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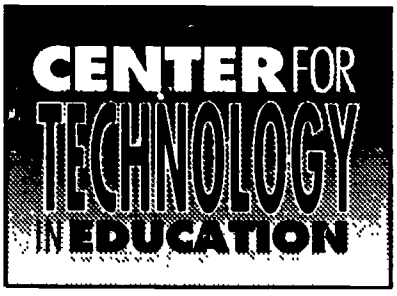
ABSTRACT

This report summarizes the results of a nationwide survey of teachers in grades 4 through 12 who are experienced and accomplished at integrating computers into their teaching. Of 1200 teachers who were sent one 16-page questionnaire, 608 returned completed surveys. The purpose of studying these teachers was to discover the ways in which they use computers in their classrooms, whether and how they believe their teaching has changed as a result of using computers, and the kinds of barriers and incentives that are important to them. Major findings show that these teachers: (1) are comfortable with computer technology, devote their own time to learning how to use computers, and receive local support for using them; (2) work in schools averaging more than twice the number of computers than other schools; (3) use computers for many purposes including demonstrating an idea, instruction, word processing, and promoting student-generated products; and (4) expect more from their students, are able to present more complex materials to their students, and foster more independence in the classroom. It is concluded that similar accomplishments on a wider scale may be achieved if ample technology, support, and time for teachers to learn the technology is provided, and if an academic and cultural structure exists to encourage teachers to take an experimental approach to their work. (DB)

ACCOMPLISHED TEACHERS

◆ Integrating Computers ◆ into Classroom Practice

Karen Sheingold
and
Martha Hadley



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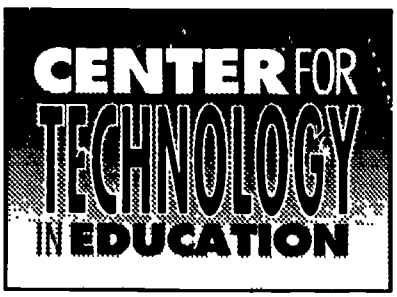

Bank Street College of Education
September 1990

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This study could not have taken place without the many organizations and individuals who recommended teachers to be included in the sample. These several hundred contacts included the state directors of educational technology for all 50 states; national organizations such as the Association for Computing Machinery, The Council of the Great City Schools, and the National School Boards Association; hardware vendors; Apple Computer and IBM; software publishers, including Sunburst, Scholastic, and Wasatch; as well as many individuals in colleges, schools, and other organizations throughout the country.

We want to give special thanks to the many teachers who, at the busiest time of the school year, took the time to complete the survey. This study is as much *for* them as it is *about* them, and we hope they find their efforts at least in part repaid by this report.

Finally, there are many people who read and commented on earlier drafts of this report—colleagues at Bank Street and at other institutions, members of the Center for Technology in Education's Advisory Board, as well as teachers and administrators in several states. Their comments helped immeasurably.

This research was supported by the Center for Technology in Education under Grant No. 1-135562166-A1 from the Office of Educational Research and Improvement, U.S. Department of Education, to Bank Street College of Education.

EXECUTIVE SUMMARY

This report summarizes the results of a nationwide survey of teachers who are experienced and accomplished at integrating computers into their teaching. The purpose of studying these teachers was to describe the range of their practices with currently available technology, the perceived value of these practices, and the circumstances that may promote or hinder effective technology use. Specifically, the goals of the study were to find out:

- who these teachers are;
- how they use computers in their classrooms;
- whether and how they believe their teaching has changed as as result of using computers; and
- the kinds of barriers and incentives that have been important for them.

The sample was selected through contacts with state and local technology directors, hardware and software vendors, professional organizations, and others. Although chosen because of their involvement in using technology for teaching and thus not representative of teachers in general, the sample includes teachers in grades 4 through 12 in all 50 states who come from the full range of public schools and communities nationwide. Of 1200 teachers who were sent the 16–page questionnaire, 608 returned completed surveys.

Findings

The major findings with respect to the central trends in the data are:

These teachers devote considerable time and effort to teaching with computers in their classrooms, and are supported in their efforts. These teachers are motivated to teach with computers, are comfortable with the technology, devote their own time to learning how to use it, take advantage of local opportunities to learn, and receive considerable local support.

The key incentive for them in teaching with computers is their students' using these tools effectively for their own learning. Student engagement with learning and the teachers' gratification from learning new skills are also important.

These teachers work in schools that have extensive technology as well as experience in using technology for instruction. These schools average more than twice the number of computers in a random sample of schools nationwide (59 per school, in contrast with 26), and many also have more sophisticated technologies (e.g., hard disk drives, laser printers, videodisc players). Most of the schools have been using computers for instruction for at least four years, and have a considerable number of teachers (42%) using the technology for instruction

These teachers use the computer as a multipurpose tool. They have a large software repertoire that includes both instructional software (e.g., drill-and-practice programs, problem-solving software) and tool uses (e.g., word processors, databases). Moreover, these teachers take multiple approaches to how computers are used in their classrooms for purposes as varied as demonstrating an idea in front of the class and remediation. The approach used frequently by the largest number of teachers (six in ten) is students' making their own products with the computer.

Using the computer has changed their teaching. For most of these teachers, computers have made a real difference in their teaching. The changes they perceive include a change in their expectations about student performance—they expect more of their students and can present more complex material; greater opportunities for individualization and for students' working independently; and changes in the roles of teachers and students such that classrooms are more student centered and teachers act more as coaches and facilitators.

It takes time for these teachers to master computer-based practices and approaches—fully five to six years of teaching with computers. Teachers' practices tend to develop from those that directly reinforce what is being taught to those that, while including earlier practices, are more expansive (e.g., tool uses). These practices tend to be well organized once teachers have had about five to six years' experience teaching with computers.

Although barriers to the integration of computers have lessened for most of these teachers over the years, significant barriers still remain. The most serious problems for these teachers are inadequate amounts of hardware and of time to plan and carry out computer-based lessons.

It is significant that the schools and teachers that appear to have the most in the way of technology resources believe they need more. We suggest that some have reached a critical juncture: They

want to accomplish more with technology, but cannot do so without more technology and unless some organizational changes take place. These include reorganizing the school schedule so that teachers have time to plan their computer-based work.

Conclusions

In summary, we have found a group of motivated teachers who are accomplished in using computers in multiple ways in their classrooms, and who report impressive changes in their teaching practice as a result. Many of the practices and changes they report (e.g., presenting more complex material to students, giving students more individual attention, allowing students to work more independently, and becoming more of a coach and facilitator in the classroom) are being sought by those who are attempting to reform schooling.

What are the factors that have contributed to their achievements? Three stand out:

First, the teachers' motivation and commitment to their students' learning and to their own development as teachers;

Second, the support and collegiality they experience in their schools and districts, and;

Third, access to sufficient quantities of technology. These factors act in combination and over the long term to enable teachers to develop their expertise to use the technology in new ways. The teachers' willingness to learn and change appears to be a critical element in this process.

Can the accomplishments of these teachers be realized on a wider scale? We believe so, but only under circumstances in which:

- there is enough technology (and, in particular, enough technology for teachers to have unrestricted access);
- there is ample support and time for teachers to learn how to use it and to plan for its use; and
- there is a school structure and culture in which teachers are encouraged and expected to take a professional and experimental approach to their work.

INTRODUCTION

As students use computers for writing, they work more independently and cooperatively. This enables me to work with individuals who need more assistance. I spend less time correcting student writing and more time discussing ideas and ways to solve writing problems. Students are permitted more physical freedom and do more shared learning in this atmosphere.

–high school teacher, New Mexico

I can now work with students in greater breadth and depth than was imaginable 20 years ago . . . in spherical trig we used to use 7-place logs and endured much tedium and many errors. Today we do statistics projects involving massive data and sophisticated analysis with relative ease and can concentrate on interpretation instead of computation. . . .Twenty years ago we put together the newspaper with linotype and Ludlow slugs and had little time for serious editing. Today, each student knows about Times Roman, Helvetica, etc., edits his own work, and even learns something about design. Teaching is a rich experience when you work with empowered students.

–high school teacher, Indiana

It has gone from direct teaching and directing to more of a monitor, facilitator, resource person. The students are doing more discovery-type learning and relying more on their resources to gain new knowledge . . . applying their skills more.

–elementary teacher, Maine

These three teachers are among a group of more than 600 specially selected teachers who took part in a nationwide survey conducted by the Center for Technology in Education in the spring of 1989. Nominated because of their involvement and accomplishments in integrating computers into their teaching, the teachers surveyed are, on the whole, a mature group who teach a range of subject matter (grades 4-12) in public schools nationwide. Their comments, along with other findings, suggest that they may be incorporating technology into their practice and classrooms in ways that deeply affect what they do and what their students experience.

The story that has emerged from this survey, however, is not a simple one. The results are at once encouraging and surprising about what the teachers are achieving with technology, and sobering about the effort, time, and support needed to realize these accomplishments.

The study was undertaken to find out who these teachers are, what they do with computers in their classrooms, whether and how they believe their teaching has changed, and the kinds of barriers and incentives that have been important for them. Through studying these teachers, we wanted to describe the range of their practices with currently available technology, the perceived value of these practices, and the circumstances that may promote or hinder effective technology use.

Prior to this study, surveys based on random samples of schools nationwide (1) reported that computer technology is playing a minimal role for most students. Although the prevalent type of computer use has changed somewhat within the past decade, it remains the case that overall in U.S. schools computers are not an integral part of subject-matter instruction. While the survey results are sobering, a number of small-scale computer-based intervention studies (2) have demonstrated significant changes in classroom practice as students and teachers incorporate computers into subject-matter learning. In these studies, as well as in a comprehensive national report by the Office of Technology Assessment (3), the central role of the teacher has been emphasized. At the same time, there are as yet unstudied schools and classrooms throughout the country where teachers are making significant and visible efforts to use computers for their subject-matter teaching. It is to these teachers that we turned to gain a broader and deeper understanding of what is happening with current technologies in some of the nation's classrooms.

This report describes the study, its general results and central trends for the teachers as a whole. In later reports, we will discuss characteristics of the subgroups that make up the larger group and provide more detailed analyses of the variability in the results.

BACKGROUND: SAMPLE SELECTION AND QUESTIONNAIRE

This study is distinguished both by the sample of teachers, and by the comprehensive nature of the questionnaire itself. We sought out a unique group and asked them to tell us a great deal about their experiences using computers in their teaching.

We sought out a group recognized for their accomplishments and asked them to tell us a great deal about their experiences using computers in their teaching.

Sample Selection

We set out to find a large number of teachers, individuals who were known for their efforts in integrating computer technology into their curricula. We wanted participants in grades 4 through 12 in urban, suburban, and rural public schools in all 50 states. We wrote letters, phoned, and pursued leads through state and local directors of educational technology in all 50 states, the hardware and software industries (e.g., Apple, IBM, Sunburst, Wasatch), professional organizations (e.g., National School Boards Association, The Council of the Great City Schools), leading educators and researchers in the field, and a magazine article that invited self-nominations.

This search resulted in a database of more than 1200 names, including teachers from every state, all major cities, and many smaller towns. Just under half were computer coordinators who were also teaching After an initial mailing of the questionnaire and a follow-up mailing to those who had not responded, we received completed returns from 608 participants from 576 different schools. This group constituted our sample.

While inclusive of all regions of the country, the sample is not, nor was it intended to be, representative of all teachers or schools. We wanted to question those teachers who were known for and experienced in the use of computers in their teaching. Moreover, we did not in advance define specific selection criteria for these teachers, but rather accepted the recommendations that were made through the referral process. Therefore, an important part of our task was to find out who these teachers were and what made them special.

The Questionnaire

The questionnaire was constructed after we reviewed related survey instruments by other researchers and interviewed groups of teachers in three states. Teachers piloted and helped to refine the draft questionnaire.

The 16–page survey took participants 30 to 60 minutes to complete. Most of the questionnaire consisted of items that were checked or ranked, with a few questions that required written responses (e.g., "Give an example of the most productive and interesting use of the computer in the curriculum you teach"). It included sections on:

- teacher's current practices using educational technology;
- ratings of barriers to integration in the past and present;
- ratings of incentives to integration;
- perceived changes in their teaching resulting from integration of technology;
- descriptive information about their own training, experience with computers, and point of view about computers; and
- demographics about themselves and their school.

RESULTS

Range of Schools and Communities

Although not a random or representative sample, the schools and communities in which these teachers work reflect the demographics of public schools nationwide, as reported by national statistics (4). In terms of school size, region of the country, size of town or city, the ethnic composition of the student populations, the distribution of this sample falls within national norms (see Table 1, Appendix). In comparison with these norms, the sample is somewhat skewed with respect to grade level, high schools being moderately overrepresented, and with respect to economic level of the students' families. Using teachers' judgments as our measure of the income level in their school community, the sample is slightly skewed toward less economically advantaged school populations.

It is significant that our results revealed very few differences related to conventional demographic variables (e.g., size of school, size of community, economic level of community).

Abundant Technology and Experience in Its Use

As expected, these schools are unusual when it comes to technology. The average number of computers in these schools, 59, is more than double the 26 reported in a recent random survey of U.S. schools (5). The number of computers varies with the level of the school, with elementary schools averaging 39 computers, middle schools 53, and high schools 83. (The comparable random sample means are 19, 26, and 45, respectively.) In most (62%), students have access to computers in both labs and classrooms, while 25% have computers in labs only, and 13% in classrooms only.

These schools are unusual when it comes to technology. The average number of computers in these schools, 59, is more than double the 26 reported in a recent random survey of U.S. schools.

A number of these schools have more sophisticated technologies, such as hard disk drives (56%), laser printers (37%), optical scanners (23%), voice synthesizers (30%), and videodisc players (33%). The most prevalent noncomputer technology available is the hand-held video camera, which 94% of the schools own.

As for experience in teaching with technology, in almost nine out of ten of these schools, teachers have used computers for instruction for four or more years, in some for more than ten years. In these schools, almost half (42%) of the teachers use computers for instruction.

Experienced and Motivated Teachers

The teachers in this sample are, on average, a mature and experienced group, more than half between 40 and 49 years old, and three quarters having been teachers for 13 years or more. In terms of gender, this group is more equally distributed than are public school teachers overall—58% women and 42% men in contrast with 68.8% women and 32.3% men nationally (6). This result could reflect technology-related factors and/or the exclusion of grades K-3 from this sample.

As a group, these teachers are comfortable with computers.

As a group, these teachers are comfortable with computers. They express very high agreement (a mean rating of 5.79 out of 6.00) with the statement, "I am personally comfortable with computers as a tool for my own work." Such comfort is not surprising, because most of the sample teachers (73%) have used computers in their teaching for five years or more, some for more than nine years. Since personal computers have been available to schools for little more than a decade, this is clearly an experienced group.

To learn how to use computers in their classrooms, these teachers have taken advantage of many different opportunities, both inservice and on their own time.

Training and support. To learn how to use computers in their classrooms, these teachers have taken advantage of many different opportunities, both inservice and on their own time (see Table 2, Appendix). Almost nine out of ten indicate that they are to some degree self-taught. Close to eight out of ten have attended conferences and workshops on their own time. About six in ten have taken inservice courses offered by the district and/or at school. And about four in ten have taken other courses offered by the school and/or district (not inservice),

courses in their graduate or undergraduate schools, or have received on-site instruction from other teachers or consultants.

Moreover, these teachers are eager consumers of information about computers and the curriculum and make use of multiple sources. Specifically, nine out of ten of these teachers get information from software catalogues, computer education magazines as well as general computer magazines, and conferences related to computer education. Eight in ten get information from workshops offered by the school and/or district, books, and other information supplied by the school and/or district. Interestir. ' most (more than eight in ten) of these teachers have computers at home for their use.

As motivated as these teachers are, they are also receiving a significant amount of local support. Most (77%) report that they have continued access to on-site support and advice. This includes help from other teachers, from a school computer coordinator or aide, a district computer coordinator, and a range of other consultants, groups, and representatives. While committed individuals, many of these teachers appear to be working in environments where they are not alone in their interest in computers for teaching, and where various forms of support are accessible in the school and district.

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Teaching with Technology: Current Practices

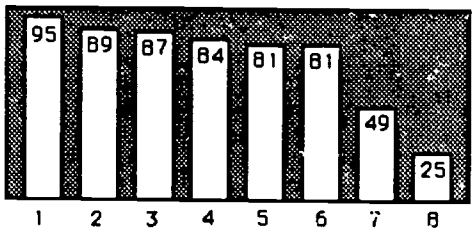
One of the most striking results of this study is the number of different uses, or practices, teachers report. On average, these teachers use between 14 and 15 different practices (each of the 37 items on the graph constitutes a "practice" for these purposes). For most of these teachers individually, then, computers are not single-use machines, ' ' rather multipurpose tools that can be used in many ways. In addition, the range of uses across the sample is most impressive. Virtually all computer-based technologies currently available to schools are used by at least some teachers in this sample—from robotics, to school-to-home telecommunications, to music composition programs, to videodiscs.

For most of these teachers, computers are not single-use machines, but rather multipurpose tools that can be used in many ways.

PERCENT OF TEACHERS USING COMPUTER-BASED PRACTICES

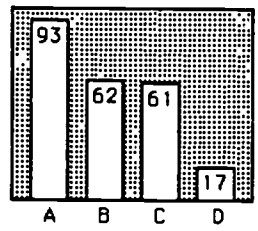
Sample 608
(Multiple Mentions)

ALL SOFTWARE TOOLS



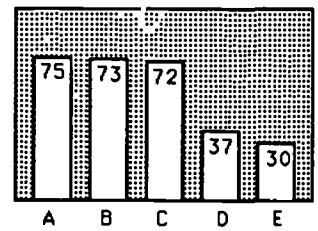
1 Text Processing Tools
2 Instructional Software
3 Analytic & Information Tools
4 Programming and Operating Systems
5 Games & Simulations
6 Graphics & Operating Tools
7 Communications
8 Multimedia

1 Text Processing Tools



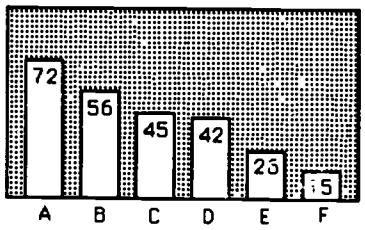
A Word Processor
B Keyboading
C Spell-Checker, Thesaurus
D Outliner

2 Instructional Software



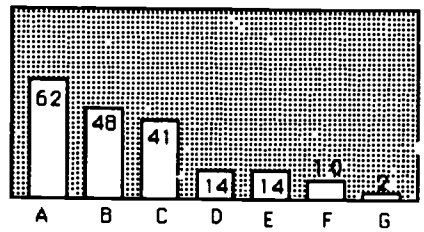
A Problem Solving Programs
B Tutorial Programs
C Drill & Practice Programs
D Software Accompanying a Textbook
E Conceptual Tools

3 Analytic & Information Tools



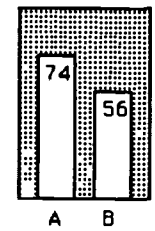
A Databases
B Spreadsheets
C Chart/Graphing
D Calculator (as part of computer)
E Lab Interfaces
F Statistical Programs

4 Programming and Operating Systems



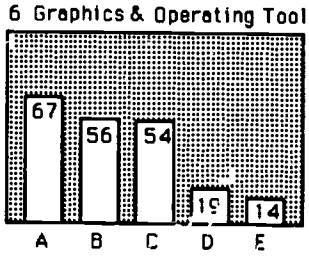
A Operating Systems
B BASIC
C LOGO
D Pascal
E Computer Authoring Programs
F HyperTalk
G Fortran

5 Games & Simulations



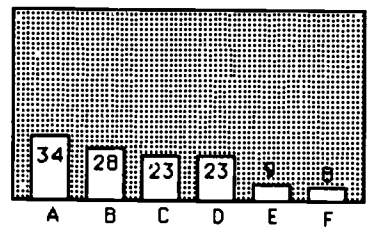
A Microworlds, Simulations, Instructional Games
B Recreational Programs /Games

6 Graphics & Operating Tools



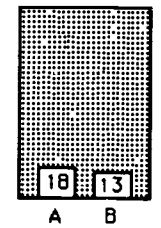
A Ready-Made Art
B Painting or Drawing
C Desktop Publishing, Page Layout, etc
D Drafting, Computer-Aided Design
E Music Composition

7 Communications



A Public Bulletin Boards
B On-Line Databases
C On-Line Services
D School-to-School Communications
E Commercial Mail
F School-to-Home Communications

8 Multimedia



A Videodisc
B Robotics

What Teachers Use

In general, these teachers have a varied repertoire for computer use in the classroom. They use a range of software that includes both content-specific applications and tools. And what they use varies in relation to both the grades and curricula they teach.

These teachers use a range of software that includes both content-specific applications and tools.

Predictably, the most popular and versatile uses are not the most advanced technologically. Text-processing tools and, in particular, word processors are used by more than nine out of ten of the teachers in this sample. They are used at all grade levels. Not only do teachers use these tools, but, when asked to give examples of their "most productive and interesting use of the computer in the curriculum they teach," those who responded (75% of the sample) gave more examples of writing and language projects than of any other uses. As one teacher illustrates:

Language arts classes through writing labs generate some fantastic copy for DTP [the class publication]. Students also have open access to the computer room beyond writing labs to utilize software tools to organize, edit, proof, and illustrate their writing pieces for publication. Our literature-based curriculum is a perfect setting to effectively use technology in developing writing skills and changing student attitudes. Students share their ideas and learn to appreciate the ideas of other students and the skills needed for effective communication.

Word processing has become part of many curricula, from the obvious language arts, to not-so-obvious social studies, to science, which is quite surprising. Indeed, word processors are the most popular applications for the science teachers in this group, 40% of whom report using them.

Using the word processor seems to be the most productive and interesting because of its versatility. It can be used for writing assignments across the curriculum, with a variety of abilities. I use it in reading, writing, science, health, speliing. AppleWorks and Logowriter give a lot of flexibility to the program.

Clearly, word processors and other text-processing tools are playing a central role in the classroom. These tools appear to have the broadest current use across the curriculum. From what these teachers tell us, these applications have affected both where and how writing gets done in their schools and classrooms.

Clearly, word processors and other text-processing tools are playing a central role in the classroom. These tools appear to have the broadest current use across the curriculum.

Instructional software runs a close second to word processing with respect to the number of teachers who use it. It includes problem-solving programs, tutorial programs, and drill and practice. These more structured programs are used to some extent in all curricular areas, except art. They are used heavily in mathematics, where 67% of those who teach mathematics use drill and practice, in foreign language (62%), and in remedial work (77%). And they are used much more in grades 4 through 6 than in grades 7 through 12 (see Table 3, Appendix). Says one elementary teacher:

I currently teach Chapter I and have found drill-and-practice games (i.e., Microzine Math Mall) excellent for reinforcing basic facts. I have also used Microzine Monitor Mysteries and "adventure" stories as motivators in reading for meaning. I have used a spelling program with mazes and a joystick for one very low, reluctant fourth grade remedial speller. We do not have much software, but I have ordered quite a bit for next year. Computers have taken over the "drill and practice" of Basic Skills, allowing me more time to develop problem solving and higher level thinking skills with my class.

Analytic and information tools are used by almost as many teachers as use instructional software, with databases the most prevalent application in this category. These uses increase significantly with grade level. Databases are used most by social studies teachers (52%), but also in science (38%) and computer literacy (40%) classes. The other analytic tools (e.g., spreadsheets, chart/graphing programs, lab interfaces) are used in science, mathematics, and, to some extent, in computer literacy classes.

Within my five geography classes, the students prepared a world database using a modified DBase III program. The students made it themselves because we did not have the money to buy a prepared database. My school is the most ethnically diverse in the country, with students born in 57 different countries. With reading-math stanines from 1-7 (with 9 high) the computer was used as a tool.

Some of these teachers have tried applications in the past that they are no longer using—most notably, BASIC and Logo, which about 30% of these teachers are no longer using.

Importantly, the computer-based practices these teachers engage in have shifted over time. Some of these teachers have tried applications in the past that they are no longer using—most notably, BASIC and Logo, which about 30% of these teachers are no longer using. In their decreasing use of these programming languages, these teachers are ahead of a similar but weaker trend recently

reported from a random sample of schools (7). In addition, about 15% of these teachers are no longer using keyboarding, drill-and-practice programs, tutorial programs, the calculator (as part of the computer), computer authoring, and recreational programs and games.

Moreover, many of these teachers are interested in trying technologies that may now be beyond their schools' current capacities. About half of the teachers would like to try school-to-home and school-to-school telecommunications, videodiscs, and robotics. About 4 in 10 would like to try on-line services, on-line databases, commercial mail systems, outliners and idea processors, music composition programs, and statistical programs. And about one third would like to try drafting and computer-aided design, lab interfaces, and HyperTalk.

About half of the teachers would like to try school-to-home and school-to-school telecommunications, videodiscs, and robotics.

Frequency and Approaches to Computer Use

Knowing *that* teachers use a type of software tells us little about *how often* they use it, or *how* they use it. A somewhat different profile emerges when teachers are asked about the three most frequently used applications or types of software in their school; we find large differences among the top three mentioned items. Word processors ranked first (75%), drill-and-practice programs second (37%), and tutorial programs (24%) third. Overall, word processors are in use much more frequently in these classrooms than are drill and practice and other types of programs. Elementary schools use word processors somewhat less than do schools at other grade levels (significantly less than do high schools), and drill-and-practice programs considerably more than do middle schools and high schools (see Table 4, Appendix).

How do students use computers in these classrooms? Just as there are many types of software in use, so too there are many approaches to and purposes for using the technology. To address these issues we asked how often (never, some weeks, most weeks, every week) students used computers for certain types of activities and purposes—e.g., drills, direct instruction by computer, students making their own products, remediation, enrichment.

Just as there are many types of software in use, so too there are many approaches to and purposes for using the technology.

Consistent with their use of different types of software, most of the teachers in this sample also use multiple approaches with computers. Especially revealing is what teachers report doing frequently—most weeks or every week.

- The most frequent use is students' creating their own products. More than 6 in 10 teachers do this most or every week, and fewer than 1 in 10 report not doing it at all.
- About 4 in 10 teachers use computers for each of the following: enrichment, remediation, or for the teacher's explaining or demonstrating an idea or skills using a computer in front of the class.
- Approximately 3 in 10 use the computer for students' doing drills, for each of the following: students' exploring instructional programs on their own during class time, or for students' receiving direct instruction by computer.
- Only 1 in 10 uses the computer for tests or quizzes, by far the least frequent activity.

Not only are students making their own products with computers in many of these classrooms, but some classrooms are engaged in project-based learning activities that include several different applications.

Not only are students making their own products with computers in many of these classrooms, but, based on teachers' open-ended descriptions of "the most productive and interesting use of the computer in the curriculum you teach," some classrooms are engaged in project-based learning activities that include several different applications. Very often, these involve writing, editing, and producing reports, newsletters, and magazines, using a variety of software tools. A fifth-grade teacher reports:

The class publishes a school newspaper. They interview students, then write and edit an article. The article is typed into the computer ("Newsroom" or "Children's Writing and Publishing Center"). The heading is designed and layout done by teams. The newspaper is then printed, copied and sold. Proceeds go to a class gift to the school.

But there are other activities as well. A teacher from the state of Washington describes a much more high tech project:

Students create media reports using videodiscs, CD-ROM, and traditional library materials to create their own "Nova" programs on videotape. Students research a topic, find appropriate video or create their own (live playground interviews), lay the video down, write and edit the narration, then audio dub their narration over the video segments. They then use VCR Companion to create titles and credits.

In other academic subjects, from science to economics to French, students use multiple applications to carry out a given project:

We are using the on-line database service, DIALOG, in grades 5 through 9 for our science classes in order to conduct research. Several schools are collaborating in this effort. Students conduct joint (interschool) experiments via electronic mail and share results with other schools. Students use AppleWorks to write reports and the Science Toolkit (lab interface) in some of the experiments. Scientists from local research and development companies work with students (via mail) to pose questions and answer them.

* * *

An economics fair project . . . students used "Magic Slate" to write letters and desktop publishing software to produce a newsletter and design posters, banners, business cards, and signs. They used "Super Print" to do a U.S. map illustrating the sources for the ingredients in their product. They all kept track of their budgets on spreadsheets.

* * *

The computer was used very effectively in my astronomy unit. The students did star, planet, and constellation research, making databases for each. Using print statements they wrote computer programs to display graphically the constellation. They first took a "star quiz" on the computer and then added their own questions to the quiz.

* * *

Telecommunications has helped students in my French classes use the language they are learning in a meaningful context. We have written collaborative stories with students in other schools, exchanged ideas on pollution and the French Revolution with students in France, participated in an international conference based in Paris, and consulted French travel databases in the French MINITEL. We have used both MIX and MINITELNET as services.

* * *

My sixth grade class built a 5m x 8m greenhouse. We installed a 100 gallon aquaculture tank and hooked the Bank Street Lab to it. We daily monitor the light intensity and the water and air temperatures in the greenhouse and graph the data. Then we use "Island Survivors" and correlate our "Biospace" data with the survival simula-

tion. We continue to search for applications of math and science in our curriculum.

In summary, most of these individual teachers use computers as a multipurpose tool. As a group, they use the full range of software and computer-related technologies, from simpler to more advanced. The word processor is the most widely used software by this group throughout the curriculum. The most widely used approach is for students to make their own products, using software tools. A number of these teachers describe as the most productive and interesting use of the computer, student projects that incorporate several different kinds of software.

Changing Classrooms

There are changes related to these teachers' expectations about student work.

In the eyes of these teachers, significant changes are taking place as they integrate computers into the curriculum. Fully 88% of the teachers in the sample indicate that computers have made a difference in their teaching, the remainder being unsure or negative.

What kinds of changes do these teachers report? Through the items they check as well as the examples they provide, there are three kinds of changes they perceive. First, there are changes related to their expectations about student work; that is, they expect more of their students, and can present more complex material. Their quotes suggest that some believe their students are grasping more difficult concepts, and developing thinking skills.

It is more exciting for me and my students. Concepts are being learned that I would never have considered 20 years ago.

* * *

I have been able to increase student productivity and enhance laboratory routines by implementing the computer as a lab tool. Students become better problem solvers and divergent thinkers when they are able to focus their lab experiments in their own direction using the computer.

* * *

My classroom is much more investigatory. I expect more higher order thinking from my students. Cooperative skills are emphasized.

How Teaching Has Changed
(for 494 teachers who say computers have made a difference)

		Percent agreement
1.	I can expect more from my students in terms of their pursuing and editing their work.	72%
2.	I spend more time with individual students.	70%
3.	I am more comfortable with students' working independently.	65%
4.	I am better able to present more complex material to my students.	63%
5.	I am better able to tailor students to their individual needs.	61%
6.	I spend less time lecturing to the entire class.	52%
7.	I am more comfortable with small-group activities.	43%
8.	I spend less time with the whole class practicing or reviewing material.	40%

The second way in which these teachers believe computers affect their teaching is that they can meet the needs of individual students better The computers permit greater individualization as well as more independent student work. They allow teachers to give greater attention to individual students:

The computers permit greater individualization as well as more independent student work.

I am individualizing again. I had given up individualization because of discipline problems which arise in large classes with a teacher-student ratio of 35 or 38 to 1. Now, if possible, I wouldn't want to be in a classroom without computers.

* * *

I am more flexible in allowing students to work on their own projects, at their own pace, and in their own order than previously. I am now looking for other ways to provide learning experiences for the children.

* * *

I have used the IBM earth science series to a great advantage. My lectures are shorter on the topics covered by the software. I let the students set their own individual pace, and take responsibility for their own learning. It gives me more time to float around the classroom and interact with the students on an individual basis.

* * *

A much more individualized approach has been evident in my classroom. It is more manageable to have students on different projects while using computers.

A third kind of change for many of these teachers is that integrating the computer has turned a teacher-centered classroom into a student-centered one, with the teacher acting more as coach than as information dispenser, and with more collaboration and work in small groups going on among students and between student and teacher:

Integrating the computer has turned a teacher-centered classroom into a student-centered one.

It has enabled me to change from a teacher-centered classroom to a student-centered classroom. It has also led to a more open-ended approach to problem solving, rather than the pursuit of one correct answer.

* * *

I have become more comfortable in the role of facilitator as opposed to a lecturer. I am able to encourage children to find answers for themselves as opposed to giving them answers.

* * *

I do not teach the whole class very often. I've moved to projects and activity centers. I work with a few students at a time.

* * *

In addition to the items above, I am able to be more 'human," a collegial relationship is possible between myself and my students as they work. The computer becomes an intellectual tool around which we operate to produce knowledge.

* * *

I enjoy teaching more. Use of the computer has allowed me to truly integrate thinking, reading, and writing skills. We share more now—students with other students, students with teacher, and teacher with students; we collaborate. Because I have changed, students are happier and there is an air of satisfaction about the learning that takes place. We take more risks. I know my students better. The computer is an integral part of daily learning activities. Also, I have stretched more professionally.

What is the impact of the use of computers on teachers' pedagogical beliefs and attitudes?

What is the impact of the use of computers on teachers' pedagogical beliefs and attitudes? The questions we posed to teachers in this survey did not explicitly address such changes, but open-ended responses suggest that they have occurred:

We spend little time memorizing factual material that can be more easily accessed by a computer. (Glitch here is that we don't have that technology available here yet—but know it will be in the future—so teach to that end.) I guess the real change is not listed above—I have a more flexible problem-solver attitude about my teaching. I'm not tied to trivia or trying to make my students trivia memory machines. I try to teach for long-term attitudes and remind my students that a computer can be used for basic facts/dates, etc.

"I have a more flexible problem-solver attitude about my teaching. I'm not tied to trivia or trying to make my students trivia memory machines."

* * *

My vision of what students should learn and what tools they should have has changed. I see a future where students think and speculate while computers perform rote arithmetic, algebraic, and statistical manipulation.

* * *

My teaching has changed because my view toward mathematics has changed. The computer offers a whole

different method of solving problems using graphing utilities.

* * *

I am more open-minded about problems having more than one answer and if a student can explain his/her solution, that is real learning.

"I am more open-minded about problems having more than one answer."

* * *

Technology has helped me reconsider a learning activity and the best tools (computer and noncomputer) to employ in presenting it to students.

* * *

I am more willing to experiment and take chances with my students. I find that if I am continually growing and being challenged, that I in turn do so for my students.

"I am more willing to experiment and take chances with my students."

* * *

I am more excited about hands-on experiences for students. It's thrilling to see students so at ease with technology and putting that knowledge to work for them.

Taken together, these findings and comments suggest that many of these teachers are incorporating technology into their practice and classrooms in ways that may deeply affect their teaching and their students' learning. It is important to point out that our survey methodology cannot validate the teachers' reports. Nonetheless, the high agreement among them that computers have made a difference, along with the more detailed information about *how* they have done so, lends credence to what they have told us.

To summarize what we have learned so far, many of these practitioners, who are highly knowledgeable about, comfortable and facile with the use of computers in their teaching, put technology to use in multiple ways for many purposes. They seem to take a flexible, even experimental, approach to their teaching with technology. In their emphasis on students' making their own products, and in their structuring of project-based learning activities for their students, they appear to be helping students to engage actively and expansively with the technology and, more important, with the material and topics they are learning. Indeed, some of these teachers appear to be creating, through their use of technology, the conditions for deep, engaged, and meaningful learning—conditions that are sought after but not yet widely prevalent in many schools.

The Development of Teachers' Practices

Such achievements take time—five or six years, our data suggest.

These accomplished teachers have acquired impressive skills, a level of comfort with computers, and knowledge about using computers for teaching. Such achievements are not easily or quickly realized. They take time—five or six years, our data suggest. And there are discernible patterns in how their practices have evolved.

Patterns of practice in relation to experience. In our sample, we have teachers whose experience in using computers for their teaching ranges from less than two years to more than ten. It is possible, then, to examine the practices and approaches teachers use in relation to their experience.

As these teachers gain more experience, they use more applications.

First, and not surprising, as these teachers gain more experience, they use more applications. Teachers with less than two years' experience use an average of 10.8 applications, while those with nine years or more average 17.1. Similarly, as teachers gain more experience, they become more comfortable with computers. In particular, the teachers with less than two years' experience are significantly less comfortable than their more experienced colleagues.

Use of word processors and databases increases, and then levels off at about five or six years, while use of drill and practice declines steadily.

If we look at the types of software teachers report using most frequently, there are clear patterns for some types. Use of word processors and databases increases, and then levels off at about five or six years, while use of drill and practice declines steadily.

- The percent of teachers who use *word processors* frequently increases (from about 60% for those with less than two years' experience, to about 80% for those with five to six years' experience), and then levels off.
- Similarly, the percent of teachers who use *databases* frequently also increases (from about 10% for teachers with less than two years' experience, to about 20% for those with five years and more), and then levels off.
- In contrast, the percent of teachers who use *drill-and-practice* software frequently decreases from more than 40% for those with less than two years' experience, to less than 30% for those with more than nine years' experience.

Consistent with these patterns are the various approaches that teachers with different amounts of experience use frequently (most or every week). Specifically, the percent of teachers who use three approaches—students creating their own products, exploring instructional computer programs on their own, and teachers explaining an idea or skill—increases steadily from two to five to six years' experience, and then levels off.

The percent of teachers who use three approaches—students creating their own products, exploring instructional computer programs on their own, and teachers explaining an idea or skill—increases steadily from two to five to six years' experience, and then levels off.

- The percent of teachers whose *students are creating their own products* with the computer increases (from 48% for those with less than two years' experience, to 65% for those with five to six years' experience), and then levels off.
- The percent of teachers whose *students are exploring programs on their own* increases modestly (from about 25% for those with less than two years' experience, to about 35% for teachers with five to six years' experience) and then levels off.
- The percent of *teachers who explain an idea or demonstrate a skill* with the computer increases (from 30% for teachers with two years or less experience to about 40% for teachers with five to six years experience), and then levels off.

In contrast, the percent of teachers who frequently use the computer for enrichment, remediation, and drill declines slowly with years of experience.

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- About 50% of the least experienced teachers use the computer for *enrichment*, while between 30 and 35% of teachers with nine years' or more experience do.
- In parallel, about 50% of the least experienced teachers use the computer for *remediation*, while between 30 and 35% of teachers with nine years' or more experience do.
- Similarly, more than 40% of the teachers with less than two years' experience use the computer for *drills or game-like drills*, while only 19% of those with nine years or more do.

To summarize, what teachers do with computers in their classrooms reflects how much experience they have had. Initial practices and approaches tend to be similar to familiar well-structured classroom technologies (e.g., the workbook), more focused on reinforcing directly what is already being taught or, for particular groups of students, providing special opportunities.

These practices continue, but play a lesser role over time as teachers become more expert and comfortable at integrating the technology with teaching. Gradually, teachers are able to manage more expansive uses that differ from more familiar technologies, that afford richer learning opportunities for all students, and that may engender new approaches to the curriculum itself.

Teachers appear to have mastered many practices and approaches within five to six years of teaching with computers. Such expertise is not the end point of teachers' development with respect to computer use in the classroom. Rather, it appears to be the point at which they have a well-organized, workable set of practices. With this foundation, they can flexibly make choices about using new applications and about using familiar applications differently.

Incentives

Given the time and effort these teachers have invested in teaching with computers, what keeps them engaged with this challenging task? Of 29 possible incentives for incorporating computers into their teaching, the most important for these teachers is that computers become "a tool for children that works for them in their learning, such as writing, analyzing data, or solving problems." This result is significant for two reasons: (1) that student accomplishment, in contrast with their own or with external rewards, is most motivating for these teachers; and (2) that students' being able to use the technology as a tool for their *own* purposes is a key incentive.

In addition to being motivated by student achievements and by the potential of the technology to increase student engagement, these teachers are motivated by their own professional growth and derive "personal gratification from the learning of new skills." This is consistent with their significant personal investment in developing and using these skills as teachers.

Taken together, these incentives, along with other information about these teachers, tell a kind of story. Many of these teachers feel comfortable with computers, are knowledgeable about their use, and are using them in classrooms in ways that they believe positively affect their teaching. They have derived personal and professional gratification from effectively using this technology for their own purposes—teaching—and are highly motivated

Highest Rated Incentives
(of 29 incentives rated)

	Mean*
1. Becoming a tool for children that works for them in their learning, such as writing, analyzing data, or solving problems.	5.26
2. Increasing enthusiasm of students for the subjects for which they use the computer.	5.21
3. Helping teachers to make a subject more interesting.	5.19
4. Personal gratification from the learning of new skills.	5.11
5. Providing a means of expanding and applying what has been taught.	5.10
6. Enabling students to acquire the basic computer education they will need to be computer-literate adults.	5.04

*six-point scale: 1 = "strongly disagree, not an incentive"
6 = "strongly agree, a major incentive"

In the daily professional life of these teachers, it is the psychic payoff of students' learning and engagement that appears to matter most.

by parallel goals for their students. They want their students to know how to make these powerful tools work for them, so they can learn better. And they value their students' involvement in computer-based work. In the daily professional life of these teachers, it is the psychic payoff of students' learning and engagement that appears to matter most.

Barriers

Although many of these teachers are highly motivated, have developed impressive expertise in using computers in their classrooms, and report that significant changes are occurring there, to a greater or lesser extent all of these teachers experience significant barriers to the integration of computers into their teaching. Teachers were asked to rate each of 35 barriers as to how problematic it was in the past and in the present. Therefore, we were able to compare teachers' current judgments about the past and the present.

Overall, these teachers rate barriers as less problematic in the present than in the past; that is, they believe there has been progress in reducing these barriers. Moreover, some barriers that were very important in the past (i.e., in the top 20%) are no longer so now. Most notably, teachers' lack of interest in using computers and weak knowledge of computers were seen as very significant barriers in the past, whereas now these are much less so. This suggests that many of these teachers are in schools where there has been significant teacher development overall in knowledge about and use of computers.

Nonetheless, five of the top seven barriers in the past remain among the top seven barriers now. Hardware remains a central concern for these teachers—too few computers, printers, and peripherals. Moreover, there is not enough time for teachers to prepare computer-based lessons, nor enough time in the school schedule for computer-based instruction, and there are problems scheduling enough computer time for different classes. In addition, two administrative barriers (financial support, help in supervising computer use) now figure centrally for these teachers. Apparently, many of these teachers, although in comparatively advantaged situations with respect to technology, continue to experience the integration of computers into their schools as a struggle for support of various kinds.

Highest Rated Current Barriers
(of 35 barriers rated)

		Mean*
1.	Teachers lack enough time to develop lessons that use computers.	4.22
2.	Problems scheduling enough computer time for different teachers' classes.	3.69
3.	Too few computers for number of children.	3.56
4.	Not enough place in the school schedule for more computer-based instruction.	3.53
5.	Inadequate financial support for computers from the school and/or district.	3.51
6.	Too few printers or other peripherals.	3.47
7.	Not enough help for supervising student computer use.	3.32

* six-point scale: 1 = "not a barrier"
6 = "a major barrier"

Highest Rated Past Barriers
(of 35 barriers rated)

		Mean*
1.	Too few computers for the number of children.	5.04
2.	Teachers lack enough time to develop lessons to use computers.	4.70
3.	Too few printers or other peripherals.	4.66
4.	Problems scheduling enough computer time for different teachers' classes.	4.16
5.	Not enough place in the school schedule for computer-based instruction.	4.11
6.	Teachers are not interested in using computers.	4.06
7.	Teachers' own knowledge of computers is still too weak or unsure.	4.04

* six-point scale: 1 = "not a barrier"
6 = "a major barrier"

Many of these teachers, although in comparatively advantaged situations with respect to technology, continue to experience the integration of computers into their schools as a struggle for support of various kinds.

We hypothesize that at least some of these schools may have reached a critical juncture: They want to accomplish more with technology, but cannot do so unless organizational changes take place.

Need for Organizational Change

Why do these teachers and schools that have the most need more? We hypothesize that at least some of these schools may have reached a critical juncture: They want to accomplish more with technology, but cannot do so unless organizational changes take place. Within some of these schools, enough teachers have had sufficient time, support, and technology to experience, integrate, and value the kinds of changes in their teaching and their classrooms that are reported here. Accordingly, these teachers have an increasing interest in and commitment to doing on a more regular basis the computer-integrated teaching they have found so valuable. To do so, however, requires more time for them to plan, more hardware, and a differently organized school schedule. To address these issues will likely require not simply small adjustments (i.e., adding another computer lab), but rather systemic changes in how the school works.

For example, for teachers to have more time during the school day to plan their computer-based lessons and activities, their schedules will have to be reorganized. This is a particular challenge if, as is likely and desirable, they want to plan with their colleagues. To legitimate planning activities for teachers requires not just changing schedules but thinking differently about teachers as professionals. It requires acknowledging that to improve the quality of what happens *inside* the classroom, teachers need to be learning, planning, working with other teachers, and reflecting in ways that can happen only *outside* the classroom. Teachers need this thinking and planning time to use technology well in their classrooms. For them to have it, however, their schools must function differently.

CONCLUDING THOUGHTS

As we put together the results of this survey, we find a compelling story of motivated and professional teachers who are accomplished in using computers in multiple ways in their classrooms, and who report impressive changes in their practice as a result.

These teachers have gone beyond just knowing how to use computers, or knowing how to add computers on to their current practice. Many have incorporated the technology into their teaching in ways they believe have transformed their practice—for example, making their classrooms less teacher-centered and more student-centered, getting students actively involved in doing projects and creating products, helping students to do more thinking and interpreting, giving students more individual attention, and allowing students to work more independently. In becoming expert at using computers for teaching, at least some of these teachers now teach differently and, they suggest, more effectively than they did in the past.

In becoming expert at using computers for teaching, at least some of these teachers now teach differently and, they suggest, more effectively than they did in the past.

It is notable that many of the practices and changes these teachers report are being widely sought by those who are attempting to reform schooling. It is important to ask, then, what factors have contributed to the achievements of these teachers. From these results, three stand out: (1) the teachers' motivation and commitment to their students' learning and to their own development as teachers; (2) the support and collegiality they experience in their schools and districts; and (3) access to the technology itself, in sufficient quantity.

What factors have contributed to the achievements of these teachers?

These factors do not operate alone, but together, to mutual benefit and effect.

• The first factor is the teachers' motivation and commitment to their students' learning and to their own development as teachers. These teachers have made a significant professional commitment to using computers in their teaching, and to learning how to do so effectively It might be assumed that this commitment derives from some kind of natural attraction to and comfort with technology. There are undoubtedly some of these teachers who are intrinsically interested in and attracted to the

...the teachers' motivation and commitment to their students' learning and to their own development as teachers.

technology. But for many, their comfort and expertise have been hard won, have come subsequent to their becoming teachers, and have involved considerable time and effort. Their motivation appears to come, in large measure, from their belief in the educational value of the technology for students and from what they see happening in their classrooms. These teachers are inspired by their students' accomplishments with and enthusiasm about the technology.

Moreover, this *is* a group that is motivated by the opportunity to learn new skills. Despite, or perhaps because of, the considerable investment and initiative that their accomplishments with technology have required, they have persisted over many years. In their personal initiative and effort, they take a very professional approach to their work.

...the support and collegiality these teachers experience in their schools and districts.

• The second factor that has contributed to these teachers' achievement is the support and collegiality they experience in their schools and districts. Many have on-site help available, local training opportunities, and work in schools where other teachers are using computers for instruction. While there is much more we would like to know about the conditions of support in these schools, we do know that on-site support and colleagueship are critical ingredients to successful technology use.

...access to technology.

• Access to technology is the third factor that has contributed to these teachers' accomplishments. On the whole, these teachers and their students have access to more technology than do teachers and students in most schools. Concretely, what does this mean? It means that the very practical barriers many teachers face—of giving enough students enough time to work with the technology, and of themselves having access to it—are less acute (although still problematic) for this group. And since most have invested in computers for themselves at home, they have gone far towards assuring that they have access to the technology on their own time.

It is the combination of the teachers' motivation and long-term effort as professionals, the support they receive, and the access to technology that make their accomplishments possible. These factors come together as the teachers become knowledgeable about hardware and software outside the classroom (on their own, from other teachers, or in workshops and classes), try it out in the classroom, and learn from what they observe their students doing. This is a long-term process that builds on

the teachers' increasing expertise and willingness to use the technology in new ways, and on what they learn from their students in the classroom as they use computers. The teachers' willingness to learn and change is a critical element in this process and one which may have been there from the beginning for some teachers, but has surely been an evolutionary process for others.

The teachers' willingness to learn and change is a critical element in this process and one which may have been there from the beginning for some teachers, but has surely been an evolutionary process for others.

We do not wish to convey that this complex process takes place in only one sequence or is characterized by only one profile of success. Just as there is more than one way to teach well, there is more than one way to teach well with technological tools.

Finally, we must ask, in an era of reform and restructuring, is it possible for the accomplishments of these teachers to be realized in less than five to six years? Can they be implemented on a much wider scale?

As to the first question, we are skeptical that the process can be made to happen quickly, although perhaps in less than five or six years. To become expert in anything takes a great deal of time, and these teachers have had both to master the technology and figure out how to teach with it. In time, of course, increasing numbers of people will enter the teaching profession already proficient in computer use. They will bring with them the technological expertise and comfort that current teachers have to learn on the job. Thus, they will have a less formidable task than do today's teachers.

As to whether these teachers' accomplishments can be realized on a wider scale, we believe so, but only under circumstances in which:

- there is enough technology (and, in particular, enough technology for teachers to have regular access);
- there is ample support and time for teachers to learn how to use it and to plan for its use; and
- there is a school structure and culture in which teachers are encouraged and expected to take a professional and experimental approach to their work.

Under these circumstances, we would expect that many teachers could achieve what these teachers have. Having done so on a larger scale would, we believe, constitute a major step towards improving teaching and learning in the nation's schools.

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APPENDIX

Table 1

Sample Composition

School Background	Percent
I. Size of School (*n*=572)	
Large (1000+)	29
Medium (500–1000)	42
Small (less than 500)	28
II. School Grade Levels (*n*=567)	
Elementary	35
Elementary and upper elementary	9
Complete school (K–12)	7
Middle school	19
High school	30
III. Type of School (*n*=571)	
Public	98
Independent/Parochial	2
IV. Ethnic Group Representation* (*n*=514) (as per respondents' perceptions,	
Caucasian	68
African/American	22
Asian	6
Hispanic	14
Native American & Alaskan	6
V. Economic Representation (*n*=522) (as per respondents' perceptions)	
Very poor	13
Working poor	25
Middle class	46
Relatively affluent	12
Very affluent	4
VI. Size of Town (*n*=561)	
Large city	40
Small city/town	25
Rural town	20
Suburban town	15
VII. Geographical Region (*n*=555)	
Northeast/Mid-Atlantic	36
West	27
Midwest	18
South	19

*Respondents were asked to write in percentages that would add to 100%. Unfortunately, their estimates did not add to 100%.

Table 2

Teacher Experience, Support, and Training

	Percent
I. Number of Years Teacher Used Computers in Their Teaching (*n*=574)	
Less than 2 years	7
3-4	20
5-6	34
7-8	19
9-10	11
10+	9
II. Teachers with Computer at Home for Personal Use (*n*=571)	
Yes	84
No	16
III. How/Where Teachers Were Trained in Computer Use (Multiple Responses) (*n*=575)	
Self-taught	87
Conferences and workshops (on own time)	76
Courses at local colleges	65
Courses offered by district (inservice)	56
Courses offered at school (inservice)	50
Courses in grad/undergrad training	44
Courses offered by school district (not inservice)	43
Instruction from other teachers	40
Instruction on site by consultants	38
IV. Access to On-site Support/Advice (*n*=573)	
Yes	77
No	23
V. If Yes...Support from (*n*=438)	
Other teachers (day to day)	69
School computer coordinator/aide	60
District computer coordinator	53
Consultants	20
Organized group of teachers	18
Software company representative	17
Hardware company representative	17

Table 3

Grade Level Differences in Current Software Use (*n*=597)

Applications	Overall Mean (Percent)	Use by Grade Level (Percent) 4-6 (*n*=338)**	7-9 (*n*=296)**	10-12 (*n*=223)**
Tools				
Spellchecker	61	56	68	72*
Databases	72	69	83*	77
Spreadsheets	56	47*	67*	70
Calculator (as part of computer)	42	35*	48	56*
Chart/graphing	45	37*	54*	59*
Painting/drawing	56	60	63*	55
Programming Languages				
LOGO	41	53*	40	27*
BASIC	48	44	57*	54
Pascal	14	8	20*	30*
Communications				
Public bulletin boards	34	32	40*	42*
Instructional Software				
Tutorial programs	73	80*	72	68
Drill and practice	72	81*	70	63*
Problem solving	75	86*	72	65*
Conceptual tools	30	30	37*	35
Games and Simulations				
Microworlds, simulations, instructional games	74	84*	70	63*
Multimedia	NS***	NS	NS	NS

*Significantly ($p < .05$) more or less than mean percent for application.
**Note multiple responses by individual teachers for grade levels taught.
***No significant grade level differences.

Table 4

Grade Level Differences in Most Frequent Software Use(n=597)

Applications	Overall Mean (Percent)	Use by Grade Level (Percent) 4-6 (n=338)**	7-9 (n=296)**	10-12 (n=223)**
Word processing	78	73	84	86*
Drill and practice	37	49*	27	23*

*Significantly ($p < .05$) more or less than mean percent for application.
**Note multiple responses by individual teachers for grade level taught.

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