1.40)
Planning	3.50 (0.59)	3.46 (1.18)	8	.94 (NS)	-.03 (-.04/1.33)
C & I	3.55 (1.25)	3.41 (0.69)	8	.79 (NS)	+.10 (.14/1.46)
Assessment	3.50 (1.21)	3.38 (0.62)	8	.80 (NS)	+.09 (.12/1.33)
Ethics	4.25 (0.20)	4.06 (1.39)	4	.81 (NS)	+.13 (19/1.42)
Productivity	3.83 (1.09)	3.56 (0.68)	8	.53 (NS)	+.23 (.27/1.16)

***Notes*.**

a. standard deviations in parentheses

b. $p < .05$ is the standard (i.e., at this level of significance the odds that the observed results would be due to chance would be 1 in 20, or 5%)

c. effect size is computed as the ratio of the difference in pre- to post-Project scores and the pooled standard deviation; the associated difference and pooled SD appear in parentheses

These results revealed that the observed pre- to post-Project differences were positive for five out of six scales, and that associated effect sizes ranged from negligible (-.03, +.04) to modest (+.23, +.29). Nevertheless, but perhaps because of the small sample size, these effects did not achieve statistical significance. Notably, however, the more substantial effect sizes were in operations and concepts and in productivity. In view of the TIS's allocation of time, these results seem to make sense. The weekly reports demonstrated that the TIS devoted substantial time to training in operations (e.g., setting up video projectors) and to helping teachers access productivity tools (e.g., GradeQuick and various email applications).

Although the evaluation team received completed pre-Project self inventories from 13 teachers, the TIS received only 9 completed post-Project inventories—and one of these was from a teacher who had not completed a pre-Project inventory. This lack of participation (perhaps unwillingness) of teachers to complete the inventories may have indicated a response bias in the data. Such bias could represent a systematic skewing (either negative or positive) of the scores or could be the result of a random process (e.g., a field trip or other scheduled event).

Moreover, as noted above, none of the apparent changes from pre- to post-assessment achieved statistical significance. Certainly this finding could be explained by small sample size or response bias, but on closer inspection it actually seems to result from curious dynamics in how individual teachers responded. It is instructive, therefore, to examine the pattern of individual difference scores for the teachers who did return both inventories. Table 3 reports results for these eight teachers for all six scales. Table 3 is arranged to emphasize the progression across teachers from negative to positive difference scores. With negative difference scores, teachers are, in effect, reporting *reduced* capacity to integrate technology at the end of the Project.

Table 3:
Array of Teachers' Individual Difference Scores

Teacher	Operations	Productivity	C & I	Assessment	Planning	Ethics[a]
A	-3.00	-2.00	-2.00	-2.00	-2.00	NA
B	-1.20	-1.33	-1.29	-0.67	-1.14	-0.75
C	-1.00	-0.17	-0.86	-1.00	-0.43	-0.75
D	-.020	+0.17	-0.86	-0.67	-0.29	0.00
E	-0.40	-0.83	-0.14	-0.33	+0.14	NA
F	+0.60	+0.33	+0.29	+0.33	+0.57	NA
G	+0.30	-0.17	+1.14	+1.00	+1.10	NA
H	+1.70	+1.83	+2.57	+2.33	+2.29	+2.25

Notes. a. Missing scores on one item for 4 participants eliminated some difference scores.

With teacher A, this reported reduction was substantial across the board—even dramatic. The equivalent effect sizes would be about -1.5 to -2.0, a huge negative effect for a long-term project. In fact, three teachers altogether (A, B, and C) reported reduced capacity across virtually all scales. Two teachers (D and E) reported negligible changes tending to an assertion of reduced capacity. And the three remaining teachers (F, G, and H) reported improved capacity at the end of the Project. Teacher H is the mirror image of teacher A: substantially—even dramatically—*increased* capacity.

Table 3 suggests that the negligible to modest positive effects that are reported in Table 2 actually masked very sharp differences among teachers. The overall somewhat positive results are misleading: One group of teachers reported much greater capacity and one reported much reduced capacity. Interview data also tended to support these findings.

Teachers' integration of technology. Another important aim of the Project was to increase teachers' meaningful integration of technology into lessons. The evaluators investigated possible increases by gathering and analyzing lesson plans and conducting and analyzing classroom observations. These data-gathering activities took place at the beginning and toward the end of the Project. In order to contextualize findings from the comparison of lesson plans and observations, the team also conducted interviews with teachers, the County Technology Coordinator, and the TMS principal. Interview data offered a variety of perspectives on the Project and its accomplishments.

Early in the year the evaluation team observed in the classrooms of 13 out of the 14 core-subject teachers at TMS. At the end of the year the team observed 10 of the 14 core-subject teachers. Each observation lasted for a complete 50-minute period. The evaluators took notes during the observation, using an adaptation of an instrument called the OPTIC.[3] The instrument differentiated between direct and constructivist approaches to instruction as well as providing a gauge of the types of technology integration that teachers were deploying. Evaluators also developed narrative accounts of the classrooms, which provided higher-inference data about the character of the pedagogy in use and the social and affective climate of the classrooms. An example of these narratives is provided in Appendix C.

Data analysis, which involved coding and categorizing data based on a priori codes relating to technology use and general pedagogical approach, suggested that direct instruction was used far more frequently than other approaches, both at the start of the year and at the end. One teacher (observed in May 2007) conducted an inquiry-based lesson with students forming small groups and using calculators. Students were observed to be highly engaged and interested in the planned activities. This was the only instruction of this sort observed—that is, one with discovery, group work, and technology used in combination.

3 The OPTIC was developed and copyrighted by the Northwest Regional Educational Laboratory, Portland, Oregon. This work was produced by the Northwest Educational Technology Consortium of the Northwest Regional Educational Laboratory under contract number R302A000016 from the U.S. Department of Education. The Northwest Regional Educational Laboratory gave the evaluators permission to use the instrument.

In general, at both the beginning and end of the year, teachers identified the objectives of lessons, provided brief explanations of new material, questioned students about new concepts, monitored completion of worksheets, checked class work and homework assignments, offered review lessons preparatory to tests, and administered tests.

Substantial technology use (including calculators and video viewing) was observed during the May 2007 visits, and this frequency of use was a notable change as compared to the observations conducted in September 2006. In May, in 6 of the 11 periods of observation, evaluators observed *students* using computers. In September, not a single student was observed using computers. As might be expected from the dominant pedagogy at TMS, the most frequent use of computer technology was for direct instruction, specifically drill and practice. In several classes, however, this drill and practice also required students to access a particular website for specific information, which was used to complete a worksheet or similar assignment.

Overall, classroom observations provided evidence that the Project improved the frequency of computer use at TMS. But they also showed that teachers retrofitted technology applications into existing methods of instruction rather than altering instructional methods to take advantage of the opportunities for inquiry, creative production, and higher-order thinking that technology had the potential to offer.

Evidence from the content analysis of lesson plans was consistent with evidence from the observations. This analysis involved the categorization of planned instructional activities using the same categories as were used for analyzing observations (i.e., categories relating to technology use and pedagogical method). Overall, the analysis showed that, both at the start of the Project and at its conclusion, most teachers derived activities from textbooks or workbooks. Many plans, in classic form, keyed the lesson to pages in particular textbooks or workbooks. Nearly all of the teachers, however, developed some plans that included other forms of pedagogy in addition to the traditional sequence of review, lecture or demonstration of new material, practice, and checking of answers. Other instructional methods seen in the lesson plans included partnered reading, group activities, problem-solving activities, writing assignments, games or puzzles, and development of interpretive products (e.g., a themed collage related to the topic of instruction).

At the beginning of the year, seven of the plans of the 13 teachers referenced the use of some technology (video presentation, use of computer lab, or training of students in familiar PC applications like Word and PowerPoint). At the end of the year, 11 of 14 teachers' lesson plans indicated an intended use of technology (one teacher's plans called only for the showing of video material). Among the 10 whose plans did call for *computer* technology, four noted hyperlinks—indicating use of the Internet for instructional purposes—and three of these suggested an instructional use of the website with students rather than simply referencing the site as a resource for the teacher. Three sets of plans indicated use of the "computer lab." It may be worth noting that the teacher whose self-inventory difference scores were the most extremely negative *did* plan for students to use the computer lab—but in this case the plan specified that a *different teacher* would accompany the students to the lab. Evidently this teacher was finding a way to meet the expectation that his or her students have computer-based instruction without personally providing it!

Insights into the dynamics influencing teachers' receptivity to the Project came from interview data. Although interviews with teachers were conducted by phone during the school day and this circumstance perhaps constrained the length of conversations and made rapport more difficult to establish than would have been the case with face-to-face interviews, teachers nevertheless offered few positive comments about the Project. Only one expressed enthusiasm for the tools and opportunities that the project made available, and even this teacher reported frustrations with network connectivity and other impediments to full use of the resources purchased or assembled by the TIS. Most teachers, by contrast, were more negative than this. One teacher stated that computers and other equipment in the classroom still remained in their boxes. Another teacher, in a statement perhaps representing the middle ground between the extremes, approved the use of technology for instruction but observed that the way classes were currently structured created difficulties.

The County Technology Coordinator believed that the TIS had done a good job training teachers and providing technical assistance and that TMS teachers were using computer technology more frequently. He believed, further, that the drill and practice software that had been purchased was being used with increased frequency and that students were doing "a little more research" using computers. The Technology

Coordinator, however, held the view that in general teachers were not taking advantage of digital technology's potential for varied instructional formats and that sufficient time was not devoted to "higher level thinking instruction." Lack of knowledge of how to accomplish such instruction was the difficulty, according to this staff member.

The TMS principal also thought the Project had resulted in more frequent use of computer technology on average, but that only a few teachers used it extensively. The principal noted that he had reviewed the results of the self-inventory and was not surprised to learn that some teachers found themselves less comfortable with computers at the end as compared to the beginning of the Project. Early in the year, reported the principal, teachers remained "distant" from the Project. By May, he said, they were "complain[ing] and ask[ing] 'How come it's not working." In this light, he noted, the TIS "got complaints both ways—when the teachers were not very interested in using the computers in the ways [the TIS] recommended *and* when they were" [the quoted passages come from the evaluation team's field notes].

When asked about the kind of changes he desired, the principal replied: (a) more long-term projects and (b) use of computer labs for longer periods of time. The major technology barrier, according to the principal, was the unreliability of Internet connectivity. The principal also noted that in the next school year the TIS would "continue" to serve as the TMS technology coordinator even though she would also be returning to the classroom as a reading teacher.

INTERPRETATION: HOW WELL DO THE EXPLANATIONS FIT THE DATA

As discussed above, recent studies (e.g., Zhao, 2007) still offer technical explanations for limited technology integration despite the fact that computer equipment is available in most schools (e.g., Becker, 2000). The TMS case sheds light on this apparent contradiction: computers and related technologies were plentiful *in the school*, but they were inaccessible much of the time. This circumstance contributed to teachers' frustration. When a teacher designed a lesson using technology, he or she could not be sure that the technology would be functional. Or it might function for part of the lesson and then require the teacher or the TIS (if she was available) to intervene in order to keep it functional. This circumstance made it necessary for teachers to attend to the content of their lessons, the students, *and* the technology—more than many of them felt prepared to handle all at once. At TMS other issues—similar to those reported in recent studies—were at play. Time was certainly perceived to be a limited resource. The TIS reported that insufficient time—for her work and for that of the teachers—was a major impediment to the success of the Project, and the evaluators frequently heard teachers complain that the Project was taking time away from the important work of preparing students for State achievement tests. Teachers told us that they were unwilling to sacrifice the time needed for test preparation in order to learn how to integrate technology. Their comments suggested that they were extremely conscious of time limitations—construing the effort to learn how to integrate technology as an intrusion into the time they needed for essential instructional tasks.

Nevertheless, teachers' actions did not reveal particular adherence to "time-on-task." Members of the evaluation team observed considerable wastage of instructional time for pep rallies, field days, sporting events, videos, and clubs. Teachers also gave students routine deskwork, some of which did not seem to have much academic relevance, as a way to free up time to talk with one another in the halls, read and write email, and perform work associated with their extracurricular assignments (e.g., coaching). "Lack of time" appeared to the evaluators to be a demurral rather than a roadblock. The complaint therefore seemed to say more about teachers' priorities than it did about the objective conditions of their work. "Lack of time" really meant something like "lack of time for activities that we see as unimportant."

The research literature also identified teachers' resistance as an impediment to technology integration, focusing either on the general reluctance to change or on more specific beliefs about teaching and learning that cannot readily accommodate the infusion of technology. In the year in which the Project was instituted, TMS teachers had been asked to change a number of their routines. The school had changed from a junior high school (grades 7-9) structure to a middle school (grades 6-8) structure, with accompanying changes in teachers' assignments, daily schedules, and rooms within the building. Teachers reported that they were angry about the changes and claimed to be experiencing high levels of stress. The technology integration project, then, functioned as an additional stressor in an already difficult year.

In addition, teachers did not believe that the types of instruction that technology would make possible were better suited to the task of preparing students for the State tests than the traditional practices they were already using. Their teaching tended to focus on the presentation of content and the assignment of practice activities, and computers did not seem to offer them a way to perform such teaching much more efficiently or effectively.

Nevertheless, the teachers were not totally resistant, and their use of computers and related technologies did increase over the course of the year. Like teachers studied in much of the recent research literature, the TMS teachers fit technology to their existing instructional methods rather than seeing technology as a motive for reshaping those methods. Thus the one inquiry lesson, mentioned above, that made use of calculators was an anomaly not only because it incorporated technology into an inquiry lesson but also because it made use of the inquiry method in the first place.

The conditions observed at TMS—technical difficulties, insufficient time, limited support, and teacher resistance—mirrored the observations that led Cuban (2001) to frame the question of technology integration in systemic and contextual terms. Surely a system bent on effective technology integration or on using technology as leverage for more pervasive change in instructional practice would behave differently. Acknowledging teachers' likely resistance, planners in such a system would do everything in their power to assure that the technology worked, that teachers had time to retool, and that ample support came from multiple sources. Apparently something other than effective planning has been going on in the educational system of which T Middle School is a part.

Two planning scenarios seem plausible, given the findings: (a) there has been no planning or (b) planning has taken place without due consideration of issues of implementation. If one is willing to see the development of a state-wide grant program as a form of planning, then the latter scenario seems to fit the facts. State department administrators did, after all, envision the program and the projects that might result from it. They did put the competitive grant application process in place and follow through with the steps involved in soliciting and choosing among proposals.

Nonetheless, remote from practice, their planning might represent little more than wishful thinking. State department administrators and perhaps county administrators as well offer technology integration as one of many solutions to the problem of raising test scores. That the means (technology integration) is not clearly productive of the ends (higher test scores) seems less important than the willingness to hold out hope. That the conditions for effective implementation are not likely to be favorable hardly seems to matter. What systemic need might cause otherwise reasonable planners to bet on this unlikely horse?

With Cuban (2001) and others (e.g., Molnar, 2005), the researchers think corporate marketing might offer a reasonable explanation. For motives quite apart from the desire to raise students' test scores, corporate executives see selling technology to schools as an attractive proposition. Tyre (2002), for example, reported that in each of the three years preceding 2002, sales of technology to schools in the United States totaled 5.6 billion dollars. Moreover, corporate executives probably bank on the fact that children who work with computers at school are likely to want computers at home. The technology industry, as Cuban (2001) noted, has a vested interest in promulgating the belief that instructional technology will help children learn—increasing their achievement, improving their critical and creative thinking, and preparing them for a changing work place. Whether or not any of this is the case, however, hardly matters, so long as educators accept these claims.

This explanation, of course, begs the question of means-ends planning for technology integration. On the terms of the marketing argument, educational planners are simply responding to manipulation when they advocate and develop programs to support technology integration. Their energy would be better spent, as Whitehurst (2003) argued, on systemic efforts to promulgate instructional methods that actually work, or, as Cuban (2001) advocated, on reclaiming better purposes for our system of common schools.

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APPENDIX A

Technical Properties of the Self-Report Inventory

The instrument included six scales, all of which exhibited high reliability estimates both using data from a pilot test with a convenience sample of 20 teachers and using data from the first administration of the instrument with the 14 teachers at TMS. Table 4 shows Alpha reliabilities for each of the scales with data from each of these two administrations of the instrument. These estimates suggest that all of the scales have high levels of internal consistency.

Table 4:
Reliability Estimates (based on the pre-assessment)

Scale	Alpha Reliabilities (Pilot)	Alpha Reliabilities (R)
Operations & Concepts	.91	.96
Planning & Designing Learning Experiences & Environments	.95	.98
Curriculum & Instruction	.95	.99
Assessment	.92	.98
Ethics and Social Justice	.81	.91
Professional Productivity	.86	.97

APPENDIX B
Teachers' Use of Technology
Self-report Inventory

INSTRUCTIONS: This inventory will be used as a pre- and post-assessment for the Enhancing Education through Technology Project at T Middle School. In order to track any changes in your perspectives that result from this project, we do need you to include information about yourself. Please provide this information and then circle the best answer to the 40 items included on the inventory.

Your Name ___________________________ Date ____________________

Your Subject Area(s) ____

To what extent would you feel comfortable …	Great Extent	→			Not at All
Setting up a new computer?	5	4	3	2	1
Adding new software to your computer?	5	4	3	2	1
Using appropriate terminology to talk about computers and computer networks?	5	4	3	2	1
Using handheld computers (e.g., personal digital assistants, IPODs, Blackberry devices)?	5	4	3	2	1
Using all of the features of a word processing program (e.g., the table feature, mail merge feature, and add an object feature)?	5	4	3	2	1
Using a spreadsheet program (e.g., Excel)?	5	4	3	2	1
Using email?	5	4	3	2	1
Using web browsers (e.g., Internet Explorer, Netscape)?	5	4	3	2	1
Using web search engines (e.g., Google, AltaVista) to find information on the internet?	5	4	3	2	1
To what extent do you spend time learning about current and emerging technologies?	5	4	3	2	1
To what extent are you able to select developmentally appropriate technology to augment lessons?	5	4	3	2	1
To what extent are you able to use appropriate technologies to differentiate instruction for diverse learners?	5	4	3	2	1

When you design learning environments and experiences, to what extent do you rely on relevant research findings about the influence of technologies on learning?	5	4	3	2	1
To what extent are you able to identify technological resources that have the potential to help your students learn?	5	4	3	2	1
To what extent are you able to evaluate technological resources to determine their alignment with learning outcomes and students' needs?	5	4	3	2	1
To what extent are you able to make effective long- and short-range plans for using technology to enhance students' learning?	5	4	3	2	1
To what extent are you able to design methods to keep track of the learning students acquire in a technology-rich environment?	5	4	3	2	1
	Great Extent		→		Not at All
To what extent are you able to align technology-enhanced lessons with state content standards?	5	4	3	2	1
To what extent are you able to align technology-enhanced lessons with student technology standards?	5	4	3	2	1
To what extent do you use technology to enable students to construct knowledge?	5	4	3	2	1
To what extent do you match technological applications to students' different interests and needs?	5	4	3	2	1
To what extent do you use technology as a way to develop higher-order thinking?	5	4	3	2	1
To what extent do you use technology as a way to encourage students to be creative?	5	4	3	2	1
To what extent are you able to keep track of the learning students acquire in a technology-rich environment?	5	4	3	2	1
To what extent do you evaluate students' progress in learning to use technology?	5	4	3	2	1
To what extent do you teach appropriate "netiquette?"	5	4	3	2	1
To what extent do you regulate students' access to internet sites?					
To what extent do you teach students about fair use and copyright?	5	4	3	2	1
To what extent do you make technology accessible to all students in your classroom regardless of their characteristics and backgrounds?	5	4	3	2	1
To what extent do you use …					
Technology for assessing students' learning?	5	4	3	2	1
A variety of technological applications as part of the assessment process?	5	4	3	2	1

Technology to gather, analyze, and interpret data that helps you make wise decisions about curriculum and instruction?	5	4	3	2	1
Technology to communicate information about students' performance?	5	4	3	2	1
Multiple methods to assess students' learning of technological applications?	5	4	3	2	1
Technological applications as a way to access professional development opportunities?	5	4	3	2	1
Technology to increase the efficiency of your work?	5	4	3	2	1
Technology to communicate with other educators in your school?	5	4	3	2	1
Technology to communicate with educators other than those in your school?	5	4	3	2	1
Technology to communicate with parents?	5	4	3	2	1
Technology to communicate with community members other than those who are parents of students in your classes?	5	4	3	2	1

APPENDIX C

Observation Vignette: 7th Grade Science Class

This classroom was bright and neat with more computers than most of the classrooms. There were more than a dozen stationary computers and one that appeared to be primarily for teacher use—I think all the classrooms had a computer that was primarily for the teacher's use, though the number of other computers varied.

As the students were coming in, and while she was greeting me, Ms. A. apologized for having a review lesson while I was there. She said that she usually does much more interesting lessons than I would see that day. For this class, she combined review of the textbook with review on the laptop computers. The computerized review was first and constituted most of the class time.

She told students to get the laptops, and they got them quickly and with no commotion, bringing them back to their tables from storage in the back of the room. As with Ms. S.'s class, this seemed to be a familiar routine. Students spent about three-fourths of the class time at the computers. They shared the laptops, with two or three students to each laptop. Students seemed engaged during most of the class, but they were not all on task. This was due in part to four interruptions related to (1) failure to connect to the Internet and (2) loss of Internet connections that had been established. Students did not seem very enthusiastic about the content, though they seemed to care what this young and energetic teacher wanted them to do. The review questions did not seem to engage them very much, but they volunteered answers and complied with her requests to try again if they answered incorrectly. Still, as I looked around the room, I saw a student here and there looking around the room or talking with a neighbor (in a conversation that may have been about the lesson, but seemed to focus on something other than the computer material). They appeared to be even less interested in the questions from their textbooks, but Ms. A.'s enthusiasm for the material helped them to focus. The material was on the scientific process, and thus was perhaps more abstract than they liked.

After the students left, Mrs. A. asked me to come back when she will be doing a creative class project on the computer. She again apologized for what she said was not a typical lesson for her classes. She added that she thinks the technology, especially the simulations, makes a big difference in her students' understanding and in their motivation. She mentioned teaching electricity through the use of computerized simulation specifically, saying that this method helped students to grasp the concepts relating to electrical circuits much better than they could have without the computer simulation. I told her that I would observe her class again when I came back to T. Middle School for another day of observation, and I set a date for that day based on her identification of the best day to come to see her class in the middle of their project. (Unfortunately, on the day that I came back to observe others and to observe her classroom a second time, she was absent because of medical tests. I hated to miss her because this teacher seems genuinely interested in improving instruction through the use of technology.)