Educational Administration Quarterly
Vol. 41, No. 1 (February 2005) 49-82

School Technology Leadership: An Empirical Investigation of Prevalence and Effect

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The general question addressed is what technology leadership attributes make what kind of difference in the success of various technology-related programs. First, this article has integrated the prescriptive literature on technology leadership with the National Educational Technology Standards for Administrators (NETS-A) and then has operationalized technology leadership in terms of NETS-A. Data from the 1998 Teaching, Learning, and Computing nationwide survey of more than 800 schools were used to examine technology leadership characteristics and their effect on indicators of technology outcomes. The findings confirm that although technology infrastructure is important, technology leadership is even more necessary for effective utilization of technology in schooling.

Keywords: *technology leadership; technology outcomes; principal; technology integration; organizational learning*

Leadership, especially from the principal, is generally acknowledged as an important influence on a school's effectiveness; this belief is supported by empirical evidence (Hallinger & Heck, 1996, 1998; Leithwood & Riehl, 2003). Studies of school improvement also point to the importance of principals' leadership in such efforts (Fullan, 2001; Fullan & Stiegelbauer, 1991; Louis, 1994).

According to quality education data (QED) surveys of U.S. district expenditures, more than $6 billion dollars was spent (not including E-rate funds) in 2002-2003 on educational technology in schools (http://www.qweddata.com/

Authors' Note: Funding for this research was provided under the National Science Foundation (NSF) grant REC-9600614; however, the views are those of the authors and should not be attributed to the NSF. The authors want to acknowledge and thank Amy Ronnkvist, Brian Dill, and Lara Cleveland for their contributions in analyzing the data presented in this report. In addition, Henry J. Becker provided considerable advice and help along the way.

DOI: 10.1177/0013161X04269517

keynumbers.htm). This heavy investment in technology suggests that school leaders feel that it shows some promise for contributing to schools' effectiveness and improvement efforts. But beyond being accountable for these expenditures, what actions should principals and other school leaders take to work toward its successful implementation?

We treat technology leadership as a school characteristic and relate it to the National Educational Technology Standards for Administrators (International Society for Technology in Education [ISTE], 2002), widely known by the acronym NETS-A. We use survey results from a national probability sample to report on the prevalence in schools of different technology leadership characteristics. Also using the data, we answer the following questions: Are leadership decisions or characteristics associated with schoolwide and classroom-based technology outcomes? And if so, what is the role of technology leadership with (or as opposed to) technology infrastructure and other school characteristics?

REVIEW OF THE LITERATURE

The NETS-A (ISTE, 2002) is the most recent set of suggestions in the literature about what school leaders, especially principals, should know and be able to do with educational technology. The NETS-A standards were developed through input from experts and partner organizations, review and comment from the field, and oversight by an advisory board. They were initially called the Technology Standards for School Administrators (TSSA) and were released in 2001. In 2002, they were integrated into the ISTE NETS standards and widely promoted. The NETS-A standards are grouped into six sections as follows:

1. Leadership and Vision
2. Learning and Teaching
3. Productivity and Professional Practice
4. Support, Management, and Operations
5. Assessment and Evaluation
6. Social, Legal, and Ethical Issues

Four to six specific standards are grouped under each section. To aid in the application of these standards, there are a set of profiles, and these are grouped separately for superintendents, principals, and district technology program directors. The ISTE published a guidebook that is intended to further aid administrators in implementing the standards (Brooks-Young, 2002). As of June 2003, ISTE's Web site reported that 29 states had "adopted, adapted, or aligned with" the NETS-A standards, which is an indication of their widespread effect on practitioners.

The majority of the other literature providing competency recommendations represents the personal opinions of the author(s) or, in some cases, syntheses of other authors. An exception is the work by Thomas and Knezek (1991), who surveyed experts in education and instructional technology to "explore the role technology is expected to play in restructured schools and to indicate the level of competence in technology-related skills needed by educational leaders" (p. 265). Next, we review the suggestions made by the NETS-A standards as well as by many other authors and agencies over the last 10 to 15 years.

All of the literature on leadership and technology acknowledges either explicitly or implicitly that school leaders should provide administrative oversight for educational technology. The NETS-A standards specify this in Section 4 on "Support, Management, and Operations" in terms of ensuring that the systems in place support technology use in the school and that technology also supports the management of such systems, including coordinating and allocating decisions and spending for equipment, networks, software, staff, and support services of all types (ISTE, 2002). Most of the literature tends to be narrow in the recommended foci for administrators. Several authors identified providing access to equipment for staff as a major responsibility of the principal (Bailey, 1997; Dempsey, 1999; Hall, 1999); still others concurred and then went on to explicitly state that principals must seek funding to provide this equipment and establish this and an ongoing budget for technology (Costello, 1997; Kearsley & Lynch, 1992, Thomas & Knezek, 1991; Thorman & Anderson, 1991).

The literature providing recommendations for technology leaders' skill sets usually asserts that principals should learn how to operate technology and use it whenever possible for carrying out their own duties, especially to communicate with others (cf. Dempsey, 1999; Hall, 1999; Jewell, 1998-1999; Thomas & Knezek, 1991; Thorman & Anderson, 1991). Several authors also state that it is a responsibility of the principal not only to learn about technology him or herself but also to ensure that other staff in the building receive learning opportunities by providing either release time (Kearsley & Lynch, 1992) or professional development opportunities (Bailey, 1997; Dempsey, 1999; Hall, 1999; Thorman & Anderson, 1991). The NETS-A standards in Section 3 on "Productivity and Professional Practice" echo these suggestions and promote technology leaders' use of technology to increase productivity and to communicate with others as an important opportunity to model for others how to effectively use technology (ISTE, 2002).

One area of competence often suggested is the need for school technology leaders to have a vision for the role of educational technology in schools. The NETS-A standards in Section 1 on “Leadership and Vision” outline how technology leaders need to develop a schoolwide shared vision for technology and ensure that the resources, coordination, and climate are in place to realize it (ISTE, 2002). Other authors also mention the importance of widespread involvement by stakeholders during the development of the technology vision and plan to foster commitment and ongoing support among all stakeholders (Costello, 1997; Jewell, 1998-1999; Thomas & Knezek, 1991; Thorman & Anderson, 1991).

In addition to the administrative aspects of the K-12 school, authors such as Bailey (1997), Bozeman and Spuck (1991), and Thomas and Knezek (1991) argue that technology leaders are expected to understand how educational technology can support what happens in classrooms, and they are to work to see technology support the needs of students’ learning and teachers’ instruction. NETS-A makes this explicit in Section 2 on “Learning and Teaching,” emphasizing the creation of learning environments that support collaboration, higher level thinking, and other learner-centered methods.

Included in the NETS-A standards but infrequently mentioned elsewhere in the literature is the need for technology leaders to assess and evaluate the role of academic and administrative uses of technology and make decisions from those data. Section 5 of NETS-A on “Assessment and Evaluation” covers various types of monitoring functions but emphasizes technology-based techniques for evaluation and accountability. Where other authors mentioned data collection for technology decision making, it was to recommend that technology leaders work from a needs assessment when planning staff development (Dempsey, 1999) or to support a more general goal of seeing what is “working” (Thorman & Anderson, 1991).

Ethical, social, and legal issues associated with educational technology are addressed in Section 6 of the NETS-A standards; these issues are often neglected in the literature. The NETS-A standards state that educational leaders should work to ensure equity of access, the safety of users, and compliance with social, legal, and ethical practices related to technology use. Kearsley and Lynch (1992) also emphasized that principals should work to ensure equitable access and opportunity to technology resources. Bailey (1997) discussed the changes in society brought on by technology and said that school leaders should ensure the teaching of students about new ethical dilemmas that might arise because of technology use and its capabilities. Pereus (2001) described legal, ethical, and security issues as risks that school leaders’ should consider in the management of technology.

Some authors emphasize leader responsibility in recognizing the meaning or use of computers in relation to the school or community cultures. Bowers (1992) writes that computers are not culturally neutral, that the language used to describe computers and encountered within software programs directs students' thoughts, that computers privilege data-based thinking, and that the use of computers influences classroom social interactions. Bowers argues that school leaders must be conscious of these facts to responsibly lead school technology efforts. From his review of official policy documents and interviews with leaders in the United States and three other countries, Slenning (2000) identified that a growing expectation of future school managers is that they are able to use information and communication technologies for sociocultural communication—that is, to bridge the diversity of cultural backgrounds and opinions of a school's stakeholders and communicate often so as to develop shared goals and understandings. Kearsley and Lynch (1992) defined leadership as inherently linked to local culture insofar as successful leaders were determined "by their ability to articulate and influence cultural norms and values" (p. 51). They asserted that it was the school leaders' responsibility to identify what technology use was consistent with the school culture and establish the infrastructure necessary to use it in those ways. In Section 6, NETS-A explicitly advocates that administrators ensure equity of access to technology. However, one area where NETS-A is weak is in the role of leadership in matters of culture and community. They tend to ignore the fact that the culture and communities within a school are needed to maximize effective technology implementation (Dexter, Seashore, & Anderson, 2002).

The foregoing literature is analytic but mostly prescriptive. A few studies have collected data on administrator technology skills, their conceptions of technology leadership, and their leadership decisions or characteristics that are associated with schoolwide or classroom-based technology outcomes. Testerman, Flowers, and Algozzine (2002) developed an inventory to capture basic technology competencies by asking for self-assessments of skills in nine domains, ranging from basic computer operation skills to word processing, media communications, networking, and setup, maintenance, and troubleshooting. Working from a small convenience sample—82 educational leadership personnel enrolled in educational leadership graduate studies—they found that in all domains, principals' mean scores were lower than graduate students, assistant principals, and central-office personnel, with significant differences between groups in the technology skill domains of basic computer operation skills, word processing, databases, and spreadsheets.

Ertmer and colleagues (2002) surveyed a group of eight administrators in an online graduate class about technology as to how they defined technology leadership. They report that respondents indicated, in general, it was "the methods they and others use to encourage and support teachers' technology use" (p. 8), noting that technology leadership was a role they shared with others in their building and that visioning, modeling, and coaching were all strategies they should use in technology leadership.

Two studies researched teacher perceptions of the effect of their principal's leadership style on their technology use. Hughes and Zachariah (2001) surveyed 40 randomly selected teachers in one state. They asked the teachers to assess their principal's leadership style and to share their attitudes regarding the implementation support present in their school for the use of technology as an instructional tool. Mean scores for these two areas were plotted on a scattergram, which showed a positive correlation between teachers' perceptions of principals who have a facilitative leadership style and the implementation support available for technology-supported instruction. Dooley (1998) examined the effect of the principal's leadership style on whether or not an innovation, such as technology use, diffused throughout a school. In her case studies of three schools, she concluded that where technology had diffused the farthest throughout the school, the principal's change-facilitation style was that of an "initiator." Dooley drew on Hall and Hord's (1987) description that initiators hold a clear vision for the school with long-range goals, are inclusive in their decision making, and set high expectations that are communicated to stakeholders.

Perhaps the strongest study examining what principals do for technology leadership and its effect on technology use is that of Baylor and Ritchie (2002), although they collected data from only 12 schools. They investigated the relative effect of the school's technology planning, leadership, professional development, curriculum alignment, technology use, and openness to change on teacher technology skill, morale, and perceptions of technology's effect on learning. They found that these outcomes were mainly predicted by the characteristics at the teacher rather than the school level. An exception was that teacher morale was also predicted by professional development, and technology's effect on content acquisition was also predicted by the strength of leadership.

Summary of Literature Review

Over the last 10 to 15 years, the scope of suggestions for what school leaders should know and be able to do with technology has broadened, with the recent NETS-A standards encompassing nearly all of the previous suggestions made by the other writers reviewed here. In the pamphlet ISTE distributes promoting these standards (ISTE, 2002), it states that the standards are indicators of effective leadership for technology. However, this is not an assertion based on data, which is understandable given the limited number of studies that test the technology-related activities of school leaders against the attainment of technology outcomes. Thus, the NETS-A standards may represent the common wisdom about what technology leadership means to the practitioners in the field. The research findings suggest that while principals may lag behind other administrators in operational skills, they tend to recognize their need to be involved and involve others with technology use in classrooms. Their efforts to facilitate technology implementation appear to make a difference but not necessarily across all situations. What is not yet known is the role and relative importance of leadership compared to technology infrastructure and other characteristics of schools. In this study, we address this question empirically.

MODELING TECHNOLOGY LEADERSHIP DECISIONS

Each of the different actions or decisions identified as characteristic of technology leadership may potentially have a measurable outcome in terms of the degree of technology integration in the school, or whatever the school's goals may be. On the basis of the literature and past research, we would expect technology leadership to have considerable effect on the quality of the technology-supported learning environment. In addition, technology leadership is likely to be influenced greatly by background factors, such as the type of school, and by infrastructural factors, such as amount spent on technology. Figure 1 depicts this model, showing that infrastructure is likely to be reciprocal with technology leadership—that is, shaped by the technology leadership as well as shaping it. The model depicted in the flow diagram was designed to show the relationship of the main indicators used (which are bulleted) to their constructs, but the main purpose is to portray the hypothesized role of infrastructure and similar background factors in relation to the process by which leadership affects technology outcomes. The literature on leadership and technology tends to ignore infrastructure except to acknowledge that they are important as resources. On the other hand, the general literature on technology in education, which is not reviewed here, tends to ignore leadership and focus on resources. Our model proposes a leadership mediation function, specifically that resources (infrastructure) have little effect on technology outcomes without the intervening aspect of technology leadership. Thus to some extent, the model integrates the leadership and nonleadership approaches to technology in education.

Figure 1. A Model of Technology Leadership

The model we will test assumes that infrastructural factors like computer density and Internet bandwidth will be correlated with technology leadership because of a mutually reinforcing relationship. In Figure 1, the boxes for both technology leadership and outcomes contain lists of the indicators from the survey that can be used to apply the model. The indicators are defined in the section called Indicators and are detailed in the appendix.

With data from the national 1998 survey, Teaching, Learning, and Computing (TLC) (Becker & Anderson, 1998),[1] it is possible to evaluate the model and explore a number of questions related to the technology leadership indicator and its role in school technology outcomes. Although these data were collected a number of years ago, there has been no subsequent national survey in which technology and leadership dimensions were both included, nor do we know of any such surveys planned either nationally or internationally. In the years since the TLC study, annual technology expenditures have risen steadily, and many more classrooms have been wired for Internet access, but the role of technology in education has not qualitatively changed, and the leadership issues remain essentially the same. Thus, the 1998 TLC data provide a meaningful basis for exploring the questions raised here.

SAMPLE

In the spring of 1998 the Teaching, Learning, and Computing (TLC) staff surveyed principals, technology coordinators and teachers from a national probability sample of schools and from two targeted or purposive samples of schools: (1) high-end technology-using schools and (2) schools that were participating (or where teachers were participating) in one of 52 identified national and regional educational reform programs.

The national probability sample of schools consisted of 898 public, private, and parochial schools selected from a national database of 109,000 schools supplied by the firm of Quality Education Data (QED) of Denver, CO, a marketing information division of Scholastic Corporation. Schools were sampled and weighted according to their size (estimated number of full-time teachers of grade 4 and above) and according to how much computer technology they had (using an index incorporating 10 different measures of per-capita technology presence). Initial contact letters and roster forms were sent to 898 schools, and after repeated callbacks a total of 655 schools (73%) agreed to participate. From these schools, 488 (75%) of the principals returned completed questionnaires and 467 (71%) of the technology coordinators completed their questionnaires.

The two purposive samples were compiled from a multitude of sources. The "educational reform" purposive sample (470 schools) came from rosters compiled from 52 different educational reform efforts. The high-end technology purposive sample (258 schools) was compiled from three types of sources: publicly available information from school Web sites and books, from one high-end technology education reform program, and from the QED database (the schools with the highest technology presence index).

Across the combined probability and purposive samples, there was a 75% response rate at the school roster stage and close to a 70% response rate at the individual respondent level. Thus, the entire survey database includes information from 1,150 schools, including completed questionnaires from approximately 4,100 teachers, 800 technology coordinators, and 867 principals.

The analysis in this report was based primarily on information from the principals' survey, although some data items from the technology coordinators' survey were merged into the principal survey data when available. The leadership analysis in this report was done on two different bases. The first part of the analysis was done on the probability sample only, which consisted of 488 principal records. Figure 2 and Table 1 give results on this base (minus about 14 principals who selectively failed to respond to the items reported). The second part of the analysis was based on the 488 principal records from the probability file plus an additional 378 from the purposive sample, which constitutes a combined total of 866 principal records. The remaining figures and tables utilized this larger sample base. The first part of the analysis was limited to the probability sample because its goal was to describe or generalize to the entire population of American schools. The second part of the analysis utilized the combined sample because its goal was to show the interrelationship among variables, which is often the same in large purposive samples as it is in representative probability samples (de Vaus, 1996). However, if the variances of key variables are very uneven across types of samples or if there are interaction effects associated with the criteria used in purposive sampling, then comparability is not likely. We examined the correlations and regressions in both the probability-only sample and the combined sample, and the results were very similar, so we chose to use the combined sample.

INDICATORS

This section describes the main indicators used in the analysis, including those of technology leadership and technology outcomes. Additional details in the construction of variables are given in the appendix.

Technology Leadership

In developing a summary measure called *technology leadership*, we identified a large number of technology-related activities and attributes that the principal and technology coordinator reported about their school in the TLC survey. Eight dichotomous indicators were selected to best represent the construct of school technology leadership, and each is described below. Several potential indicators of technology leadership were dropped because of their relatively low correlations with other indicators of technology leadership. Among the indicators dropped were the type of school technology goals, receipt of technology donations, and the presence of a formal technology coordinator position.[2]

The technology Leadership composite index selected was the sum of the following eight organizational policies or actions present at the school. Each is defined and briefly discussed in relation to the six categories of NETS-A standards, which, as noted earlier, are congruent with the research literature reviewed.

Technology committee is an indicator that refers to whether or not a school had a computer or technology committee. According to NETS-A Section 1 on “Leadership And Vision,” technology leaders need to develop a schoolwide shared vision for technology and ensure that the resources, coordination, and climate are in place to realize it. Having a technology committee generally is an organizational mechanism for developing consensus on technology visions and for distributing the leadership function across different administrative and instructional staff.

Principal days indicates that the principal spent 5 or more days on “technology planning, maintenance or administration” (quotation is from a phrase in a question included in the study's Principal's Survey Booklet; see Becker & Anderson, 1998). during the school year. This indicator cross-cuts all six sections of the standards because it does not specify any particular leadership function or purpose on which the principal's time had been spent.

Principal e-mail means that the principal reported regular use of e-mail to communicate with at least two of the following four groups: teachers, administrative staff, students, and parents. This is typical of the emphasis of the NETS-A section on "Productivity and Professional Practice." The standards in that section stress that technology leaders should model using technology to increase productivity and to communicate with the school's stakeholders.

Staff development policy represents that the school had a policy of "periodic staff development regarding technology," (quotation is from a phrase in a question included in the study's Principal's Survey Booklet; see Becker & Anderson, 1998) according to the principal. Such an indicator relates directly to Section 2 of NETS-A on "Learning and Teaching." According to the standards, technology leaders must plan for teachers learning to use technology to support innovation and teaching for critical, creative, and complex thought, in addition to supporting students' learning needs with technology.

School technology budget represents whether or not a school had a budget for technology costs over which the principal or someone else in the school had sole discretionary authority. The NETS-A section on "Support, Management, and Operations" specifies that educational leaders must provide direction for using technology for management and operations. It also specifies that leadership must coordinate technology decision making regarding spending for equipment, networks, software, staff, and support services of all types.

District support means that in the principal's judgment, his or her district (or diocese) supported technology costs relatively more than did other districts. None of the NETS-A standards relate directly to this dimension, but under certain conditions, district support can be essential to a school technology program.

Grants refers to the fact that the school or district had obtained a special grant "in the last three years for an experimental program where at least 5% of the funding was dedicated to computer-related costs" (quotation is from a phrase in a question included in the study's Principal's Survey Booklet; see Becker & Anderson, 1998). Depending on the nature of the grant and the program(s) funded, this activity might meet the standards in several sections of NETS-A.

Intellectual property policy represents that the school had a policy about "honoring intellectual property rights, e.g., copyrights" (quotation is from a phrase in a question included in the study's Principal's Survey Booklet; see

Becker & Anderson, 1998), according to the principal. The last section of the NETS-A standards is labeled "Social, Legal, and Ethical Issues," and it emphasizes that technology leadership implies awareness of such issues. It also states that educational leaders should establish and refine policies that address issues of equity of access, the safety of users, and compliance of staff and students with legal and ethical guidelines for technology use.

It can be seen from these eight components that our school *Technology leadership* indicator represents some of the most important organizational decisions or policies and has the potential to facilitate improved utilization of information technology throughout the school. These components were not selected to represent the domains of NETS-A, but five indicators reflect the content of sections of NETS-A. The remaining three indicators are general in nature, cutting across the domains or sections of NETS-A.

Technology Outcomes

For this investigation, several outcome measures were selected to examine the role of technology leadership on educational technology utilization in schools. The three outcome indicators are net use, technology integration, and student tool use. Each of these indicators was constructed from a number of questionnaire items.

Net use is a measure of the extent to which teachers' and others in the school used e-mail and the World Wide Web for a variety of different purposes. The indicator measures the frequency of teacher and student use of e-mail and the Web and should not be confused with use of a school's local network facilities.

Technology integration measures the degree of integration of technology into the curriculum and into teaching practices. It is based on the estimated number of teachers who were integrating technology into various types of teaching activities, as reported by the technology coordinator. (See Appendix for specific activities included.)

Student tool use measures the extent to which students used computers during the school year to do academic work, including writing reports, essays, and so forth; simulations in science and social studies, spreadsheets, and databases; and looking up information on CD-ROMS, the Web, and other computer-based resources.

These three technology outcome indicators were not combined, but each was used separately in model estimations. More details about each indicator are given in the appendix.

FINDINGS

The findings presented here are organized into four parts. The first section reports what proportions of schools possessed each of the eight technology leadership components. The second section gives percentages for all U.S. schools on the adoption of technology-related policies. Third are the breakdowns of technology leadership by school demographic factors, exploring which types of schools have more or less technology leadership. Finally, we examine some aspects of the model (Figure 1), focusing on the relationship between a school's technology leadership and its technology outcomes.

What Are the Distributions of the Eight Technology Leadership Indicators?

First, we examine the percentage of U.S. schools in 1998 that had each of eight technology leadership characteristics as measured by the eight technology leadership component indicators. Figure 2 shows that more than three fourths of the schools had a technology committee, a staff development policy, and an intellectual property policy. About 60% of the principals said that they spent 5 or more days in the current year on technology matters, and 53% of the schools had their own technology budget with their own discretionary control. Thus, a majority of the schools had these five leadership characteristics.

Fewer than half of the schools had the three remaining technology leadership components. An impressively large number of schools (43%) reported to have received a grant "in the past three years for experimental programs where at lest 5% of funding was dedicated to computer-related expenses" (quotation is from a phrase in a question included in the study's Principal's Survey Booklet; see Becker & Anderson, 1998). A third of the principals said that their district was supportive of technology costs relative to other districts. But only 29% of the principals said they regularly used e-mail with at least two of the following four groups: teachers, administrative staff, students, or parents. Undoubtedly, a higher proportion of principals now would meet this *principal e-mail* criteria as more schools have acquired high broadband Internet connections. However, this finding does suggest that principals may be slower in changing their own personal practice in using technology than they are in implementing school technology programs and policies.

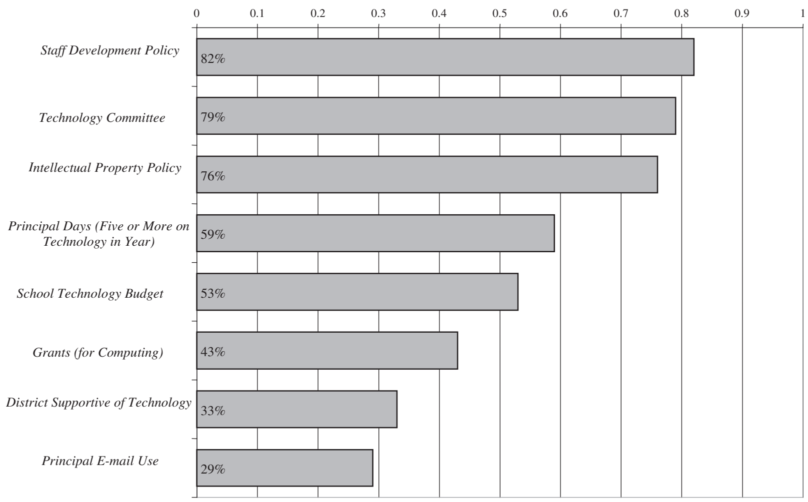

Figure 2. Percentage of U.S. Schools With Each Leadership Characteristic (*N* = 473 – Probability Sample Only)

What Technology Policies Were Found in U.S. Schools?

As most schools had both policies (staff development and intellectual property), it should be insightful to examine school policies more closely. In fact, the principal survey also asked if policies were in place for several related aspects of technology. Table 1 lists each of the policies on which we queried the principals to find out if the school had such a policy. We did not ask if the policy was written but only whether or not there was one "in place." Thus, the policy could have been made at the district or even the state level. Table 1 gives the percentages of schools in the United States that reportedly had these policies and also breaks down the percentages into the three school levels.

The most pervasive policy listed was the "prohibition of use of adults-only materials," with 85% of all school principals indicating they had such a policy. More than three fourths of all schools also had policies regarding unauthorized system access and "honoring intellectual property rights, e.g., copyrights" (quotation is from a phrase in a question included in the study's Principal's Survey Booklet; see Becker & Anderson, 1998). Often these three policy principles are packaged together as a single acceptable use policy (AUP), which defines an implicit contract between the school and

TABLE 1
Percentage of Schools With Each Different Technology Policy in Place (n = 474)

Policy	*Elementary School (%)*	*Middle School (%)*	*High School (%)*	*Total (%)*
Prohibition of use of adults-only material	78	91	86	85
Periodic staff (teacher) technology training	76	83	80	80
Security from unauthorized system access or entry	67	80	88	78
Honoring intellectual property rights (e.g., copyrights)	71	79	81	77
Equity in access to technology (within school building)	63	71	64	65
Installation of software not purchased by school	51	63	68	60
Classes or types of students that get to use computers	48	50	36	44
Computer game playing on school computers	29	43	51	41
Student computer-related competency requirement	31	37	47	38
Restriction of software purchases to approved list	30	38	38	35

SOURCE: Teaching, Learning and Computing survey of K-12 schools in United States (see Becker & Anderson, 1998).

computer system users (Dill & Anderson, 2003). Althouch these policies are statements of ethical expectations, schools establish such standards in part to protect themselves from potential legal and political problems as well. The Internet provides access to people, resources, and ideas, many of which are illegal or deemed harmful by parents. Establishing these ethical policies provides schools with the necessary educational context for addressing the many difficult issues that are likely to arise.

Another pervasive policy was "periodic staff (teacher) technology training" (quotation is from a phrase in a question included in the study's Principal's Survey Booklet; see Becker & Anderson, 1998), with 80% reporting such a policy. Other technology curricular policies were not as common, with only 38% having a "student computer-related competency requirement" and 44% having a policy on "classes or types of students that get to use computers." However, 65% reported a policy on "equity of access to technology." Only 41% had a policy on "computer game playing" (quotations are from a phrase in a question included in the study's Principal's Survey Booklet; see Becker & Anderson, 1998).

The percentages are given in Table 1 by three school levels to show any differences by level. In general, policies were less common in elementary schools than in high schools and middle schools, but the differences were modest. However, although 51% of high schools had a policy on computer game playing, only 31% of elementary schools had one. Significantly, almost as many elementary schools had ethical policies as did higher level schools.

The pervasiveness of technology policies is confirmed by the fact that more than half (63%) of the K-12 schools had at least 6 of the 10 possible policies in place. Technology policies are organizational mechanisms to deal with potential problems or to implement educational goals related to technology. Their pervasiveness reflects the growth of technology in education and implies that the technology leadership of many schools is functioning to some extent.

School Demographic Differences in Technology Leadership

In this section, we investigate the question of whether technology leadership differs across different types of schools. The analysis focuses on the overall measure of technology leadership but includes some data for four of the component indicators. Technology leadership is broken down into different categories in Table 2, and Figure 3 shows some of these contrasts in bar charts.[3] Similar contrasts for four of the component indicators are given in Figures 4a through 4d by level, school socioeconomic status (SES), and public versus private schools but are limited to principal days, district support, grants, and principal e-mail. The remaining four indicators tended to have smaller differences and thus were not depicted graphically. The findings are discussed separately for each major demographic factor.

School level. First, we answer the question of whether or not technology leadership differs by type of school as defined by grade ranges. As Table 2 and Figure 3 show, elementary schools were significantly lower than middle schools and high schools on the overall indicator of technology leadership. Middle schools and high schools were more likely than elementary schools to get grants, have technology committees, have strong district technology support, and have principals that were heavy e-mail users, as shown in Figures 4a through 4d. On the other leadership indicators, elementary schools were essentially the same.

The lower average technology leadership levels among elementary schools does not mean that they are less likely to have strong technology

TABLE 2
Leadership Means Across Categories of Demographic Variables

	M	SD	N
School level			
Elementary school	4.28	1.85	459
Middle school	4.75	1.71	201
High school	4.92	1.67	206
School socioeconomic status			
Low	4.62	1.52	85
Average	4.54	1.75	345
High	4.71	1.88	355
Title 1 percentage			
0% to 10%	4.92	1.62	197
11% to 22%	4.79	1.77	201
23% to 40%	4.65	1.85	189
41% to 100%	4.41	1.78	169
Public/private			
Public	4.70	1.76	755
Catholic	3.66	1.69	43
Other private	3.29	1.62	67
School size			
Large	5.01	1.59	214
Average	4.32	1.87	483
Small	4.59	1.71	168

leaders. They are lower in part because elementary schools tend to be smaller and consequently more informal. Larger schools are more likely to have technology committees and to have their own budgets, both of which are consistent with more formal organizational structures. Formal policies or procedures are less necessary in a smaller school where informal solutions are more feasible.

Public/private. Overall, private (or nonpublic) schools[4] were significantly lower than public schools on our measure of technology leadership. This was especially true for getting grants and principal's use of e-mail (Figures 4c and 4d). Whereas 56% of the public schools had received a grant within the previous 3 years, for which at least 5% went for technology costs, only 15% of private schools had done so. And while 44% of public school principals reported using e-mail with two or more groups, only 8% of those in private schools reported it. It would appear that private schools had some significant disadvantages in this regard. Principals at private schools were less likely to say their district was relatively more supportive of technology costs, partly

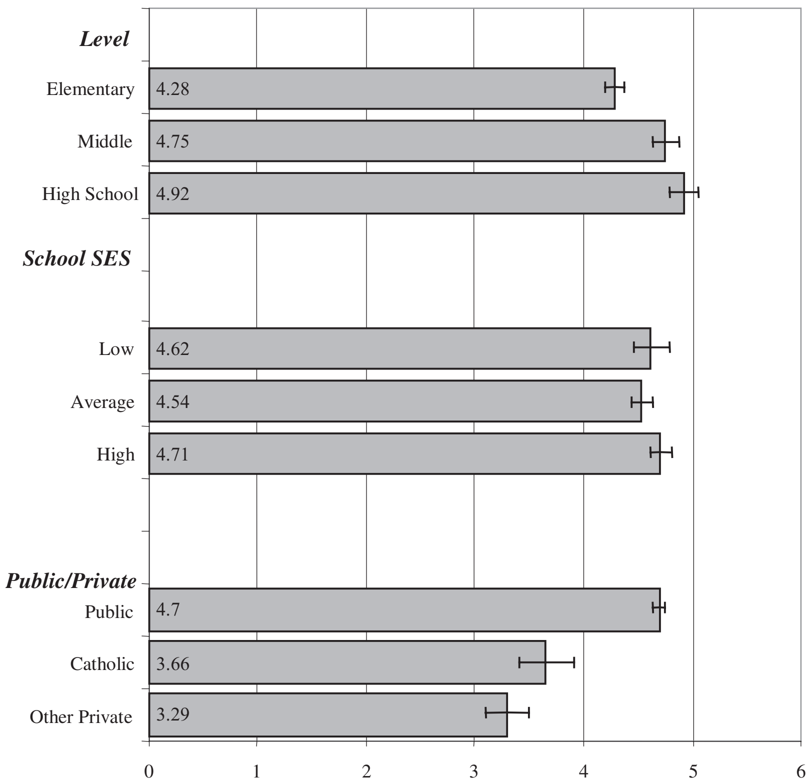

Figure 3. Technology Leadership Composite (*n* = 866)
NOTE: SES = socioeconomic status.

because some private (or nonpublic) schools do not have a district (or a dioceses). (More than half of the principals in both Catholic and "other private" schools responded as if they had a district.) Private and public schools were about equally likely to have a technology committee, to have technology policies in place, to have a technology budget, and to have a principal that spent at least 5 days a year on technology. The technology leadership disadvantage of private schools derived mainly from relatively lower use of e-mail by principals and receipt of less technology funding. The latter may be because of fewer sources of technology funding being available to most private schools.

School SES. As shown in Table 2, there was lower overall technology leadership when the percentage of Title 1 eligible students (i.e., those meeting official poverty criteria) was greater. That overall pattern was also found

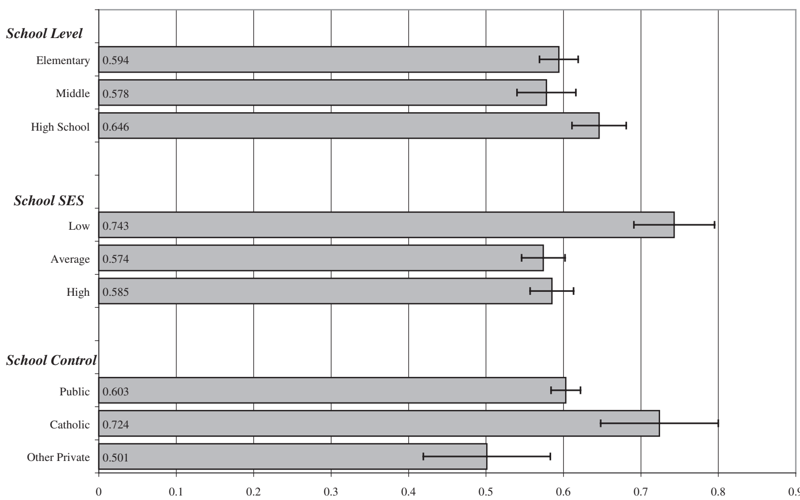

Figure 4a. Percentage of Principals Devoting 5 or More Days to Technology (*n* = 749)
NOTE: SES = socioeconomic status.

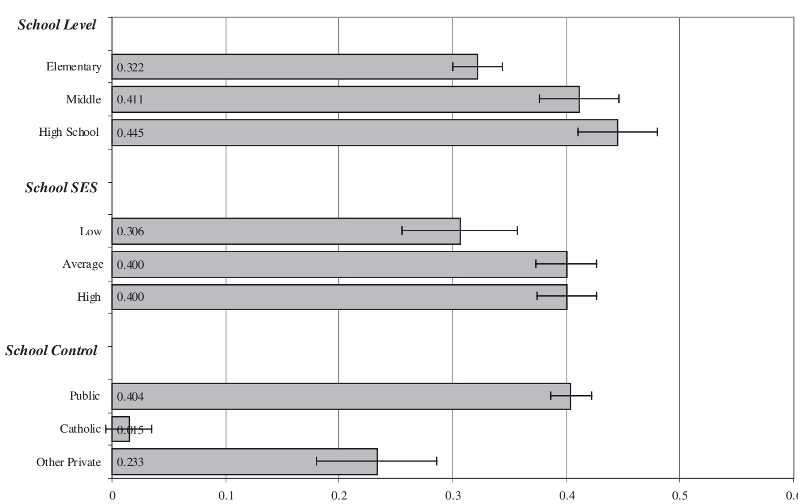

Figure 4b. Percentage With District Supportive of Technology Costs (*n* = 848)
NOTE: SES = socioeconomic status.

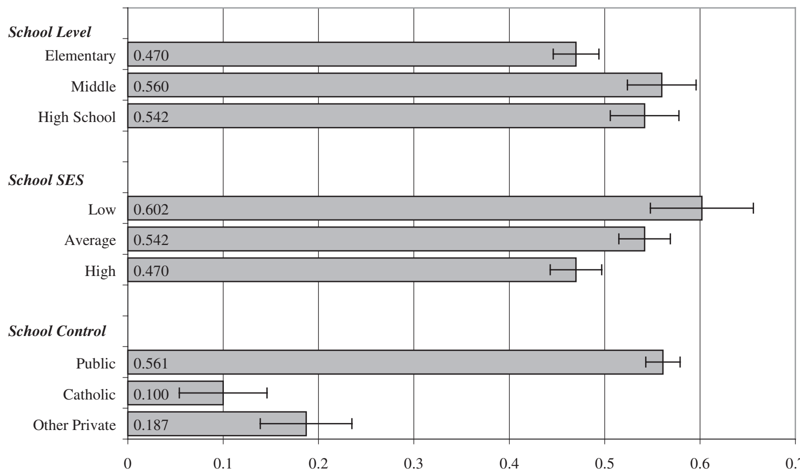

Figure 4c. Percentage With Grants for Technology (*n* = 835)
NOTE: SES = socioeconomic status.

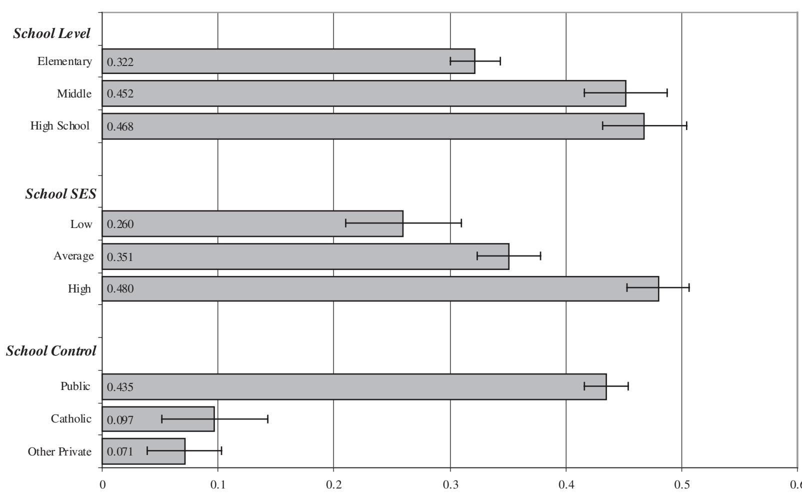

Figure 4d. Percentage of Principals Using E-mail (*n* = 820)
NOTE: SES = socioeconomic status.

when we used average income of households in the school's zip code as the indicator of school SES (as depicted in Figure 3). Across school SES levels, which were based on average income in the school's zip code, the differences were quite small.

Schools in the lowest SES level were more likely (60% vs. 50%) to report having received a grant covering technology costs (Figure 4c). Also, principals in these lowest SES schools were more likely to spend time on technology. Despite these slight disadvantages, the principals in higher SES schools were likely to use e-mail more extensively and to report higher district support. Thus, in terms of technology leadership, the digital divide was not uniformly wide, perhaps because of compensatory programs. However, it is still possible to conclude that as of 1998, such programs had not fully compensated for the lower technology leadership in schools with the most students eligible for Title 1 funding.

It might be tempting to conclude that the digital leadership divide probably has disappeared since the data were collected because the E-rate program provided a large amount of technology funding in the years immediately following. But the pattern of spending on technology suggests otherwise. Anderson and Becker (2001) found that in 1998, the gap between poorer and richer schools' spending on software and technology support (including professional development) was relatively greater than the gap of spending on hardware. The E-rate program was largely limited to hardware rather than software or support; thus, the gaps in both technology leadership and effective utilization of technology may be even greater than or no less than they were in 1998.

Summary of findings on school demographics. Larger schools, public schools, and those with higher SES had structural advantages in terms of technology leadership. This does not mean that small schools, private schools, or poor schools lacked strong technology leaders in the traditional sense. Rather, the schools with lower technology leadership were those with fewer mechanisms, policies, or processes in place that made it possible for the organization as a whole to effectively adapt technology for its educational mission. Although these data revealed a digital technology leadership divide on the basis of SES, the gap was not as wide as that which existed in school technology spending. Although the differences were not large, it is significant that schools with the most students below the poverty line tended to have lower technology leadership than schools with the least Title 1–eligible students.

The Role of Leadership in Technology Outcomes

Table 3 shows the correlation matrix of each of the three dependent variables and the five independent variables used in the regression models. Technology leadership had a significant and positive correlation with each of the dependent variables, and in each case. technology leadership was the independent variable with the largest correlation with the technology outcome indicator. The school's overall technology leadership score had a higher correlation with each technology outcome indicator than did all the infrastructure indicators with each technology outcome.

Tables 4, 5, and 6 display the results of the multiple regressions on each of the three dependent variables. The models not only regress technology leadership on each technology outcome variable but also regress four infrastructure variables: the ratio of *students per computer*, the typical measure of computer density; whether or not the school had high-speed Internet access (*T1 access*); the *per student hardware expenditures*; and *the per student software expenditures*.

Only two variables, technology leadership and students per computer, were statistically significant predictors across all three outcome variables. Technology leadership clearly was the strongest predictor for all three. T1 access and per student software expenditures were significant predictors but only for the outcome variable *net use*. These results support the path model depicted in Figure 1, with the exceptions that students per computer has a modest direct effect in all three models and T1 access and per student software expenditures had small direct effects in the net use (Y1) model. The regressions confirm a very strong effect of technology leadership on the utilization and integration of technology. Second, they reveal that infrastructure and expenditure factors do not have relatively large direct effects on technology outcomes.

The sizes of the R^2, which indicates the amount of variance explained by the independent variables as a whole, for the three models are noteworthy. For the net use model, the R^2 was .29; for technology integration, it was .14; and for student tool use, it was only .06. Thus, the amount of variance explained for net use was more than twice as much as for the other two technology outcomes. This large a difference suggests that the processes underlying net use were quite different from the other two. In fact, the skills for using the Web and e-mail are much easier, and both teachers and students often learn them outside of school. The learning underlying technology integration and student tool use is much more demanding for both teachers and students. The leadership challenge for net use was considerably less than for the other two technology outcomes, which tend to be classroom-based rather than school-based.

That the amount of explained variance and the number of significant predictors for net use were much higher than for the other two models suggests that a much less complex process was involved for net use. E-mail and Web use, compared to extensive integration with instruction or to teaching

TABLE 3
Correlation Matrix of Variables for Multiple Regression

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. Net use (Y1)	1.000							
2. Technology integration (Y2)	0.530	1.000						
3. Student tool use (Y3)	0.380	0.454	1.000					
4. Technology leadership	0.449	0.320	0.199	1.000				
5. Students per computer	–0.241	–0.245	–0.161	–0.229	1.000			
6. T1 access	0.380	0.171	0.148	0.298	–0.143	1.000		
7. Per student hardware expenditures	0.152	0.133	0.060	0.130	–0.190	0.200	1.000	
8. Per student software expenditures	0.208	0.163	0.097	0.178	–0.218	0.131	0.502	1.000

TABLE 4
Regression Results for Demographic Variables on Net Use (Y1)

	Net Use (Y1)			
	b	SE	*Beta*	p *Value*
Constant	8.942	0.318		.000
Technology leadership	0.429	0.058	.332	.000
Students per computer	–0.047	0.019	–.109	.013
T1 access	1.215	0.212	.255	.000
Per student hardware expenditures	0.000	0.000	–.012	.807
Per student software expenditures	0.006	0.003	.097	.047

NOTE: R^2 = .29, adjusted R^2 = .28.

TABLE 5
Regression Results for Demographic Variables on Technology Integration (Y2)

	Technology Integration (Y2)			
	b	SE	*Beta*	p *Value*
Constant	16.402	0.773		.000
Technology leadership	0.717	0.141	.251	.000
Students per computer	–0.152	0.046	–.161	.000
T1 access	0.633	0.515	.06	.22
Per student hardware expenditures	0.000	0.001	.026	.624
Per student software expenditures	0.009	0.007	.063	.244

NOTE: R^2 = .14, adjusted R^2 = .13.

extensive tool use, may diffuse on its own once the requisite infrastructure is in place. However more complex pedagogical methods of using technology may also require other conditions, such as specialized professional development programming.

IMPLICATIONS

A Summary of Findings

In this report, the concept of school technology leadership was operationalized and aligned to technology goals, policies, budgets, committees, and other structural supports for improving technology's role in learning. Although this was not a test of the validity of the NETS-A standards, the findings are consistent with and reinforce the standards and suggest that further

TABLE 6
Regression Results for Demographic Variables on Student Tool Use (Y3)

	Student Tool-Use (Y3)			
	b	SE	*Beta*	p *Value*
Constant	11.785	0.607		.000
Technology leadership	0.303	0.11	.141	.006
Students per computer	–0.078	0.036	–.11	.03
T1 access	0.701	0.404	.088	.083
Per student hardware expenditures	0.000	0.001	–.020	.725
Per student software expenditures	0.005	0.006	.046	.411

NOTE: R^2 = .06, adjusted R^2 = .05.

research on their implications is warranted. The study confirmed that technology leadership played a very central, pivotal role in technology-related outcomes, and the findings also revealed considerable diversity in technology leadership and organizational support systems.

Implications for Theory

Our tests of a model of the role of technology leadership on school outcomes implies that improved theoretical direction is needed on how leadership and resources optimally combine to utilize technology to support learning and teaching goals. Perhaps the most important finding from our analysis is that technology leadership has greater leverage on desired outcomes than does technology infrastructure and expenditures. Refinement of the conceptual dimensions of technology leadership would help to address the challenge of optimally defining how technology leadership and resources interact.

Although there has been considerable work on distributed leadership in general, these conceptions need to be applied to technology leadership. Rapid technical change and highly uneven distribution of expertise make technological leadership particularly challenging. Such work should incorporate leaders' ability to cope with complex change (Fullan & Stiegelbauer 1991) and organizational capacity for continuous learning (Senge et al., 2000). Focusing on theories of learning organizations would help to theoretically address how to incorporate culture and community into refined conceptions of technology leadership.

Both theoretical and empirical work is needed on how technology leadership optimally fits together with leadership in educational administration more broadly. Do the characteristics and roles that make one more effective also make the other more effective? When does time and attention to technology interfere with the fulfillment of other administrative roles, for example, public relations or fiscal management? How can districts and schools best divide technology leadership functions?

Implications for Practice

The component parts of technology leadership illustrate that technology leaders must be actively involved with technology—crafting policies, using e-mail, and generally spending time on it. In other words, our results suggest that a school's technology efforts are seriously threatened unless key administrators become active technology leaders in a school. Administrators who have not previously assumed these responsibilities might begin with a school technology audit to determine the degree to which the school has adequate technology goals, policies, budgets, committees, and supporting elements in place and where they should begin.

Even with the limited number of indicators used in this analysis to measure technology leadership, we demonstrated an effect on several important technology-related outcomes. This supports the cogency of the model's components, and indicates that leaders' involvement in a range of key technology leadership areas (i.e., leadership and vision; learning and teaching; productivity and professional practice; support, management, and operations; and social, legal and ethical issues) is important for successful technology use in a school. In short, our findings reinforce the importance and usefulness of the NETS-A standards as guidelines for successful practice.

The analysis of technology leadership characteristics by school demographic factors found considerable variation across demographic categories. Although some of this variation may be the result of the limitations of the indicators of technology leadership, undoubtedly, some result from differences in the conditions of technology leadership, many of which have to do with a school or district's infrastructure. However, administrators and other practitioners should understand that our study concludes that although technology infrastructure is important, for educational technology to become an integral part of a school, technology leadership is even more necessary.

Implications for Research

The importance of the questions and conclusions from this study suggest the need to replicate the study with more recent data and alternative indicators. Unfortunately, more recent data were not yet available when this was written. Some researchers have been calling for longitudinal investigations of technology, and leadership should definitely be a major part of any such large-scale studies across time. The preliminary findings of this study suggest that it would be important to follow trends in the digital technology leadership divide. Often, those using the rhetoric of the digital divide claim or imply that the problem can be solved by funding infrastructure, but evidence is building that even more important than such resources are support services and other processes generally associated with technology leadership.

Standards such as NETS-A will be refined over time, and a research agenda on technology leadership should keep up with such changes and monitor the evolving capacity in schools for technology leadership. To do an adequate job of operationalizing technology leadership across time will require considerable research on alternative ways of defining indicators. In this study we treated the construct unidimensionally, but a multidimensional approach is needed, especially given that the goals vary so much across different technology-supported programs and projects. Perhaps equally important as progress on tools for studying technology leadership would be work on developing additional measures of technology outcomes. So far, we have only looked at a few measures of student and teacher utilization of technology. Even more important would be to utilize a variety of alternative measures of student learning in relation to technology leadership. Focusing on technological outcomes in terms of innovations in management or assessment would be another approach.

As indicators are refined and additional data become available, it will be possible to revisit the questions that we explored in this study regarding the mediating role of technology leadership. Specifically, when does technology leadership play an intervening or indirect role in technology implementation in relation to infrastructure and other school characteristics? Another way of focusing this question is how do resources and leadership interact in the context of technology implementations for learning and teaching? Ultimately, the research could make improved practice much more feasible.

APPENDIX
Indicator Descriptions

District Support

District support indicates how much a principal feels their district or diocese supports costs of technology relative to other districts or dioceses. Responses are coded as follows: 1 = school district supports technology more than other districts; 0 = district supports costs of technology the same or less than other districts.

Grants

This variable indicates that the school or district obtained special grant(s) in the past 3 years for experimental programs where at least 5% of funding was dedicated to computer-related expenses. A value of 1 indicates that at least 5% of grant funding went to computing, and 0 indicates less than 5% of grant money went for computing or that the school did not receive grant money for experimental programs.

Intellectual Property Policy

The intellectual property variable indicates that the school currently has a policy in place honoring intellectual property rights (e.g. copyrights); 1 = yes, 0 = no.

Internet Type

This variable indicates the relative speed or bandwidth of the school's access to the Internet. It was based on a question in the technology coordinator questionnaire that asks respondents to identify how their school's computers or local area networks (LANs) are connected to the Internet. This variable was created by examining the type of connections to the Internet for instructional computers. Types of access are defined as follows: 0 = none or no Internet connection, 1 = modem, 2 = ISDN or 56K, 3 = T1 bandwidth or higher.

Net Use

Net use is a measure of the extent to which teachers' and others in the school used e-mail and the Web for a variety of purposes. The variable is the sum of frequency of teacher and student e-mail and Web use, not just the type of a school's networking facilities. To create the variable, four questions were dichotomized such that responses of one half or more are coded 2 and less than one half are coded 1. The questions include, How many teachers have personal Internet accessible e-mail through school or privately? How many teachers are using e-mail regularly (say weekly)? How many teachers have used the World Wide Web in their teaching? How many students have been involved in direct use of the Web at school?

These questions were summed with four additional dichotomous (2 = yes, 1 = no) questions about whether or not the school's networking facilities and connectivity have been used in programs such as school-to-work transition programs, class or individual projects where the Internet is used to acquire information from community or other groups, communications to parents about the school program, homework assignments via Web pages or e-mail, and students accessing information on school servers from home. Net use is the sum of all eight responses and ranges from 6 to 16.

Per Student Hardware Expenditures

Per student hardware expenditures covers the previous 2 years and is calculated by dividing the total hardware expenditures during the 2-year period by the total number of students in the school.

Per Student Software Expenditures

Per student software expenditures covers the previous 2 years and is calculated by dividing the total software expenditures during the 2-year period by the total number of students in the school.

Principal Days

Principal days on technology indicates that a principal reported spending 5 or more days on technology planning, maintenance, or administration during the current year. The question asked about 8-hour equivalent days. Five was selected as a cutting point so that it would divide the sample approximately in half. The variable was coded 1 if the principal spent at least 5 days on such activity and 0 if the principal spent fewer than 5 days on technology activity.

Principal E-mail

Principal e-mail was constructed from principal responses to questions about any regular use of e-mail to communicate with teachers, administrative staff, students, and parents. The variable is dichotomized so that 1 indicates principals who regularly e-mail with more than one of the groups, and 0 indicates principals who regularly e-mail with no groups or only one group.

Public/Private

Public/private, which is also called school control, is the variable where 1 = public schools, 2 = Catholic schools, and 3 = all other private schools.

School Level

School level represents the level of the school where 1 is elementary schools, 2 is middle schools, and 3 is high schools. This variable was created by examining the median grade of the school. Initially, school grade levels were from the sampling database that was constructed from the quality education data (QED) database. This information was updated with responses provided by the school principal. Elementary schools were those schools with median grade ranges of 5.5 or below, middle schools have median grade ranges of 5.6 to 9.4, and high schools are those having median grade ranges of 9.5 or above.

School Socioeconomic Status (SES)

The SES of the school was obtained using QED data based on the income level of households within the school's zip code. The original variable was based on a 6-point scale where 0 = not classified, 1 = low SES, 2 = low to average SES, 3 = average SES, and 4 = average to high SES, and 5 = high SES. These categories were then collapsed into a trichotomous variable where 1 indicates low SES, 2 indicates average SES, and 3 indicates high SES.

School Size

School size identifies the relative size of the school's enrollment (i.e., large, average, or small). This was calculated by using the number of students enrolled at the school from the principal questionnaire (if missing, number of students from QED database was used) and taking into account school level. Small, average, or large differs depending on the level. A value of 1 indicates a large school, 2 is an average school, and 3 is a small school. The intervals defined as small, medium, and large were set so that about one fourth of the schools fell into the "small" category, one half into the "medium" category, and the top fourth into the "large" category. The cutting points were defined separately for elementary, middle school, and high schools so as to avoid contaminating the school size variable with the school-level variable. The result was the following breakdowns. For elementary schools, large schools had more than 600 students, average had 300 to 600 students, and small had fewer than 300 students. For middle schools, large schools had more than 900 students, average had 300 to 900 students, and small had fewer than 300 students. Finally, for high schools, large schools had more than 1500 students, average had 500 to 1500 students, and small had fewer than 500 students.

Students Per Computer

The ratio of students per computer is the number of students divided by the number of computers. This variable was calculated by dividing the student enrollment by the total number of computers used for instruction. It is missing if either the numerator or denominator is zero or missing.

School Technology Budget

If a school had its own budget for technology, this variable was coded 1. Otherwise, it was coded 0. (Many districts do not give schools their own budgets with discretion over technology spending.)

Staff Development Policy

The staff development variable indicates that the school currently has a policy in place for periodic staff (teacher) development regarding technology; 1 = yes, 0 = no.

T1 Access

T1 access indicates whether or not the school had a high-speed Internet access—that is, a bandwidth higher than 56K or an ISDN line. It was coded 1 if they did and 0 otherwise.

A value of 1 indicates the school had a such a budget, and 0 indicates that an agent of the school did not have sole discretionary authority over such a budget.

Title 1 Percent

Title 1 percent is the percentage of students who qualify for Title 1 programs. The data comes from the QED database and is grouped into four categories, where 0 = 0% to 10%, 1 = 11% to 22%, 2 = 23% to 40%, and 3 = 41% to 100%.

Student Tool Use

Student tool use measures the extent to which students use computers during the school year to do academic work, including writing reports, essays, and so on; simulations in science and social studies, spreadsheets, and databases; and looking up information on CD-ROMS, the World Wide Web, and other computer resources. Technology coordinators were asked roughly what percentage of student use of computers would involve each of the above categories of activity, where responses were coded 1 = 0%, 2 = 5%, 3 = 10%, 4 = 15%, 5 = 25%, 6 = 40% and above. Student tool use is the sum of responses to the three questions.

Technology Integration

Technology integration indicates the relative number of teachers who are integrating technology into their teaching activities of various types, as reported by the technology coordinator. Technology coordinators were asked what proportion of the teachers in their schools did the following: experiment with new teaching methods involving computers, use computers for their own professional tasks, sometimes have students use computers to do curricular assignments, involved in planning or implementing Internet-based activities, and see technology coordinators for advice about integrating technology and curriculum. The following scale was used to estimate the proportions: 1 = none, 2 = almost none, 3 = about one fourth, 4 = about half, 5 = about three fourths, 6 = almost all, and 7 = all. Technology integrated teaching is the sum of scores across these activities.

Technology Leadership

Technology leadership is a variable that measures school technology leadership. It represents the organizational decisions, policies, or actions that facilitate effective utilization of information technology throughout the school. The technology leadership variable is the sum of eight other indicators: budget, district support, grants, intellectual property policy, principal days, principal e-mail, staff development policy, and technology committee. Each of these variables is dichotomous, coded 1 and 0, and described in further detail in this appendix.

NOTES

1. The Teaching, Learning and Computing (TLC) 1998 survey was conducted by Henry J. Becker, Principal Investigator, at the Center for Research on Information Technology and Organizations (CRITO) (http://www.crito.uci.edu) at the University of California, Irvine (http://www.uci.edu), California 95697-5500 and by Ronald E. Anderson, Co–Principal Investigator, at the Department of Sociology at the University of Minnesota, Minneapolis, Minnesota 55455. The study is funded by a grant to the University of California, Irvine, from the National Science Foundation's Division of Education and Human Resources, with additional funding from the U.S. Department of Education's Office of Educational Research and Improvement (NSF Grant #: REC-9600614). Copies of the survey questionnaires and all the reports can be obtained at http://www.crito.uci.edu/tlc/

2. Why the variables dropped did not correlate with the remaining indicators of technology leadership may be of interest. We speculate that the dominant goal for technology was not associated with other aspects of technology leadership, because schools are generally attempting to achieve several major goals and that leadership functions are fairly similar no matter what the dominant goal. Relatively few schools receive substantial technology donations, and those that do usually receive hardware, which may not be the school's area of greatest need. The presence of a formal technology coordinator in a school as an indicator is complicated by the fact that a district position sometimes substitutes for a school position, and a technology coordinator position is often labeled with a different job title. Often, there is disagreement on what roles are formal versus informal. The 1998 Teaching, Learning, and Computing (TLC) (Becker & Anderson, 1998) survey found that 55% of the schools had a "formal" tech coordinator, but 93% were served by at least one tech coordinator. The discrepancy between these two numbers reflected the ambiguities and complexities mentioned. Although every school needs to be served by at least one technology coordinator, the presence of one may not be a good measure of technology leadership.

3. The bar charts in Figures 3 and 4 use tiny t-bars at the tip of each bar to depict the standard error (*SE*) for each subgroup. The total length of each t-bar (sometimes called an error bar) is equivalent to two *SE*s plus or minus one SE from the mean of the subgroup. If the t-bars of two groups overlap, then it is a good indication that the difference between the groups is not statistically significant.

4. Because there were only 43 Catholic schools and 67 "other private" schools in our sample, in interpreting this analysis, we did not distinguish between Catholic and "other private" schools.

Only public versus all private school comparisons are noted here, even though the statistics for all three groups are given in Table 2 and Figures 3 and 4. Readers are cautioned about interpreting any differences between Catholic and "other private" schools as significant.

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