Large-scale research study on technology in K-12 schools: Technology integrat...
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Large-Scale Research Study on Technology in K–12 Schools: Technology Integration as It Relates to the National Technology Standards

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Abstract

This article highlights the results of a survey (N=2,156) in one of the largest school districts in the country, focusing on teachers' instructional modes related to technology integration as outlined in the National Educational Technology Standards for Students. Approximately 50% of the teachers who responded to the survey indicated that they were using technology as a classroom communication tool. Smaller percentages were reported for technology integration as a productivity, research, or problem-solving tool. In comparisons across subject areas, statistically significant differences were noted when teachers used computers as a research tool or as a problem-solving/decision-making tool. In both cases, science teachers reported the highest usage, followed by mathematics teachers. (Keywords: technology, standards, NETS for Students, classroom integration.)

Expenditures to equip schools with computers and related technology have steadily increased at the national, state, and school levels. The financial investment has resulted in both an improved student-to-computer ratio and increased connectivity to the Internet. Nationwide, the ratio of students per computer has fallen from an average of 10.1 in 1995 to 5.4 in 1999–2000 (Quality Education Data, 2001). The percentage of public schools that have Internet access has increased from 35% (1994) to 99% (2002), and the percentage of public classrooms connected to the Internet has risen from 3% in 1994 to 87% in 2001 (Kleiner & Farris, 2002).

As a result of the significant investments being made in hardware, software, and infrastructure, there is a need for evidence regarding the instructional integration of technology in K–12 classrooms. It is apparent that with the acceleration in the pace of technological innovation and saturation in society, skills such as problem solving, synthesizing information, and communicating via technology are essential for today's students (CEO Forum, 2001).

This study was conducted to determine the extent to which individual teachers in a large school district were using technology as a tool for their students' education. In particular, the research addresses the use of technology as a classroom tool for research, communication, productivity, and problem-solving, as outlined by the National Technology Standards for Students. Analyses include comparisons across grade levels (elementary, middle, and high schools) and sub-

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ject areas (English, mathematics, science, and social studies). The results of this study can be used to structure inservice training programs, preservice education curricula, and interventions for individual teachers.

REVIEW OF THE LITERATURE

National Educational Technology Standards

Technology standards are not new in the education field. After microcomputers entered schools in the 1970s and 1980s, educators struggled with defining appropriate computer skills for students (Bitter, 1983). At that time, computer literacy was often equated with basic operations and programming. Although several states provided guidelines to benchmark computer literacy at different grade levels, they did not require students to meet such standards in order to graduate (Roblyer, 2000).

In the past few years, a flood of standards has engulfed education. Standards in content areas, such as reading, writing, mathematics, and science, have emerged at the state and national levels. In some cases, these standards are tied to accountability via funding, student advancement, or certification. For example, the Education Commission of the States estimated that at least 23 states would require students to pass a standard exam to graduate in 2002 (National Center for Policy Analysis, 1999). In addition, President Bush signed the No Child Left Behind Act of 2001 in January 2002. This law requires all states to establish a system of tests to measure students' achievement. In particular, it mandates tests in reading and math for students in grades three through eight, beginning in 2004. In 2005, science testing must begin ("Bush signs education reform law," 2002). The Enhancing Education through Technology Act of 2001, which is Title II, Part D of No Child Left Behind, provides grants for states that meet specific requirements to integrate technology into the curriculum. One of the requirements is that the grant application must include a description addressing "how the State educational agency will ensure ongoing integration of technology into school curricula and instructional strategies in all schools in the State, so that technology will be fully integrated into the curricula and instruction of the schools by December 31, 2006" (Title II, Part D, §2413).

Concurrent with the "standards movement," government officials and educators advocated the need to emphasize technological skills (Trotter, 1997). Rather than focusing on hardware and programming, these skills (often referred to as technological literacy) involved using technology as a tool to communicate, conduct research, and solve problems. Several states took the initiative to set technology benchmarks for various grade levels, and several national organizations undertook the mission of developing national standards for both students and teachers (Bennett, 2000; Roblyer, 2000).

In 1998, the International Society for Technology in Education (ISTE) published their National Educational Technology Standards (NETS) for Students, and, in 2000, published standards for teachers. As of March 2003, 29 states had adopted, adapted, or aligned with the ISTE standards for students, and 30 states were using the ISTE standards for teachers (ISTE, 2003). In some states, such as Alabama and North Carolina, students must pass a computer skills test

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before graduation. In other states, such as Delaware, Maryland, South Carolina, Tennessee, and Texas, students are required to pass a technology course as a part of their curriculum (Burke, 2001).

Because the ISTE standards serve as the foundation for many state standards, this study was conducted to ascertain the degree to which these guidelines were being addressed in the classroom. NETS for Students provides six areas of technology competencies:

- Basic operations and concepts
- Social, ethical, and human issues
- Technology productivity tools
- Technology communication tools
- Technology research tools
- Technology problem-solving and decision-making tools

The categories provide a framework for linking performance indicators to the standards for grades PreK–2, 3–5, 6–8, and 9–12. The intent is that technology be an integral component or tool for learning within the context of academic subject areas (ISTE, 1998).

In the first category, *basic operations and concepts*, students should be able to demonstrate a basic understanding of technology, such as computers, televisions, VCRs, and audio tape players. Performance indicators at various grade levels might include exhibiting proficiency in the use of computer terminology, proper care of the monitor, and selection of a printer.

The second category, *social, ethical, and human issues*, pertains to topics involving the use of technology. A sample performance indicator would include students demonstrating their ability to evaluate media images and to make responsible choices about what they see and hear.

In the third category, *technology productivity tools*, students use various forms of technology to create media such as documents, movies, pictures, and spreadsheets. In addition to using the computer, students demonstrate proper use of an assortment of hardware, such as probes, scanners, and digital cameras to construct their knowledge.

The fourth category, *technology communication tools*, focuses on students' use of media to converse and interact with peers, experts, and other audiences. Students should be able to collaborate, communicate, and interact effectively with a range of audiences for both directed and independent learning.

In the fifth category, *technology research tools*, students use technology as a tool to locate, evaluate, and collect information from a variety of sources. Performance indicators include proficiency in evaluating the accuracy, relevance, appropriateness, comprehensiveness, and bias of online information.

The sixth category, *technology problem-solving and decision-making tools*, involves the use of technology to develop strategies for recognizing and solving problems. Students should be able to identify a problem, determine if technology is useful in solving the problem, and if so, select and implement the appropriate tools.

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This study concentrated primarily on categories three through six, the classroom use of technology as a tool for productivity, communication, research, and problem solving.

Studies Related to Stages of Technology Integration

Historically, most of the studies related to educational technology have focused on quantifying the numbers of computers or Internet access in classrooms, rather than investigating the manner in which the technology is integrated into the curriculum (Smerdon, et al., 2000). In the 1980s, researchers began to analyze the process of technology integration and attempted to measure how teachers used technology in the classroom. Two important initiatives included the Apple Classroom of Tomorrow (ACOT) project and the Level of Technology Implementation (LoTi) scale.

Apple Classrooms of Tomorrow

The Apple Classrooms of Tomorrow (ACOT) project began in 1985, and it involved a collaboration among universities, research agencies, Apple Computer, and a cross section of K–12 schools (Sandholtz, Ringstaff, & Dwyer, 1997). Each participating student and teacher received two computers—one for home and one for school. "The intent was to create model, technology-rich learning environments in which teachers and students could use computers on a routine, authentic basis" (Bitter & Pierson, 2002, p. 115).

The ACOT study was primarily a qualitative, longitudinal study, with data collected via classroom observations, student logs, teacher journals, and weekly reports. The project focused on both the process of technology integration and the phases of adoption at the classroom level (Coley, Cradler, & Engel, 1997). Several findings related to the integration of technology emerged from the project. For example, the study found that technology:

- encourages fundamentally different forms of interactions among students and between students and teachers
- engages students systematically in high-order cognitive tasks
- prompts teachers to question old assumptions about instruction and learning (Dwyer, 1994, p. 8).

The ACOT research also produced an adoption model for the use of technology in the classroom, which is known as the Stages of Instructional Evolution. This model asserted that educators go through five stages of thought and practice when adopting technology:

- ***Entry***—Learn the basics of using technology.
- ***Adoption***—Use new technology to support traditional instruction.
- ***Adaptation***—Integrate new technology into traditional classroom practice.
- ***Appropriation***—Focus on cooperative, project-based, and interdisciplinary work, incorporating the technology as needed and as one of many tools.
- ***Invention***—Discover new uses for technology tools (Apple Computer, Inc., 1995).

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The ACOT study served as a foundation for research related to using technology as an integral part of teaching and learning. Linda Roberts of the U.S. Department of Education stated, "The lessons learned provide a rich foundation of experience and knowledge to guide current investments in technology at the local, state, and national level" (as cited in Apple Computer, Inc., 1995, p. 1).

Levels of Technology Implementation

The Levels of Technology Implementation (LoTi) scale was developed by Dr. Christopher Moersch in 1995 to "provide a data-driven approach to staff development and technology planning" (Moersch, 1999, p. 41). Teachers are asked to complete a 50-item questionnaire, indicating their perceptions about how they are using technology in the classroom. The results provide a profile for the teacher across three specific domains—the teachers' level of technology implementation (LoTi), personal computer use (PCU), and current instructional practices (CIP). The LoTi acronym is used in two ways when referring to this scale—to describe the domain of the survey that determines the degree to which the teachers perceive they are using technology, and as the overall score for the instrument that combines the LoTi, PCU and CIP domains. Based on a teacher's overall LoTi level, recommendations can be made for staff-development programs and specific interventions to enable him or her to move to a higher level (LoTi, n.d., Technology Use Profiles section).

A teacher's overall LoTi level corresponds to the LoTi scale, which consists of eight levels ranging from 0 to 6:

- Level 0—Non-use
- Level 1—Awareness
- Level 2—Exploration
- Level 3—Infusion
- Level 4a—Integration (Mechanical)
- Level 4b—Integration (Routine)
- Level 5—Expansion
- Level 6—Refinement

The higher the level, the more the teacher is integrating technology and moving from teacher-centered activities towards learner-centered activities. For example, teachers at Level 1 do not use technology in their classrooms and utilize a teacher-centered curriculum. Teachers at Level 3 use activities that encourage students to draw conclusions from information they find. This approach is more learner-centered and involves a higher level of technology use. At Level 6, teachers utilize a learner-based curriculum, and the technology activities engage students in solving real-life problems (LoTi, n.d., LoTi Breakdown section).

A case study was conducted with the LoTi questionnaire and 120 teachers from the Los Angeles Unified School District (LAUSD). The responses showed that "approximately 49% of the teachers' highest level of instruction achieved a Level 2 classroom use of technology" (Moersch, 1999, p. 42)—meaning they were using technology primarily as extension or enrichment activities, rather

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than as an integral part of the curriculum. "Approximately 28% of the teachers' highest level corresponded with Level 4 classroom technology use" (Moersch, 1999, p. 42)—meaning that technology was being used as a tool to solve problems and increase students' understanding of concepts. According to the results of the CIP portion of the questionnaire, approximately 39% of the teachers felt that they were not utilizing learner-centered activities; 59% felt that it was somewhat true that they were using learner-centered activities. Based on this study, recommendations were made to the LAUSD. These recommendations included ensuring that all classroom teachers had a working computer and printer in their classrooms, providing assistance to teachers who showed lower levels of technology implementation, and encouraging higher-level teachers to design units that illustrated how they use technology in their curricula (Moersch, 1999).

Large-Scale Surveys Related to Technology Integration

The ACOT and LoTi projects both provide insight into teachers' various stages of technology use and integration, and in many ways set the stage for national standards to emerge. Recently, three large-scale, survey-based studies have been conducted to determine how teachers are using computers in instruction, including research by the National Center for Education Statistics (NCES), the Center for Research and Information Technology and Organizations, and the Consortium on Chicago School Research. Each of these studies included aspects related to the integration of technology, and they provide relevant background information for the current research.

National Center for Education Statistics

In 1999, the National Center for Education Statistics (NCES) administered a short (three-page) survey that investigated teachers' use of computers and the Internet in the classroom (Smerdon, et al., 2000). The sample for this survey consisted of 2,019 full-time teachers in the United States—1,016 elementary school teachers and 1,003 secondary/combined school teachers. To derive the sample of teachers, a sampling frame of 78,697 regular public schools was constructed from the 1995–96 NCES Common Core of Data Public School Universe file (Smerdon, et al., 2000). A sample of 1,000 schools was selected from the sampling frame after it was stratified by instructional level and school size. "Within the primary strata, schools were also sorted by type of locale (central city, urban fringe, town, rural), geographic region, and percent of students in the school eligible for free or reduced-price school lunch to produce additional implicit stratification" (Smerdon et al., 2000, p. B–4). Each of the 1,000 selected schools was asked to submit the names of all "regular" classroom teachers (full-time teachers who taught in any of grades 1–12, excluding those whose primary teaching assignment was bilingual/English as a second language education, special education, or vocational education). After the teachers' names were submitted, "teacher sampling rates were designed to select at least one but no more than four teachers per school, with an average of slightly more than two teachers per school"—resulting in a total of 2,019 teachers (Smerdon et al., 2000, p. B–5).

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The Executive Summary of the NCES survey reported that approximately half of the teachers who had computers or the Internet available in their schools used them for classroom instruction to some extent. The following describe the most common uses of computers:

- 61% reported student assignments that involved word processing or spreadsheets.
- 51% reported assignments that required Internet research.
- 50% used technology in the classroom for practicing drills.
- 50% recounted assignments that focused on using technology to solve problems and analyze data (Smerdon et al., 2000).

Center for Research and Information Technology and Organizations

A similar study, called Teaching, Learning, and Computing (TLC), was conducted by the Center for Research and Information Technology and Organizations (Becker, 2001). This 1998 study included a 21-page survey of more than 4,000 teachers (grades 4–12). Approximately one-half of the schools in the study were "selected according to size and presence of computer technology, over-sampling larger schools and those with a greater density of various computer technologies" (Becker, 2001, p. 2). The other schools involved in the study were referred to as "purposive samples" and were selected from either "High-End Technology" schools (schools with substantial amounts of computer technology per capita) or "Reform Program" schools (teachers or schools who had been participants in a national or regional program involving major school or instructional reform). "At each sampled school, three to five teachers (3 in elementary, 5 in middle and high schools) were selected with probabilities related to the teacher's reputed use of technology and group projects and emphasis on higher-order thinking" (Becker, 2001, p. 3). In addition, a few teachers were selected by the principal, based on exemplary instructional practice or participation in instructional reform.

The primary results of this study (which relate to technology integration in subject areas) are illustrated in Figure 1. This chart is based on the percent of teachers who reported "frequent computer use," which was defined as 20+ uses by a typical student per academic year.

Based upon these data, the author concluded that students were most likely to encounter technology in self-contained elementary classes or in technology-related courses in high school (such as computer, business, or vocational settings). "The one area where one might imagine learning to be most impacted by technology—students acquiring information, analyzing ideas, and demonstrating and communicating content understanding in secondary school science, social studies, mathematics, and other academic work—involves computers significantly in only a small minority of secondary school academic classes" (Becker, 2001, p. 4).

Consortium on Chicago School Research

In 2000, the Consortium on Chicago School Research conducted a study to obtain baseline data on the instructional use of computers and the Internet in Chicago public schools (Hart, Allensworth, Lauen, & Gladden, 2002). By including survey questions in conjunction with a biannual survey of teachers and

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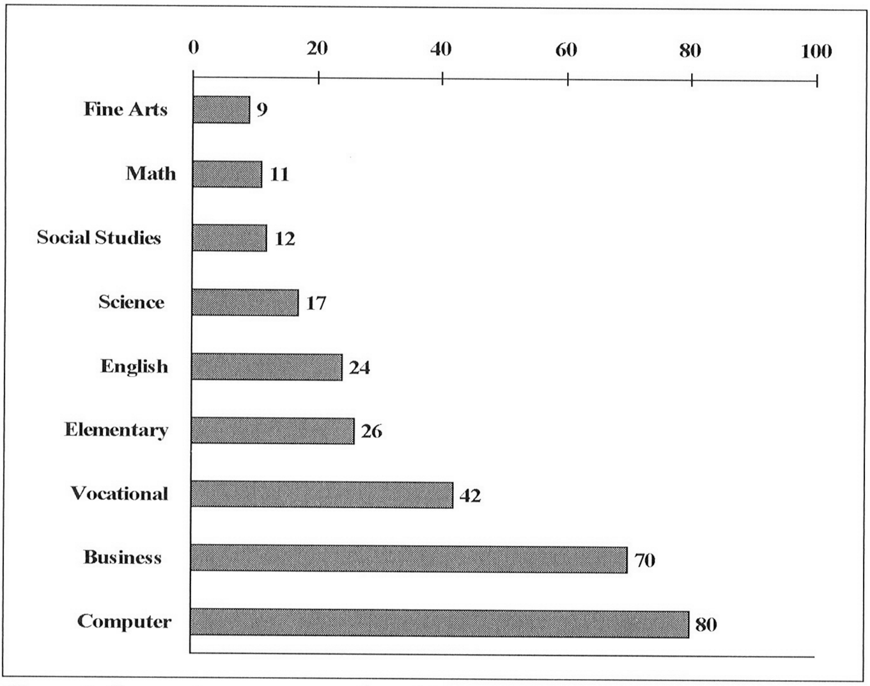

Figure 1. Frequent computer use by subject area (expressed as percentage).

students, the researchers obtained information from 8,572 elementary and 2,642 high school teachers. These surveys represent responses from 434 of the 577 schools in Chicago (representing a 75% participation rate for schools). Students in grades six through ten were also surveyed, with 87,732 responses.

Based on the data, the researchers concluded "the district lags behind the rest of the country in providing teachers and students with adequate access to computers and the Internet" (Hart et al., 2002, p. 1). They also investigated teachers' assignment of technology-related lessons and projects. Based on the responses from the teachers, they categorized teachers' levels of technology integration as follows:

- 6%—***Highly integrated***—Assign basic to moderate tasks on a weekly to daily basis; more complex activities such as demonstration, e-mail, computer programming, and Web page creation are assigned anywhere from once or twice a semester to daily.
- 11%—***Integrated***—Assign basic tasks as much as once or twice a week and moderately uncommon tasks, such as analyzing or graphing data and creating presentation, from once or twice a semester or once or twice a month; some occasionally assign using technology for demonstrations or e-mail.
- 24%—***Modestly integrated***—Assign basic tasks once or twice a semester to once or twice a month. Most also assign moderately uncommon tasks up to once or twice a month but do not assign more complex tasks such as demonstrations.

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- 31%—*Limited integration*—Assign low-level tasks such as word processing, practice drills, and research on the Internet from once or twice a semester to once or twice a month. Never assign any more complex tasks.
- 29%—*No integration*—Never assign technology to students in their target class (Hart et al., 2002).

Although there are differences in the selection criteria, survey questions, and findings of the studies conducted by NCES, TLC, and the Chicago Consortium, the studies provide important background information and comparisons for the research outlined in this article.

METHOD

A large school district in Florida was selected for the study. This district is number 22 on the list of the largest 100 public elementary and secondary school districts in the United States (Young, 2002). Within the district, there are 113,017 students; approximately 36% of the students are eligible for free and reduced-price lunches (Young, 2002). The district has a technology supervisor at the district level, and technology workshops are offered for teachers on a regular basis.

Instrumentation

In order to investigate teachers' use of technology in the classroom and to relate that use to the NETS guidelines, a survey was designed and sent to all teachers in the school district. Four domains were selected as focal points of the survey—integration; support; preparation, confidence, and comfort; and attitude toward computer use. This article focuses on aspects related to NETS—the integration domain.

The survey was constructed and reviewed by experts in technology and measurement. A pilot test was conducted with graduate students, including many K–12 teachers. At that point, psychometric information based on the pilot responses and participants' comments was used to guide minor revisions to the survey. The final document consisted of a four-page booklet—the first page was used to collect demographic information and the remaining pages addressed the four domains of investigation.

Data Collection

After obtaining clearance from the university's Institutional Review Board and the school district, the survey instrument was sent to all teachers in the school district. For each school, a letter addressed to the principal outlined the purpose of the study and requested assistance with the distribution of the individual surveys within the school. Once distributed, each teacher received a letter describing the study and either a paper version of the survey or instructions regarding participation using the Web-based version.

To determine which schools received the Web versions of the survey, a matched sample of schools was randomly selected. Using information from the Florida Department of Education's Web site (www.firn.edu/doe/doehome.htm), schools were matched based on grade level, school size, percentage of students

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receiving free or reduced lunches, non-White representation, and mobility rate. Approximately 20% of the schools were selected to receive the Web version (one school of each matched pair was randomly assigned to either the Web or paper version). However, schools that were chosen to participate in the Web version also received additional paper surveys in the event that individual teachers preferred to respond via paper.

To promote an optimal response rate, both individual and school-based incentives were offered. At the individual level, participation was encouraged by allowing teachers to register for a chance to win a free technology workshop provided by the Florida Center for Instructional Technology. Participants were also informed that the three schools with the highest percentage of teachers responding would win an on-site training session. A Web site was created so that participants could keep track of the response rates for their school and other participating schools that had responded.

Investigations into potential differences in response rates (paper vs. Web) suggested that teachers were more likely to return the survey via paper (39% response rate) than via the Web (10% response rate). However, follow-up analyses supported the premise that the Web sample and the paper sample were representative of the same general population (Lang, Raver, White, Hogarty, & Kromrey, 2000).

Respondent Sample

The sample of 2,156 respondents represents an overall response rate of 35%, of which 17% were male and 83% were female. These respondents represented a range of educational backgrounds, a variety of disciplines, and a diversity of teaching experience. Sixty-one percent of the respondents held bachelor's degrees, 36% held master's degrees, 2% held specialist or doctoral degrees, and 1% did not fit within these categories. Of the 547 respondents who indicated a core subject area, 33% specialized in English, 28% math, 20% science, and 19% social studies. Fifty-one percent of the respondents taught in elementary school, 26% in middle school, and 23% in high school. Across all three school levels, approximately 61% of the respondents had ten or more years' teaching experience. (See Table 1.)

Access to technology was reported both as the availability of a computer lab and the number of computers in the classroom. The average class size was 22, ranging from 1 to 60 students per classroom. More than 61% of the teachers reported access to a computer lab; the remaining 39% did not have access to a lab. The number of computers in the classroom ranged from 0 to 20. (See Table 2.)

Table 1: Years of teaching experience: By school level

	Years of Experience			
School Level	≤1	2-10	11-19	≥20
Elementary	6%	37%	22%	35%
Middle	8%	33%	22%	37%
High	5%	24%	27%	44%

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Table 2: Number of Computers in the Classroom

Computers in Classroom	Percentage
0	13%
1	26%
2	21%
3	13%
4	10%
5-9	12%
10-20	5%
Total	**100%**

RESULTS

As mentioned previously, the instrument was divided into logically and practically different sections/domains. Psychometric characteristics related to nonrespondent bias and factor analysis for each section are presented in detail in an article that focuses on the development and validation of the instrument (Hogarty, Lang, & Kromrey, 2003). Cronbach's alpha was calculated for each section of the survey. The analyses are based on classroom teachers' responses that did not contain missing data. Responses from other school personnel (such as guidance counselors) were excluded.

The survey included a section with items directly related to four teaching modes in NETS for Students (using technology as a research tool, communication tool, productivity tool, and problem solving/decision-making tool). The reliability estimate (Cronbach's alpha) for this set of items was .89 for the paper version and .87 for the Web version. Teachers responded on a 5-point frequency scale to items such as those shown in Table 3.

To simplify the presentation of results, the data were collapsed into two categories for analyses—*Yes* if the technology integration took place at least once a week, and *No* if the frequency was less than once a week. Results were examined for differences by school level and subject area. All tests of statistical significance were conducted at the .05 level.

Table 3: Integration of Computers into the Classroom

Directions: Listed below are teaching modes in which computers may be used. Indicate how often you use computers in each teaching mode. If you feel an item does not apply then circle (NA).	1=not at all 2=once a month or less 3=once a week 4=several times a week 5=every day	
As a research tool for students	1 2 3 4 5	NA
As a problem solving/decision making tool	1 2 3 4 5	NA
As a productivity tool (to create charts, reports or other products)	1 2 3 4 5	NA
As a communication tool (e.g., e-mail, electronic discussion)	1 2 3 4 5	NA

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School Level Differences

The χ^2 test of independence was used to compare elementary, middle, and high school teachers' integration of computers in the classroom. The proportions, Cramer's V, and probabilities are presented in Table 4 and graphically illustrated in Figure 2. When teachers used computers for problem-solving with their students, a statistically significant difference was observed across the three levels, χ^2 (2, N=1654)=15.5317, p=.0004. The proportion of elementary teachers was 29%; middle school teachers, 23%; and high school teachers, 20%. Odds ratios revealed that elementary school teachers were almost twice as likely (1.68) to use computers as a problem-solving or decision-making tool than were high school teachers.

Similarly, a statistically significant difference was found among the three levels when teachers used the computer as a communication tool with their students: χ^2 (2, N=1,671)=14.3777, p=.0008. The proportion of elementary teachers was 59%; the proportion of middle school teachers 54%; and that of high school teachers 48%. Odds ratios revealed that elementary school teachers were more likely (1.56) to use computers as a communication tool than were high school

Table 4: Integration of Computers in the Classroom by School Level

Use of Technology	Elementary	Middle	High	Cramer's V	Prob.
Problem-Solving Tool	29%	23%	20%	0.10	0.0004
Communication Tool	59%	54%	48%	0.09	0.0008
Productivity Tool	37%	40%	38%	0.02	0.6464
Research Tool	32%	34%	40%	0.07	0.0123

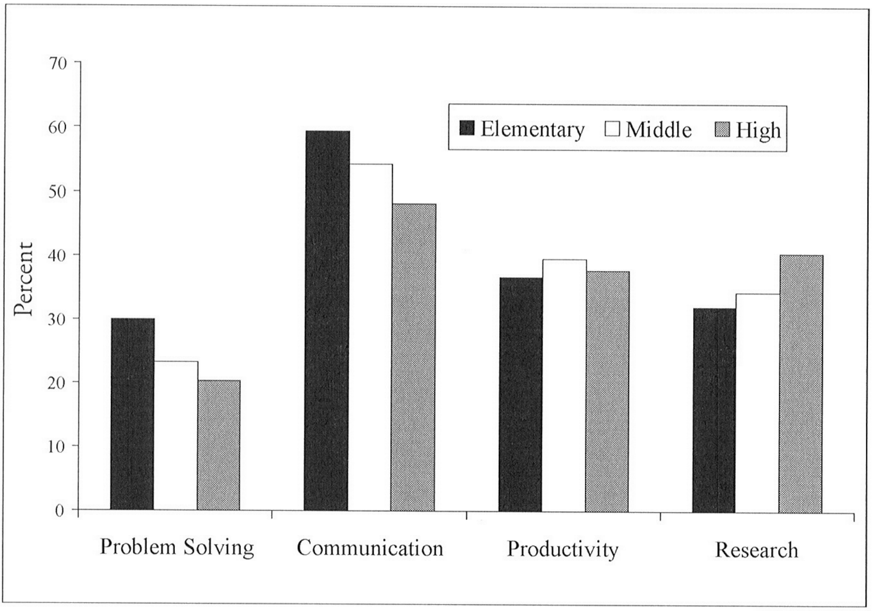

Figure 2: Integration of Computers in the Classroom by School Level

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teachers. Statistical significance was also noted across levels for the use of the computer as a research tool: χ^2 (2, N=1,668) p=.0123, with the proportion of elementary school teachers at 32%; middle school, 34%; and high school 40%. Statistically significant differences were not found across school levels for computer use as a productivity tool.

Subject Area Differences

The χ^2 test of independence was also used to compare English, math, science, and social studies teachers' integration of computers in the classroom. (See Table 5 and Figure 3.) In these analyses, only responses from middle and high school teachers were evaluated because the elementary schools did not use subject level differentiation.

A statistically significant difference was found across subject areas when teachers used computers as a research tool for students, χ^2 (3, n=413)=20.3431, p=.0001. The proportion of science teachers was 51%; social studies teachers, 44%; English teachers, 30%; and math teachers, 24%. Science teachers were

Table 5: Integration of Computers in the Classroom by Subject Area

Use of Technology	English	Math	Science	Social Studies	Cramer's V	Prob.
Problem-solving Tool	10%	17%	28%	23%	0.17	0.0066
Communication Tool	49%	49%	59%	54%	0.08	0.4535
Productivity Tool	32%	33%	48%	40%	0.13	0.0617
Research Tool	30%	24%	51%	44%	0.22	0.0001

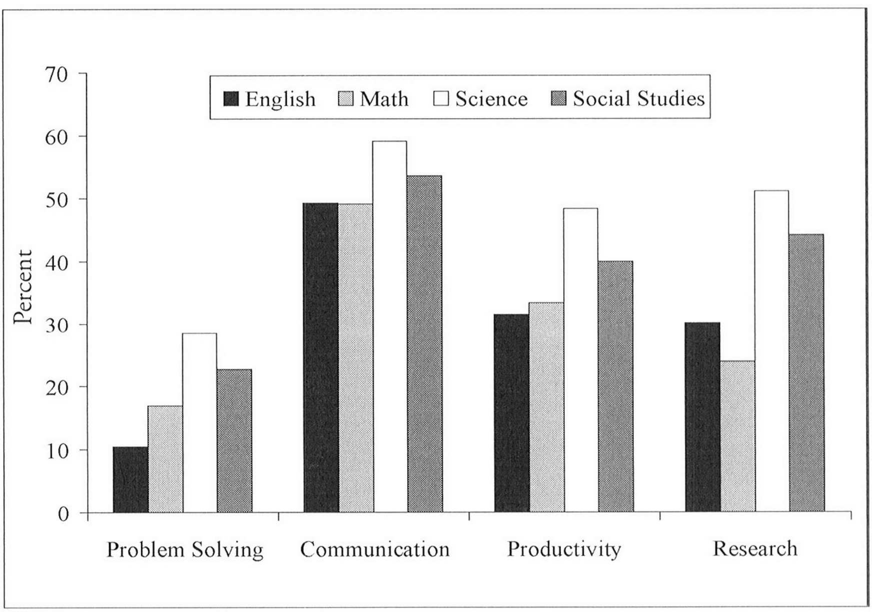

Figure 3: Integration of Computers in the Classroom by Subject Area

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found to be three times (3.33) as likely as math teachers and twice (2.42) as likely as English teachers to integrate computers as research tools. Similarly, social studies teachers were more than twice (2.52) as likely to use computers as a research tool in the classroom than were math teachers.

A statistically significant difference was also noted across the subject areas when teachers used computers as a problem-solving and decision-making tool with their students, χ^2 (3, n=409)=12.2470, p=.0006. The proportion of science teachers was 28%; social studies teachers, 23%; math teachers, 17%; and English teachers, 10%. Science teachers were found three times (3.42) as likely as English teachers, and social studies teachers were more than twice (2.52) as likely as English teachers, to use computers as a problem-solving tool in the classroom.

No statistically significant differences were evidenced between the subject area groups when computers were used as productivity tools or communication tools. In both cases, however, computers were used more in science than in any of the other content areas.

DISCUSSION

Teachers are a key element in addressing the technology standards outlined by the International Society for Technology in Education. This study investigated teachers' integration of technology through the administration and analysis of a survey that was sent to every teacher in a large school district. The response rate was 35% (N=2,156), and multiple analyses were conducted with the data.

With regard to integration of computers into the classroom, it appears that some components of the NETS for Students guidelines are being addressed in the schools that were surveyed. However, the degree to which the standards are being addressed varies a great deal by school level and subject area, with few of the percentages presented in Tables 4 and 5 surpassing 50%.

Although the survey items were slightly different in the NCES instrument, the results of this survey indicate a comparable number of teachers using computers in the classroom for research. Instead of using a *frequency of use* scale, the NCES instrument focused on *extent of use*—with values for *large extent, moderate extent, small extent,* and *not at all.* Values for the "Internet research" and "Using technology to solve problems and analyze data" categories were:

Internet research

- 21% Small extent
- 19% Moderate extent
- 12% Large extent
- 51% Total reported in Executive Summary (Does not sum to total due to rounding.)

Solve problems/analyze data

- 23% Small extent
- 19% Moderate extent
- 8% Large extent
- 50% Total reported in Executive Summary (Smerdon et al., 2002).

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If one assumes that moderate and large extent (in the NCES study) are roughly equivalent to a frequency of at least once a week (in this study), the numbers are comparable between the two studies—Internet research for NCES = 31%; Internet research for this study = 32% (elementary), 34% (middle), and 40% (high school). Likewise, the percentage of teachers using technology for problem solving in the NCES study (moderate plus large extent) equals 27%; this study reported 29%, 23%, and 20% for elementary, middle, and high school, respectively. Additional integration of technology must take place in this district before all students will have the opportunity to achieve the performance indicators set forth by NETS.

When comparing differences in teachers' integration of computers for various levels (elementary, middle, and high school), odds ratios found that elementary teachers were twice as likely to use computers as a problem-solving tool or communication tool than high school teachers. These results support findings by Becker, Ravitz, and Wong (1999), who found that "elementary teachers are more apt to use computers on a regular basis with their students" (p. 2). This could be due to the fact that elementary teachers generally have more flexibility in their schedules to integrate innovative approaches. Additional impetus, based on these findings, should be focused on encouraging high school teachers to embrace technology for communication and problem-solving activities.

In the investigation of subject area differences, results indicate that science teachers were three times as likely as math teachers and twice as likely as English teachers to integrate computers as a research tool. Science teachers were also three times as likely as English teachers to use computers as a problem-solving tool. English teachers did not exhibit the largest frequencies in any of the four areas that focused on technology integration and use in the classroom. These results were supported by the Chicago study, which reported mathematics teachers assigning technology at a rate higher than the system average, and English teachers at less than the system average (Hart et al., 2002). However, the results of the current study differ from TLC, which found that "the English teachers (24%) had their students use computers frequently. At the other extreme, only 11 to 17 percent of secondary math, social studies and science teachers frequently assigned computer work…" (Becker et al., 1999, p. 7).

There are several factors that could explain the discrepancy between the results of this study and the 1999 study by Becker, et al. The population for this study and the Chicago study included *all* teachers from a single, large school district. The Becker study included a national sample; however, many of the teachers (n=1,832) were "purposively" sampled from high-end technology schools and reform program schools. The remaining teachers (n=2,251) "were selected with probabilities related to the teacher's reputed instructional practices and use of technology" (Becker, 2000, p. 8). At each sampled school in the Becker study, only three (elementary) or five (middle and high school) teachers were selected. Purposively sampling technology-savvy teachers may have resulted in the variation of results.

The differences could also be related to the two-year interval between the studies, or they could be related to the structure of the survey questions or the

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definition of *frequent use*, which the Becker study defined as 20+ uses by a typical student per academic year and this study defined as at least once a week. Further investigations could focus on additional subject area use of technology in the classroom, as well as subject area differences that might exist in teacher preparation and training. Findings could then be used to outline subject-specific training needs (for inservice workshops) and could help structure courses for teacher preparation programs.

Limitations of the Study

Some limitations of this study should be noted. First, the study included teachers from only one school district. This district offers inservice technology training and support for teachers through workshops, public television programs, and technology specialists. Surveys of teachers in other states or school districts with different levels of access to technology or various levels of technical support may produce different results.

The fact that the survey results are based on self-reported data is another limitation. One might predict that those teachers who voluntarily responded to the survey were perhaps more interested in computers than those teachers who did not respond. The incentives (technology workshops) may have also served to bias the results towards teachers interested in computer use.

CONCLUDING REMARKS

The goal of national and state technology standards is to establish a baseline level of technology competence for all students. "When students are able to choose and use technology tools to help themselves obtain information, analyze, synthesize, and assimilate it, and then present it in an acceptable manner, then technology integration has taken place" (U.S. Department of Education, 2002, p. 79). Large-scale surveys of teachers, such as this one, can provide data to help answer key questions, such as those recently outlined by NCES: "Is technology integrated into the teaching/learning environment?" and "Are technology proficiencies and measures incorporated into teaching and learning standards?" (U. S. Department of Education, 2002, p. 74).

This study provides data that indicate many teachers are implementing technology as a tool for research, communication, productivity, and problem solving; however, the goal of technology integration across all subject areas and grade levels is yet to be reached. The proportion of teachers using computers as a tool in the classroom in this study ranged from 20% (problem-solving tool in high schools) to 59% (communication tool in elementary schools). Across subject areas, the range was 10% (problem-solving tool in English) to 59% (communication tool in science).

The Enhancing Education through Technology Act of 2001 requires that state educational agencies "assist every student in crossing the digital divide by ensuring that every student is technologically literate by the time the student finishes the eighth grade, regardless of the student's race, ethnicity, gender, family income, geographic location, or disability" (No Child Left Behind Act, Title II, Part D, §2402). As this Act takes effect and technology standards are being

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implemented throughout the nation, measures related to technology integration become crucial. The survey instrument discussed in this article is currently being used in several technology integration research initiatives. For example, several districts throughout Florida have adopted the instrument to gather baseline data or to track progress. In addition, the survey served as a framework for a statewide, Web-based study that is currently underway. Copies of the instrument may be obtained from the first author.

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