Computers Meet Classroom: Classroom Wins

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Examines why computers are used less often in classrooms than in other organizations; suggests that technological innovations have never been central to national school improvement movements, and that the dominant cultural belief about teaching, learning, and proper knowledge and about the way schools are organized for instruction inhibits computer use. (Source: ERIC)

Main Article

Today, computers and telecommunications are a fact of life as basic as electricity. They have altered the daily work of large businesses and industry. Yet why is it that with all the talk of school reform and information technologies over the last decade, computers are used far less on a daily basis in classrooms than in other organizations?

The question often generates swift objections. What about the $19.6 million Quince Orchard High School in Montgomery County (Maryland), where there are 288 computers for 1,100 students? Or the Juan Linn School in Victoria (Texas), where a computerized integrated learning system (ILS) provides instruction to 500 students and records daily their work? What about the thousands of elementary and secondary school teachers who have students work together on computers to write, tally figures, draw, and think? Are there not many experiments under way such as Apple's Classroom of Tomorrow, micro-computer laboratories, and exciting software that tutors students in academic subjects and skills? The answer to all of these questions is that such instances do exist but they are scattered and atypical among the 80,000-plus public schools across the nation, where over 2 million teachers teach over 40 million students.(n1)

So why is instructional use of information technologies (computers, television, multimedia machines and software, etc.) still the exception and not the rule in American schools? The answers to this question are important in assessing claims of policymakers who argue that such technologies can fundamentally reshape schooling and entrepreneurs seeking profits in the schooling market who offer a vision of classrooms where students work three or more hours a day on computers.

I will argue that the familiar excuses used to explain the snail-likepace of technological progress (insufficient money to buy machines, teacher resistance, little administrative support, and inadequate preparation for those becoming teachers) are plausible but ultimately superficial. Such explanations assume that schools are just like other places facing technological innovation. If sufficient money, support, and preparation are mobilized, computerization of classrooms will occur. I argue that there are fundamental reasons within schools as institutions that make them substantially different from businesses, industries, and other organizations.

Schooling is less vulnerable to electronic technologies than these other institutions for two reasons: First, certain cultural beliefs about what teaching is, how learning occurs, what knowledge is proper in schools, and the teacher-student (not student-machine) relationship dominate popular views of proper schooling.

Second, the age-graded school, an organizational invention of the late nineteenth century, has profoundly shaped what teachers do and do not do in classrooms, including the persistent adaptation of innovations to fit the contours of these age-graded settings. To make this argument I concentrate on school use of computers.

THE SPREAD OF COMPUTERS IN SCHOOLS

As an innovation, school use of computers has spread swiftly, widely, and, on occasion, deeply. But the picture is clouded. A few statistics on computer use suggest the broad outlines of the picture.

In 1981, 18 percent of schools had computers; in 1991, 98 percent had them.

In 1981, 16 percent of schools used computers for instructional purposes; by 1991, 98 percent did so.

In 1981, there were, on average, 125 students per computer; in 1991, there were 18.

In 1985, students used computers in school labs just over 3 hours a day; in 1989, that figure had risen to 4 hours a day.(n2)

These few numbers give a sense of an expanding technological base in schools.

A closer inspection of those figures and others, however, reveals that individual students who use computers (and not all do) spend, on average, a little more than one hour a week (or 4 percent of all instructional time) with computers. What students do with computers varies greatly. For eleventh-grade students who use the machines, computers were seldom used in subject areas and where they were used, the purpose was to teach about computers. An Office of Technology Assessment study concluded that students from high-income families have far more access to computers in schools than do peers from low-income families. Black students use computers in schools less than white students, especially in elementary schools. Pupils whose native language is not English have even less access to computers. Finally, low- achieving students are less likely to use machines to enhance reasoning and problem solving and more likely to use them for drill and practice.(n3)

These figures, however, obscure the imaginative applications of computer technology to instruction in special education, where blind, deaf, and multiply disabled students are able to read, write, and communicate in ways that heretofore were unavailable, and of new software for drafting courses, auto mechanics, business, and other vocational courses.(n4) Such figures also ignore the massive computerization of administrative work in districts and schools previously done by means of typewriters and telephone.

The overall picture, however, after the introduction of the personal computer a decade ago and persistent efforts to improve schooling, suggests at best that computers are an expanding but marginal activity in schools with wide variation in administrator, teacher, and student use. A one-line caption for all of this activity over the last decade is: Computers meet classroom; classroom wins.

For technology advocates who have studied the history of machine technologies in schools, this good-news/bad-news picture of computer use should be an old story. The introduction of film and radio into schools in the 1920s and 1930s and instructional television in the 1950s and 1960s saw a similar pattern of blue-sky promises of the new technology revolutionizing instruction and learning. One quotation will suffice to make the point of high hopes:

I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks. I should say that on the average we get about two percent efficiency out of schoolbooks as they are written today. The education of the future, as I see it, will

be conducted through the medium of the motion picture . . . where it should be possible to obtain one hundred percent efficiency.(n5)

The promise of these new machines was anchored in the dream of increasing teacher and student productivity. More could be taught in less time with these machines and students could learn more and even better than from textbooks or even the teacher. The promise was invariably followed by sporadic and limited entry of machines into classrooms, growing practitioner disillusionment with the inaccessibility of the machines, academic studies documenting small learning effects from the new technology, and a final round of blame usually deposited on the backs of teachers. With another technological invention, this cycle of ecstasy, disappointment, and blame would begin anew.(n6)

TECHNOLOGIES AND SCHOOL REFORM

What is curious about these earlier technologies and their cycles of optimism and pessimism is that none were associated with national reform movements. If there is any pattern at all in the movements to reform schools that have swept across the nation since the middle of the nineteenth century, it is that none were dependent on instructional technologies beyond teacher, blackboard, textbook, and pen and paper.

Mid-nineteenth century common school leaders Horace Mann, Henry Barnard, and others sought to make schooling accessible to all students regardless of ethnicity or class. They created thousands of schools for students to attend, prepared teachers for those schools, and installed a common curriculum accessible to those who attended. Although instructional technologies were absent from such a movement, a managerial technology was present in the organizing of age-graded elementary schools and subject-centered, departmentally focused high schools with their multiperiod daily schedule of recitations.(n7)

A half-century later, another generation of reformers sought to transform schools into instruments of social reform. These progressive education reformers wanted schools to make millions of immigrants into Americans and to reduce the corrosive effects of slum housing, urban crime, and poverty. Moreover, reformers wanted these schools to focus on more than the mind of the child; children's psychological and social development was part of the educator's responsibility. Furthermore, the school's academic curriculum had to change because children learned best when their interests were actively engaged and harnessed to what occurred in the home, neighborhood, community, and nation. Throughout the early decades of twentieth century, progressive educators sought ways of transforming schools to secure these aims. Many educators in pre-World War II schools saw the motion picture and radio as useful tools to help achieve their aims. But these new technologies were marginal to their vision for new forms of teaching and learning.

Following World War II, a series of national reform movements to improve schools included raising academic standards in the 1950s, desegregating schools and creating open classrooms in the 1960s, and instituting back-to-basics and minimal competency testing in the 1970s. New instructional technologies were mentioned and even promoted temporarily (such as television in the 1950s and 1960s and computer-assisted instruction in the 1960s and 1970s) but the center of gravity to any of these reforms was nontechnological. Machines were blips on the outer edges of reformers' radar screens.

This was not so in the 1980s and 1990s. With massive technological changes in the work place and in daily life, school reformers throughout the last decade have turned increasingly to computers in schools as a solution for inefficient teaching with textbooks to the whole class and as a means of cracking what they viewed as calcified bureaucracies. Hundreds of formal reports from corporate leaders, foundations, professional associations, and federal agencies have consistently underscored how schools have failed in achieving their purposes and how important schools are to the nation's economic success.

"Our survival as an economic power in the international marketplace is at issue," said David Hornbeck,

former state superintendent of schools in Maryland. "We have fewer youth overall and a greater proportion are from groups with whom the schools have historically failed," he continued. "For the first time in our history, we must improve the level of student achievement significantly and simultaneously." How might we achieve this end? Hornbeck's answer is to use computers in school:

The computer motivates. It is nonjudgmental. It will inform a student of success or failure without saying by word or deed that the student is good or bad. The computer individualizes learning, permitting mastery at one's own pace. In most instances, the learner has far more autonomy than in many other teacher directed settings.... Such generic qualities allow the learner more often than not to be in charge. This is a quality missing in the lives of many students, especially those who are at-risk, due to environmental, physical, mental or language disabilities.(n8)

For melting bureaucracies, technologically driven reformers assume that highly decentralized organizations are more effective than large, hierarchically organized, arteriosclerotic ones in providing services to varied groups with diverse needs. To connect district office, schools, and classrooms within school systems, information technologies (local area networks, etc.) are essential tools to permit rapid responses among and between decentralized units and to have, for example, different teachers or different staffs across a district work together.(n9)

Thus, in the 1980s and early 1990s, strong impulses moved these coalitions of school reformers that included corporate executives, public officials, foundation officers, school administrators, and teachers to embrace computers and telecommunications as a way of unfreezing the perceived inefficiencies and rigidities of American schooling.

IMPULSES FOR USING THE LATEST TECHNOLOGIES IN SCHOOLS

Basically, three impulses converged in reforming schools through electronic technologies. Although I offer them separately, they are entangled, and enthusiasts for technology often combine one or more of these impulses in their advocacy for a particular program. Within each impulse is a set of values about how schooling, teaching, and learning ought to be.

First, there is the drive to bring schools technologically in step with the work place because of the fear that students will be unprepared both to compete in the job market and to adjust to the changing marketplace where bank teller machines, bar codes on products, answering machines, and other electronic devices prevail. The computerized work place and the ubiquity of telecommunications in daily routines outside the home have convinced advocates of modernizing schools that students must become familiar with electronic technologies. The values behind this impulse are the importance of highly skilled individuals enhancing national economic competitiveness and the intrinsic worth of being up to date. Computers, in other words, are the future and schools must prepare students for it.(n10)

This impulse and its value of preparing students for jobs derives from the turn-of-the-century social role of public schools to prepare students for vocations and the proposition that in an increasingly high-tech world graduates must know how to handle electronic machines.

A second impulse has come from a diverse coalition of academics, educators, and foundation officials who have neoprogressive(n11) values, including that of self-directed learning for children. This coalition, leaning on the work of American (John Dewey and Jerome Bruner), European (Maria Montesorri), and Russian (Lev Vygotsky) scientists and educators, seeks to change schools in which learning comprises tediously absorbing large bodies of nonfunctional knowledge unconnected to life. They want schools in which teachers help students construct their own understanding. Neoprogressives view students as active learners creating knowledge that makes sense to them. They want schools in which such knowledge is shared by all

members of the community, and diverse mixes of adults and children work easily together in varied groupings. Interactive computers and telecommunications are mind-tools that could make these self-directed learning communities possible, according to such advocates.(n12)

Where these neoprogressive notions anchored in cognitive sciences and the work of talented veteran teachers come together is in recent curricular reforms in math and science. The American Association for the Advancement of Science, for example, published in 1989 a thorough examination of the science, mathematics, and technology curriculum offered in public schools from kindergarten through senior high school. *Science for All Americans* (SFAA) has become the primary document for Project 2061, a long-term school reform undertaken by the National Science Foundation aiming at no less than a fundamental overhaul of both what science content is taught and how it is presented to students.(n13)

Finally, there is the impulse for productivity. This highly prized value of making teaching and learning efficient is historic and, when harnessed to electronic technologies, unrelenting. The lure of productivity--teaching more in less time for less cost--can be traced back to the origins of public schools in the early nineteenth century and has been a consistent goal for schooling ever since.(n14)

Accompanying the introduction of films, overhead projectors, and radio into schools, beginning in the 1920s were unabashed claims that these machines would enhance teachers' efficiency in conveying knowledge, supervising students, and enhancing student motivation to learn.

In the June 1932 issue of the *American School Board Journal*, for example, an ad shows a photo of a serious-looking middle-aged male teacher using an overhead projector. Facing the class, the teacher is writing on the slide with his right hand and with his left hand keeping a finger on the notes that he uses with the class. The ad reads:

The B&L Overhead Projector simplifies Visual Instruction . . . reduces the problem of discipline in the darkened room, makes the teacher's work easier by permitting him to sit before the class, facing pupils, with all notes and materials for the lesson ready at hand....

The Overhead Projector provides for this time-and-saving, over-the teacher's-head projection with an ingenious system of mirrors, solidly mounted and practically indestructible. The instrument is inexpensive.... It conserves the teacher's energy, concentrates pupil attention, and eliminates the necessity of an assistant.(n15)

Advertisements for computers make similar points today, without hesitation or subtlety. "Faster, better, and cheaper" is the drumbeat of the productivity impulse.

These interlocking impulses have been fueled in the 1980s and early 1990s by high-octane values--economic competitiveness, individual self-directedness, and efficiency. As the figures cited earlier revealed, however, teachers' use of computers and telecommunications has yielded mixed results.

Some obvious questions arise. Are the growing number of new schools devoted to using computers and telecommunications a sign that these are, indeed, schools of the future? Or is the apparently marginal use of computers in classrooms a sign that this technology is going to be used just as earlier ones were, that is, peripherally, seldom disturbing customary ways of teaching and learning? Or is this marginal use of computers in schools a sign of steadily growing acceptance of the new technologies and that, in time, most classrooms will become more machine-friendly?

Because these questions ask about the future, in the next section I sketch out three scenarios of what might be ten years from now. Each story line is plausible, has substantial evidence to support it, and can be assessed for the likelihood of its materializing. After describing each I will pick those that I believe are

likely to be dominant a decade from now.

THREE SCENARIOS

THE TECHNOPHILE'S SCENARIO: ELECTRONIC SCHOOLS OF THE FUTURE NOW

These are places that have sufficient numbers of machines, software, assorted accessories, and wiring to accommodate varied groups of students in classrooms, seminar rooms, and individual work spaces. The technophile's vision of such schools is anchored in making teaching and learning far more productive and meaningful than both are now. The dream that spurs technophiles is one of students who learn more and with far less difficulty than in regular classrooms and teachers who help students understand content and use skills that seldom would have appeared in whole-group-taught lessons and texts.

Better machines and software are central to this vision; they are seen as tools by which both teachers and students liberate themselves from inflexible ways of teaching and learning. Students will come to rely on the machines and one another to teach them and teachers will become coaches to help students with what needs to be learned. Lectures, recitations, textbook assignments, and fifty-minute periods will be as implausible as dinosaurs in a zoo.

The strategy for achieving the vision is to create total settings that have a critical mass of machines, software, and like-minded people who are serious users of the technologies. The tilt is toward making big changes swiftly rather than creating pilot programs in schools or incrementally buying a few machines at a time.

Two examples of the technophile's vision inspired by mixes of the three impulses described earlier may help make the scenario specific. Consider first a productivity-driven version of the scenario that emphasizes, in a phrase favored by advocates, "instructional delivery systems."

A student would take his paper to a writing center where he would be asked by a terminal to type his name, his teacher's name, and the title of his paper. Having done this, the computer screen will then ask him to input the first symbol that the faculty member has written on his paper. Here the student might type CS or rule #42, and the screen would say, "John, this is the third time you have missed a comma splice. In your papers entitled 'My Most Embarrassing Moment' and 'An Analysis of Two Poems by Emily Dickinson' you had comma splices, and you have not yet mastered what a comma splice is. I am going to explain it to you once again, give you some drill and practice until you have mastered it, and urge you not to make this mistake again."

Conceptually what is happening here is that the student is receiving personal instruction in precisely the areas where he needs help *without the teacher being present*. The work bonus has been used effectively by extending the effectiveness of the teacher.

At the end of each instructional period in the computer center, a list will be given to the teacher which divides the students into various groupings of approximate ability as of that day. Thus the teacher will be able to work individually with groups that are quite close together back in the classroom. The [computer lab] managers will also generate individual seatwork on a high-speed printer that the students can take back to their rooms with them. Thus, while some may be working with teachers in individual groups, others might be doing individualized seatwork with problems generated to their precise level at that moment.(n16)

Other technophiles offer neoprogressive flights into the future to dramatize how new technologies can create student-centered schools. One extended example will give the distinct flavor of this version of the scenario.

Julio was just a little nervous as he approached the entrance of the central building. After all, the first day

with new clustermates was always an unknown. He turned and watched the shuttle . . . tak[e] on a group of seven Early Learners and an adult Mentor that had emerged from the door in front of him. The brilliant sun gleamed on the door's shiny sensor panel but before he could produce his ID disk, it opened to reveal a smiling eight-year girl, dressed in the latest neo-nineties fashion.

"Hi, you must be Julio. My name is Wanda Thompson. Welcome to the Energy Cluster.... C'mon, I'll introduce you to the Cluster Director and she'll help update your slate." She led Julio past a group of very young children who were arranging kinesthetic manipulatives demonstrating heat transfer under the watchful eye of a boy not much older then Julio. . .

"Here we are," she said at last. "Julio, meet Mentor Lee, Energy Cluster Director."

"Welcome, Julio Narvaez, to the Energy Cluster," offered the small, gray- haired woman.... Noticing Julio's fascination with her hair and wrinkles, she chuckled, "Yes, I know . . . the `juvie' treatments would `improve' my appearance, but I just like my own 88 year-old face." Her gentle laughter made Julio smile. . .

"Shall we load your slate?" Mentor Lee asked....

"Go ahead and scan the intro screens, Julio."

Julio did so, noticing how the layout of the building complex was divided into specific areas dedicated to lab use, telecommunications, general meeting areas, and recreational areas.... Next his slate displayed the time dimensions as it showed him which areas of the building were in use at different times of the day....

As he scanned other information, Mentor Lee loaded Julio's ID disk into her desktop unit and studied the holograph which displayed his mastery of different areas of the curriculum . . . and areas not yet mastered.... Touching another button, she reviewed the computer's recommended list of activities and projects that would match the Cluster's resources and personnel to Julio's profile and preferences. She . . . made a few changes and passed the disk back to Julio to encode in his own machine.

"There, that should get you started. Wanda will be your Peer Facilitator and your Cohort Mentor will be Dominic Ferron. He'll help you get started in that broadcast power project that we have just begun. With your interest in applications for solar power, you should be a big help there. We need your help in providing Spanish language instruction . . .; I've listed you as a peer tutor. I've noticed you need a little work in spatial geometry so I scheduled you in for some lectures and structured group work with mentor Lewis. I'm especially glad that you have done so well in the social sciences, we really are in need of a good archivist for your cohort's experiences. We're glad to have you here, Julio....

Julio smiled as he walked with Wanda towards his first project. He was ready.(n17)

THE PRESERVATIONIST'S SCENARIO: MAINTAINING WHILE IMPROVING SCHOOLING

If technophiles ignore the influence of the age-graded school organization and prevailing cultural beliefs about teaching, learning, and the student-teacher relationship, preservationists seek to maintain and enhance both. In this scenario, policymakers and administrators put computers and telecommunication technologies into schools largely to improve productivity but not to alter substantially existing ways of organizing a school for instruction. While some teachers and

administrators use these technologies imaginatively and end up being profiled by the media, most uses are fitted by teachers to the durable grammar of the classroom and school. To preservationists, the central fact is, as Saul Rockman put it, "What a teacher does with *it* is more important than what the *it* is."(n18)

The vision buried within the preservationist's story is one of schools' continuing to do for society what they have historically done: pass on prevailing values and accumulated knowledge to the next generation, improve ways of teaching and learning the prescribed curriculum, sort out those children who achieve academically from those who do not, and give taxpayers as efficient a schooling as can be bought with available funds. Caution toward major changes, hammered out of these traditional aims for schooling, leads to adding-on to what exists now.(n19)

Much evidence makes this scenario plausible. Some examples are: mandating computer literacy as a graduation requirement; adding computer science courses to the curriculum; creating a computer lab, scheduling teachers once per week to bring their classes there, and hiring an aide to help students use the available software; placing one computer in each classroom; buying software that is part of a textbook adoption; buying an integrated learning system that centralizes daily lessons for each student with results of the students' work being reported the next day. Other examples would be school boards and administrators' adopting Christopher Whittle's Channel 1, where students are required to watch news and advertisements daily.(n20)

In this scenario, computers and other forms of technology are seen as important but peripheral helpers to the main business of teaching students. Teachers adapt these tools to help students be more productive and do a better job of what they are supposed to do in schools. The result is that new technologies reinforce what schools have done for over a century.

THE CAUTIOUS OPTIMIST'S SCENARIO: SLOW GROWTH OF HYBRID SCHOOLS AND CLASSROOMS

In this scenario, cautious optimists acknowledge the power of organizational structures and cultural beliefs to shape routine school and classroom practices but see these beliefs and structures changing slowly. They believe that putting computers into classrooms will yield a steady but very slow movement toward fundamental changes in teaching and schooling. Advocates of this scenario see it occurring slowly but inexorably, much like a turtle crawling toward its pond. It is slow because schools, as organizations, take time to learn how to use computers to guide student learning. It is inexorable because, as Allan Collins says, "The nature of education must inevitably adapt to the nature of work in society."(n21)

Here again appears the productivity-driven dream of efficient machines freeing students from the tedium of traditional instruction--but in this scenario enthusiasts for faster, better, and cheaper instruction and learning need to be ultra-patient. A competing neoprogressive picture of the future also rests within this story: Schools can become small learning communities where students and adults teach one another through a deliberate and slow application of technologies to schooling.

Is there evidence for this scenario? There is a small but growing body of evidence that introducing a half-dozen computers into a classroom or creating micro-computer labs, over time, alters how teachers teach (e.g., they move from teaching the entire class as one group to using small groups and individualized options) and how students learn (e.g., they come to rely on one another and themselves to understand ideas and to practice skills). Thus, the classroom and school organizations shift, albeit slowly, from wholly teacher-directed and self-isolating ones to places where students, working with peers in and across classes, begin to take responsibility for their learning.

In schools in which the numbers of computer-using teachers and hardware reach a critical threshold, different organizational decisions are made. Teachers from different departments or grades begin to work together and move toward changing the regular time schedule. Schoolwide decisions on using technologies become as routine a matter as decisions on nontechnological matters. Hybrids of the old and the new, of teacher-centered and student-centered instruction, proliferate in this scenario.

Examples of this scenario can be found in the work of Denis Newman and his colleagues at a Harlem elementary school (grades 3-6) since 1986. Their goal was to create classrooms in which technology was used collaboratively in the way scientists work in labs. By the second year of the project, there were two separate labs with over fifty computers, all networked, and with connections into several classrooms.

The Earth Lab project, as it was called, brought teachers and students to the labs but the projects they worked on spilled over to their classrooms. Using Local Area Network (LAN) and an electronic mail linkage, the connections made, in Newman's words, "the boundaries between classrooms and class periods more permeable."(n22) Students could pursue tasks on their own initiative and not wait for a bell to ring. The school newspaper had space on the network and the electronic mail system made it possible for editors and reporters to stay in touch and collaboratively work on articles and layout for the paper. Newman and his colleagues also noted that the science projects that brought small groups of students together spilled over to other curricular areas and teachers would use groups to research social studies topics.

By the fourth year (1989), Newman reported that one-fifth of the students (there were 700 in the entire school) had signed up for the "Computer Mini-School," involving six classes covering grades 3-6. The limited goal of getting students and teachers to work collaboratively on science projects in a computer lab in 1986 had slowly evolved into school-within-a-school.(n23)

The evolution of a computer lab and a LAN into a school-within-a-school is one instance of a neoprogressive version of hybrids. Another is a school-wide version in which computer technologies and conventional curriculum and instruction overlap. These can be found in scattered schools around the country. Hanshaw Middle School in Modesto (California), with over 800 seventh- and eighth-graders (of whom almost four out of five are Hispanic), is a case in point. George Leonard describes how "teachers work in teams, children sit around tables rather than in rows, and every room contains a computer lab in which all the computers are linked into a network." Principal Charles Vidal has sought to eliminate the textbook as the primary source for teaching. "Instead," Vidal says, "teaching teams work out core subjects from which related knowledge develops. Social studies provides a core for history and English. Science serves as a springboard into math." Students must also do eight "exploratories" in arts, home economics, and technology. The technology exploratory contains twenty-eight five-day sessions in, for example, desktop publishing, hydroponics, and robotics.(n24)

Hybrids also can be found among individual teachers working alone in their classrooms. Teachers report how they wove computers into their regular work with students:

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 products. They all kept track of their budgets on spreadsheets.

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. . . .

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.(n25)

Now, which of these scenarios is most likely to occur, that is, has a 75 percent chance of happening in most

schools across the country?(n26)

LIKELY SCENARIOS?

The least likely scenario is the electronic school of the future. While such schools will be built, they will remain exceptions and, in time, will probably disappear as the next generation of technology, invariably cheaper and improved, comes of age. Thus, although such schools exist now, I find it unlikely for two reasons that they will spread.

First, in either ignoring or downplaying the influence of the age-graded organization and dominant cultural beliefs, technophiles minimize the power of traditions and practices that have endured for centuries and perform important functions in society. Cultural beliefs such as that teaching is telling, learning is listening, knowledge is subject matter taught by teachers and books, and the teacher-student relationship is crucial to any learning dominate popular and practitioner thinking. Most taxpayers expect their schools to reflect those centuries-old beliefs.

Furthermore, in not paying much attention to the age-graded school, technophiles fail to see how this century-old form of school organization shapes classroom practice with its self-contained classrooms separating teachers from one another, a curriculum divided into segments of knowledge and skills distributed grade by grade to students, and a schedule that brings students and teachers together to work for brief periods of time. These structures, profoundly influencing how teachers teach, how students learn, and the relationshps between adults and children in each classroom, are especially difficult to alter after a century of popular and practitioner acceptance. Because of these factors, schools have learned how to tailor technological innovations to fit the contours of the age-graded school and the self-contained classroom. For the most part, technophiles disregard these traditions and their influence.

Second, previous experiences of instructional television, language laboratories, and programmed learning in the 1960s and 1970s suggest caution to policymakers. Districts built new schools and purchased and installed hardware for those technologies. In less than a decade administrators found that the machinery was either unused, obsolete, or not repairable after breakdowns.(n27)

These reasons help to explain the reluctance of districts to make major investments in new hardware beyond a model program or demonstration school. Thus, the technophile's scenario is least likely to occur.

The other two scenarios are likely to occur but there are important differences between them. Both are basically the same story of computer use in schools but each is interpreted differently. Each scenario stresses different facts and derives entirely different meanings from those facts.

Preservationists argue that schools will take any new technology and tailor it to mirror millennia-old cultural beliefs held by most adults about the nature of teaching, learning, and knowledge that form the core of modern American schooling. Thus, when IBMs and Apples appear in schools they are drafted to continue doing what is deemed important.

Preservationists also point out how the popular age-graded school not only persists through reform after reform but offers many advantages for a democracy seeking to educate millions of students from diverse backgrounds. Such schools have moved wave after wave of immigrants through a system with much-admired efficiency, preservationists argue. Such schools have learned to customize technological innovations to fit the grammar of the age-graded school and its self-contained classroom.

For example, when the overhead projector was introduced in the 1930s, its use grew, albeit slowly, so that by the 1990s it is a mainstay of most classrooms. Why? The overhead projector extends what teachers ordinarily do and is even better than a chalkboard. Teachers can still lecture, explain, and ask questions of

the entire group at one time. Even better, teachers can add overlays and new transparencies without worrying about erasing a chalkboard or turning their backs to the class. So here is one machine that took decades to be fully integrated into routine teaching practice. It did not challenge prevailing practice; it enhanced it.

Preservationists argue that the same process is occurring for computers and telecommunications. Teachers and administrators often use the new machines to enhance conventional teaching practices within the age-graded school. It is not policymakers who determine computer use in schools; it is the practitioners. This scenario is happening now and, according to preservationists, will continue for the immediate future, given the history of previous uses of machines in schools.

Cautious optimists, however, reinterpret the same facts, giving them a breezy, sunny-day spin. The optimists' version of the story displays much patience with the time that it will take to make schools technologically modern. Conceding that there are many instances of technologies being used to reinforce existing practices, optimists shift their attention to the slow growth of technological hybrids, those creative mixes of the old and the new in schools and classrooms.

Preservationists acknowledge such exemplars but see them as mutants, exceptions far removed from the evolutionary trajectory of technology in schools. Optimists point to hybrids of teacher-centered and student-centered instruction and see them as the leading edge of an evolving movement that eventually will bring schools more in sync with the technological imperatives of the larger society. These hybrids of teacher-centered and student-centered instruction, the optimists say, are foreshadowings of the future, not instances of powerful machines being used for trivial purposes. Thus, the current reasons for the fumbling incorporation of high-tech machinery into schools (such as lack of money to buy machines, teacher resistance, inadequate preparation of teachers, and little administrative support) will gradually evaporate as the hybrids slowly spread and take hold. It is an evolutionary scenario using a clock that tells time by decades rather than years.

If preservationists assume the familiar realities of popular beliefs about schooling and age-graded schools as permanent and make straight-line projections into the future, cautious optimists recognize that these familiar realities even now undergo imperceptible change. Optimists acknowledge that the age-graded school must be transformed into a more flexible, ungraded, collaborative organization. They see the teacher-student relationship as central to using the powerful machines. These machines will never replace the teacher because the emotional bond between teacher and student is the basis for learning in schools. All of the hybrids of teacher-centered and student-centered instruction that optimists point to with pride reveal teachers working differently with their students, more as coaches and helpers.

Finally, optimists know that schools adapt every innovation to fit organizational imperatives but they also know that administrators and teachers have brought new technologies into classrooms after putting their fingerprints on them. These practitioner-made hybrids are instances, optimists argue, of the power of school people to alter their circumstances and make students grin rather than groan over school work.

IS THE PRESERVATIONIST OR THE CAUTIOUS OPTIMIST SCENARIO LIKELY?

I argue that the preservationist's scenario will continue in the immediate future for high schools and the cautious optimist's scenario will emerge for elementary schools. My evidence for both scenarios occurring at different levels of schooling derives from how schools are organized for instruction at the two different levels and my studies of how teachers have taught over the last century.

Elementary and secondary schools differ markedly in the complexity of content students face in classrooms, allocation of time to instruction, and external arrangements imposed on both levels from other institutions.

Children in elementary grades learn basic verbal, writing, reading, and math skills. Content is secondary and often used as a flexible vehicle for teaching skills. But in the upper grades of elementary school, and certainly in the secondary school, not only are more sophisticated skills required of students but these skills are embedded in complex subject matter that in and of itself must be learned. Literary criticism, historical analysis, advanced math problems, quantitative analysis in chemistry, all require knowledge of complex facts and their applications. High school teachers, therefore, university-trained in subject matter, will remain fundamentally didactic in methods because subject matter often drives classroom teaching practices.

Student and teacher contact time differs markedly at both levels. While the self-contained classroom remains the dominant form of delivering instruction at both levels, elementary school teachers generally spend five or more hours with the same thirty or more students. They see far more of a child's strengths, limitations, capacities, and achievements than does a high school teacher, who sees five groups of thirty students less than an hour a day. Over a nine-month school year, the elementary school teacher sees a class of thirty children nearly 1,000 hours; a high school teacher sees any one student no more than 200 hours in class during the year or about one-fifth of the time that elementary school colleagues spend with pupils. Contact time becomes an important variable in considering organizational issues of grouping, providing individual attention, varying classroom tasks and activities, and rearranging furniture. In elementary schools, the *potential* to make organizational changes in these and other areas is present just because the teacher has more contact time with the same children; such potential does not exist for thirty students within a fifty-minute period. Whether such changes occur in the lower grades, is, of course, an entirely separate issue, but the organizational difference in allocation of instructional time allows for possible changes in elementary school classrooms.

Finally, external pressures from accrediting associations, college entrance requirements, and job market qualifications have a far more direct and unrelenting influence on high schools than on lower-grade classrooms. In the high school, strong pressures on teachers and students derive from meeting the demands of Carnegie units; College Board, Scholastic Aptitude, Advanced Placement, and state and national standardized achievement exams; certifying agencies; and other external constraints.

While there are urgencies that press teachers and students in the lower grades, especially in getting students ready for the upper grades, flexible responses are possible. Grades (e.g., fourth and fifth) can be merged. Groups within a class can include a range of ages and performance. Whole days and even weeks can be set aside for special concentration in academics or other events. Not so in high schools.

These three structural differences-emphasis on subject matter, contact time, and external pressures-may well account for the fact that I found many shifts in elementary school teaching practices and few in high school classrooms.

My research into how high school teachers have taught subject matter since the 1890s clearly supports the preservationist's story. High school teachers, bound by a social organization of instruction that includes teaching two or three different subjects and seeing 150 to 200 students daily in five or more fifty-minute classes, have created a durable, practical pedagogy that researchers have documented consistently in English, history, science, and math over the last century.(n28)

In elementary school classrooms, I found evidence of this practical pedagogy but I also found strong evidence of substantial changes in teaching practices that resembled the hybrids that optimists identified. I found, for example, that in the 1890s, the one form of grouping for instruction in both elementary and secondary school classrooms was teaching the entire group of students at the same time; within three decades, under the insistent pressure of progressive educators, newer forms of grouping began to appear in elementary schools--small groups for the teaching of reading--and a growing array of instructional materials made it possible for teachers to tailor teaching to differences among students. A century later, elementary

school teachers routinely use a mix of whole-group, small-group, and individual options in their classrooms. While some high school teachers do use varied groupings in their classes, dominant practice remains teaching the entire whole group for fifty-minute periods.

The repertoire of classroom teaching practices has also broadened over the last century. In the 1890s, lecturing, using the textbook, questioning students on what they know, assigning homework, and tests were the primary tools of the classroom teacher. A century later, these tools persist as standard practice in secondary school academic subjects. In elementary schools, however, that teaching repertoire has expanded with the addition of visits to community institutions and new materials and technologies. While field trips, films, videocassettes, television, and computer labs may not be mainstays of most classroom instruction, they are sparingly used, again testifying to the slow growth of hybrids in instruction. Such instances of change in classroom practice provide additional evidence for the cautious optimist's scenario of technological hybrids' slowly changing the conduct of schooling.(n29)

The point I wish to make is that how the age-graded school is organized for instruction at the two levels determines to a large degree which scenario will be most likely to occur. The preservationist's scenario is most likely in high schools, where disciplinary subjects reign and the number of classes and students teachers teach remains high. The cautious optimist's scenario is more likely to occur in elementary schools, where organizational differences make possible shifts in practice and where hybrids of teacher-centered and student-centered instruction have, indeed, evolved slowly over the last century.

There are, however, emerging national policies that may influence both the pace and the direction of these scenarios in the 1990s. One is the current movement for national goals, standards, and testing. If the movement continues its momentum, especially in its concentration on national examinations with strong consequences for individual students' futures and school funding (such as the National Assessment of Educational Progress [NAEP]), the movement may largely channel new technologies to fit existing patterns of teaching and learning because what fuels the drive toward national goals, standards, and testing is the lure of increased student productivity. Concentration on quantitative standards reinforced by high-stake test results usually diminishes risk-taking in classroom and school innovations. My guesswould be that continued national pressure would bolster the preservationist's scenario for *both* elementary and high schools, while limiting innovations in information technologies that might not meet the standard of higher test scores such as the ones pushed by neoprogressive reformers.

The other emerging national policy is the growing privatization of public schooling. The spread of Channel 1 in schools (it now reaches over 7 million students in 11,000 secondary schools, almost one-third of the U.S. total) is a Faustian bargain for schools that receive hard-to-get machines in exchange for twelve minutes of news and commercials that students must watch daily. Channel 1 is especially popular in big cities that are cash-poor and seldom offer access to such equipment to their mostly poor, ethnic students. Moreover, the siphoning away of public school students to private schools through voucher-type experiments and leased operation of public schools by businesses might increase the uses of electronic technologies in the short term, as, for example, in Christopher Whittle's proposed Edison Project, but might straitjacket classroom uses of technology over the long term if the imperative to produce high test scores on national exams persists. If this move toward privatization continues, masses of poor children left behind in large cities will seldom experience creative uses of technology. Both of these emerging policy directions give me pause in considering which of the scenarios will get the most play in the closing years of this century.(n30)

Thus far, I have argued that the likely scenarios might vary by school level and that neither scenario promises swift changes in the waning years of this century. But likely is not desirable. What is the desirable scenario for the next decade? Which of the scenarios, if they are reasonable approximations of what might happen in the next decade, should policymakers and practitioners help along? To ask about desirability is to

ask about the values embedded in the goals of schooling. In short, what do we want students to do and be?

DESIRABLE FUTURES

Reform coalitions in the 1980s and 1990s sought to incorporate new technologies into their efforts to improve schooling. Within these coalitions were blended impulses that drove them to raise funds, lobby for legislation, and design school reforms. Those urges, then and now, contain prized values about what children should learn and how they should learn it:

To prepare today's students for a future in which electronic technologies rule the work place, the marketplace, and the home. Values of having schools that are modern and equipping individuals (and the nation) to compete in a changing economy are strong within this push for technologies.

To make teaching and learning self-directed, active, engaged, and community-enhancing. The prized values here are in teaching for understanding, cultivating student autonomy, and creating adult-child learning communities. Students will be self-directed, thoughtful, independent, and able to work well with others.

To make teaching and learning productive, that is, better, more of it, and faster. The core values sought are efficiency in the use of limited school resources and enhanced individual productivity so that future workers will make U.S. businesses internationally competitive.

Although I identify these impulses and their values separately, they often merge in the minds of reformers and practitioners. Frequently, these values are entwined in any one proposal for school change. Sometimes the values are so entangled within the scenario that they are obscure; sometimes they are made explicit.

So which scenario is desirable? Each reader will fasten on one or another of the stories depending on his or her values and experiences. For me, I can answer easily enough: the cautious optimist's, particularly where the tilt is toward neoprogressive ideas. I try to teach within that tradition and have come to use computers extensively in my writing, research, and, on occasion, teaching; in effect I have evolved into one of the hybrids mentioned in the scenario.

Yet even as I favor using information technologies as tools to create self-directed learners, independently thoughtful students, and learning communities, I still have strong reservations about the desirability of extensive classroom use of computer and telecommunication technologies: Computers can do what they do well but what they can do well may not be best for students' development, learning, or instruction. I do not know, for example, the collateral or unintended [earnings that students absorb from working with computers. I worry that extensive classroom use of computers ultimately may corrode the teacher-student relationship, the social climate of a classroom, and the importance of students' learning to work collaboratively. These are my beliefs, my reasons, my faith--and my fears. I can argue for all of them with passion, although the evidence I have is spotty.(n31)

But is it only one's preferences that determine desirability? Are these judgments no stronger or better than one's taste for chocolate chip ice cream? Are there other standards by which one can choose one scenario over another and work toward its enactment?

One standard might be: What does the research say? For within two of these scenarios (technolophile and cautious optimist) are unexamined core assumptions that can be empirically tested: Computers are more cost-effective for instruction than other means of teaching; the use of computers in classrooms or in computer labs will not mechanize teaching; and, finally, the impact of computers on children's learning is positive. If, for instance, there is strong evidence that computer technologies produce more student learning than do conventional approaches, then the technophile and optimist scenarios become worthy of support, regardless of one's values--one could argue. Sadly enough, the research evidence on all three questions is

ambiguous and unhelpful in determining policy.(n32)

Another possible standard that stakes out a middle ground between personal preferences and scientifically sound evidence is turning to traditional beliefs to judge the worth of a scenario. Consider, for example, the historic belief that all students must learn the basic elements of the national political system and the common features of the culture or the belief in the importance of teacher-student relationships in promoting learning. These traditional beliefs have a long history in public schooling and have strong justification for their durability; they can be used also to judge scenarios.

Even with these three possible standards, no scenario emerges clearly or easily as desirable. We end up with conflicting advocacies, defenses and rebuttals to policy proposals, and analyses of a claim's strength by its evidence. Policymakers and practitioners are seemingly in no better shape than trial lawyers trying to determine guilt or innocence when only a few witnesses are available, evidence is spotty, and reasonable doubt is strewn across the landscape. Only a best judgment can be made and the judgment, more often than not, is a mix of facts and values. No clear, convincing, and unambiguous evidence points like an arrow toward an unavoidable conclusion guiding policymakers, practitioners, or researchers to choose among the scenarios. Cases for or against a particular scenario can be made from data arrayed to bolster claims. So be it.

SUMMARY

What happened to my initial question? I asked why, with all the talk of school reform and computers over the last decade, electronic technology is used far less on a daily basis in classrooms than in other organizations. My answer is that technological innovations have never been central to any national movement to improve schooling since the origins of public schools a century and a half ago. Not until the 1980s and 1990s have new technologies been part of the rhetoric of reform. Thus, after all has been said and done--more has been said than done.

Second, the seemingly marginal use of computers and telecommunications in schools and classrooms is due less to inadequate funds, unprepared teachers, and indifferent administrators than to dominant cultural beliefs about what teaching, learning, and proper knowledge are and how schools are organized for instruction.

There are three plausible stories for what the next decade holds in store for the use of computers in teaching. Each of these scenarios contains diverse values mirroring the impulses that reformers bring to their goal of school reform. The likely scenarios, which may bedifferent from the desirable ones, point to little substantial change in the closing years of the twentieth century. Where two scenarios differ is that optimists see hope in the hybrids that have emerged, a hope that over decades these hybrids will become routine, producing significantly different classrooms and schools; preservationists see far more stability than change in the years to come with teaching and learning staying pretty much as they currently are. However the story of computers in schools comes out in the coming decades, one line, slightly amended, remains constant, if not true: Computers meet classroom; classroom wins--for now.

The title of this article comes from Decker Walker's caption for an advertisement he saw on computers in the classroom. See "Computers and Curriculum," in Microcomputers and Education, 85th Yearbook of the National Society for the Study of Education Part 1, ed. Jack Culbertson and Luvern Cunningham (Chicago: University of Chicago Press, 1986), p. 31. I wish to thank Gary Lichtenstein, David Tyack, and Luis Osin for their comments on this draft. This article is a revision of a paper commissioned for the Aspen Institute Seminar in Technology, August 1992.

Notes

(n1) "Computers in School: A Loser? or a Lost Opportunity," *Business Week*, July 17, 1989, p. 108; U.S. congress, Office of Technology Assessment, *Power On!: New Tools for Teaching and Learning*, OTA-SET-379 (Washington, D.C.: Government Printing Office, 1988), p. 199.

(n2) U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States*, 1991 (Washington, D.C.: Government Printing Office, 1991), p. 150; and Quality Education Data, "Technology in Public Schools, 1991-1992: Extract" (Denver: Quality Education Data, 1992), pp. 1-2.

(n3) U.S. Congress, Office of Technology Assessment, *Power On*, p. 6.

(n4) The Alliance for Technology Access is a network of resource centers that specializes in using computers to help individuals with disabilities, *CompuCID*; also see Susan Russell et al., *Beyond Drill and Practice: Expanding the Computer Mainstream* (Reston, Va.: The Council for Exceptional Children, 1989).

(n5) Thomas Edison, quoted in Larry Cuban, *Teachers and Machines: The Classroom Use of Technology since 1920* (New York: Teachers College Press, 1986), p. 9.

(n6) Ibid., pp. 4-6.

(n7) For the common school movement, see David Tyack and Elisabeth Hansot, *Managers of Virtue* (New York: Basic Books, 1982); and Carl Kaestle, *Pillars of the Republic* (New York: Hill and Wang, 1983).

(n8) David Hornbeck, "Technology and Students at Risk of School Failure," in *Education Policy and Telecommunication Technologies*, ed. Arthur Sheekey (Washington, D.C.: U.S. Department of Education, Office of Educational Research and Improvement, 1991), pp. 1-2; emphasis in original.

(n9) See Christopher Dede, "Imaging Technology's Role in Restructuring for Learning," in *Restructuring for Learning with Technology*, ed. Karen Sheingold and Marc Tucker (New York: Center for Technology in Education, Bank Street College of Education, 1990), pp. 49-72.

(n10) *A Nation at Risk*, for example, forged the linkage between national economic productivity and school productivity. The report recommended a half-year of computer sciences as a high school graduate requirement. See National Commission on Excellence in Education, *A Nation at Risk* (Washington, D.C.: Government Printing Office, 1983), p. 26.

In examining the impulses during reform coalitions, l read about and listened to the reasons reformers used in explaining why new technologies were crucial in improving schools. I have merged reasons that I felt were close enough to be cousins and, in doing so, probably created both ambiguity and mild confusion, if not annoyance, for some readers who wanted clarity or distinctiveness. For a more exact delineation of the specific impulses for computers in schools see Israel Scheffler, "Computers at Schools;" *Teachers College Record* 87 (Summer 1986): 514-28.

(n11) I use the word *neoprogressive* to link the ideas of these reformers with those of reformers a century earlier who were pedagogical progressives challenging the then inflexible ways of teaching, learning, and organizing schools. The ideas of Francis Parker, John Dewey, William H. Kilpatrick, and such diverse practitioners as William Wirt and Ella Flagg Young were applied to schools and classrooms in the decades before and after the turn of the century. Notions of active engagement of children in what they were learning, group work on projects, and focus on both the mind and emotions of children as they developed were central to this earlier generation of reforms. See Lawrence A. Cremin, *The Transformation of the School* (New York: Vintage, 1961); and David Tyack, *The One Best System* (Cambridge: Harvard University Press, 1974).

(n12) For instances of these ideas, see Howard Gardner, *The Unschooled Mind: How Children Think and How Schools Should Teach* (New York: Basic Books, 1991); end John Seely Brown, Allan Collins, and Paul Duguid, "Situated Cognition and the Culture of Learning," *Educational Researcher*, January-February 1989, pp. 32-41. For a clear portrayal of the neoprogressive view of computer use see articles by Judah Schwartz, Sylvia Weir, and the writers for the Laboratory of Comparative Human Cognition in "Visions for the Use of Computers in Classroom Instruction," *Harvard Educational Review* 59 (1989): 51-86; and "Responses to 'Visions for the Use of Computers in Classroom Instruction' " *Harvard Educational Review* 59 (May 1989): 206-25.

(n13) See American Association for the Advancement of Science, *Science for All Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology* (Washington, D.C.: American Association for the Advancement of Science, 1989). Also see National Science Teachers Association, *Essential Challenges in Secondary Science: Scope, Sequence, and Coordination* (Washington, D.C.: National Science Teachers Association, 1989); and National Council of Teachers of Mathematics, *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (Washington, D.C.: National Academy Press, 1989).

(n14) See, for example, Carl Kaestle, ed., *Joseph Lancaster and the Monitorial School Movement* (New York: Teachers College Press, 1973); Raymond Callahan, *Education and the Cult of Efficiency* (Chicago: University of Chicago Press, 1962); Arthur Melmed, "Productivity and Technology in Education," *Educational Leadership*, February 1983, pp. 4- 6; and U.S. Congress, Office of Technology Assessment, *Power On!*, pp. 171-72.

(n15) *American School Board Journal* 84 (June 1932): 97.

(n16) Dustin Heuston, "The Future of Education: A Time of Hope and New Delivery Systems" (unpublished paper, WICAT systems, Orem, Utah, 1986; cited in Royal Van Horn, "Educational Power Tools: New Instructional Delivery System," *Phi Delta Kappan*, March 1991, pp. 527-33; quote on p. 533; emphasis in original).

(n17) Draft of *Texas Technology Model for 2061 Project*, 1991, pp. 2-4. For another example of older students using technologies in an early twenty-first century "school," see Christopher Dede, "Imaging Technology's Role in Restructuring for Learning," in *Restructuring for Learning*, ed. Sheingold and Tucker, pp. 51-52.

(n18) Saul Rockman, "Telecommunications and Restructuring: Supporting Change or Creating It," in *Educational Policy and Telecommunications Technologies*, ed. A. Sheekey (Washington, D.C.: U.S. Department of Education, 1991), p. 25; emphasis in original.

(n19) The essays of David K Cohen fit within this scenario. He has analyzed succinctly and well reasons why electronic technologies are marginal to the conduct of schooling. See, for example, David K Cohen, "Educational Technology and School Organization," in *Technology in Education: Looking toward 2020*, ed. Raymond Nickerson and Philip Zodhiates (Hillsdale, NJ.: Lawrence Erlbaum Associates, 1990), pp. 231-64. Cohen examines the fit between innovative technologies--in general--and the scarcity of incentives for change within public education. His emphasis on the social organization of the school mirrors my own and has enriched my analysis. Also see David Tyack and Elisabeth Hansot, "Futures That Never Happened: Technology and the Classroom," *Education Week*, September 4, 1985, p. 40. My first foray in this subject, *Teachers and Machines*, offered an argument and evidence for this scenario also. Brian Wilson makes the preservationist's point by his "law of suppression of radical potential." A new technology that can substantially alter organizational routines and practices, he argues, is viewed by members of an organization as a way of accomplishing more easily and efficiently what they are already doing. See his

Misunderstanding-Media (Cambridge: Harvard University Press, 1986).

(n20) U.S. Congress, Office of Technology Assessment, *Power On!*, pp. 201- 02.

(n21) Stephen Kerr, "Lever and Fulcrum: Educational Technology in Teachers' Thought and Practice," *Teachers College Record* 93 (Fall 1991): 114-36; idem, "Technology, Teachers, and the Search for School Reform," *Educational Technology Research and Development* 37 (1989): 5-17'; Allan Collins, "The Role of Computer Technology in Restructuring Schools," in *Restructuring for Learning with Technology*, in ed. Sheingold and Tucker, pp. 29-48 (the quote from Collins is on page 36); and Denis Newman, "Opportunities for Research on the Organizational Impact of School Computers," *Educational Researcher* 19 (1990): 8-13.

(n22) Denis Newman, "Technology's Role in Restructuring for Collaborative Learning" (Paper presented to the NATO Advanced Research Workshop on Computer Supported Collaborative Learning, Maratea, Italy, September 1989), p. 11.

(n23) Ibid.

(n24) David Dwyer's work at Apple Computers in researching and evaluating Apple Classrooms of Tomorrow (ACOT) has yielded a number of studies in particular schools that sup port this neoprogressive vision of teaching, learning, and slow change in organizing instruction. See Jane David, "Partnerships for Change," ACOT Report #12 (Cupertino, Calif.: Apple Computer, Inc., 1992); and Robert Tierney et al., "Computer Acquisition: A Longitudinal Study of the Influence of High Computer Access on Students' Thinking, Learning, and Interactions," ACOT Report #16 (Cupertino, Calif.: Apple Computers, Inc., 1992).

A hybrid of neoprogressive and behavioristic influences can be seen in recent generations of ILSs. One of the most sophisticated that I have seen (as of 1992) is RAMA 3, a multisubject computer-assisted instructional program for grades 1-8 created at the Center of Educational Technology in Tel Aviv, Israel. Earlier versions of the ILS are being used by over 100,000 students, or almost 10 percent of the total school population. The system includes not only powerful computers and software programs but printed booklets, continuous staff development

for teachers, and a large maintenance department. See Luis Osin, "A Computerized Learning Environment Integrating Prescribed and Free Student Activities" (Proceedings of the East-West Conference on Emerging Computer Technologies in Education, Moscow, April 1992); and Centre for Educational Technology, "Annual Report" (Tel Aviv, Israel: Author, November 1992).

(n25) George Leonard, "The End of School," *Atlantic*, May 1992, p. 32.

(n26) I assume that no major political, economic, or social trauma dramatically alters popular perceptions about the expected role or organization of schools in this culture. Were a serious political upheaval in the national government, a severe economic depression, or grave urban disturbances requiring sustained military intervention to occur, popular views of what schools ought to do would probably change, and calls for fundamental alterations in the purposes and organization of schools would ensue. Under such conditions, the notion of "likely scenarios" would be foolish.

(n27) Karen Sheingold and Martha Hadley, "Accomplished Teachers: Integrating Computers into Classroom Practice" (New York: Center for Technology in Education, Bank Street College of Education, September 1990), pp. 1, 13; also Decker Walker, Bruce Keepes, and George Change, "Computers in California High Schools: Implications for Teacher Education" (unpublished paper, 1991) and their designation of teachers who were "pioneering," p. 11.

(n28) Cuban, *Teachers and Machines*, pp. 27-50.

(n29) Larry Cuban, *How Teachers Taught* (New York: Longman, 1984); see also Ernest Boyer, High School (New York: Harper & Row, 1983); Theodore Sizer, *Horace's Compromise* (Boston: Houghton-Mifflin, 1984); and Arthur Powell, Eleanor Farrar, and David Cohen, *The Shopping Mall High School* (Boston: Houghton-Mifflin, 1985).

(n30) Cuban, *How Teachers Taught*, pp. 135-36, 199-200.

(n31) I raise these points in *Teachers and Machines*, pp. 95-98. In the literature that I have read since I completed this book (1986), except for an occasional article, I have yet to see serious examination of these questions. The prevailing assumptions of the worth of computers in classrooms, their supposed superiority to other means of teaching and learning, and the seemingly benign influences of the technology have yet to be thoroughly examined. The articles that Douglas Sloan compiled andedited in *The Computer in Education: A Critical Perspective* (New York: Teachers College Press, 1985) remain strong rebuttals to the prevailing uncritical acceptance of computers in classrooms. Stephen Kerr is one of the few researchers who examines seriously the deep-set beliefs of both technophiles and technophobes.

(n32) See Cuban, *Teachers and Machines*, pp. 84-98, for the answers that I gave to these policy assumptions and the available research in 1986. The Office of Technology Assessment's (OTA), *Power On!* directly addresses the question of impact of information technology on learning and, in general, comes up with a favorable conclusion, acknowledging the shortcomings of the evidence (see pp. 41-65). For cost-effectiveness studies, again, *Power On!* analyzed studies and found that computer-assisted instruction for "doing what we currently want schools to do" is of value (p. 81). Beyond that, however, OTA questioned the ways that previous cost-effectiveness of computers in classrooms or schools was determined but did recommend that such studies needed to be done (pp. 69-81). Basically, *Power On!* assumes that computers are necessary for schools to improve; the study seldom raises questions about the computer's worth as a learning tool or its less-than-benign effects on the conduct of schooling. Henry J. Becker examined thirty evaluations of Integrated Learning Systems. Although he reports a "moderately positive effect on student achievement," he points out clearly that "the poor quality of most evaluations and the likely bias in what does get reported at all provide too weak a platform for district purchasing decisions" (p. 1). See "Computer-Based Integrated Learning Systems in the Elementary and Middle Grades: A Critical Review and Synthesis of Evaluation Reports," *Journal of Educational Computing Research* 8 (1992): 1-41.

For a recent argument on the social meanings of bringing computers into school; the effects of gender, race, and class on computer uses in schools; and the mechanization of teaching, see Michael W. Apple, "The New Technology: Is It Part of the Solution or Part of the Problem in Education?" *Computers in the Schools* 8 (1991): 59-81.

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