Appendix E Public School Teachers Using Machines in the Next Decade

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It is hard to be clever about the folly of making predictions. I could cite instances of those who have predicted everything from the end of the world to the end of printed books. I could cite others whose business is forecasting the immediate future as, for example, Central Intelligence Agency executives who missed the collapse of the Soviet Union. Or I could turn to those who saw a revolution in schoolteaching with the invention of film, radio, television, and computers. None of these is clever or even amusing.[1]

I prefer candor to cleverness so, with the risks of forecasting in mind, I will create three plausible "futures" of teachers using computers, CD-ROMs, modems, and other telecommunications in their classrooms. These scenarios will have a patina of credibility because they are anchored in what exists now and are seasoned with the experiences of both partisans and opponents of teachers using these machines in their classrooms. I then will identify the most likely of these three scenarios to occur in teachers' classrooms. I am reasonably confident which scenario will materialize, although the less courageous side of me surrounds the likely "future" with at least one qualifier.

So, I want to be clear at the very beginning of this essay that my "prediction" is no more than an educated guess based upon the claim that schools are unique organizations, the fabric of social

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[1] For recent prophesies about the end of printed books, see D.T. Max, "The End of the Book?," Atlantic, vol. 274(3) September 1994, pp. 61-71. For forecasts on electronic machines' impact on public schools, see Larry Cuban, *Teachers and Machines: The Use of Classroom Technology Since 1920* (New York, NY: Teachers College Press, 1986).

beliefs woven around public schools, and what has occurred in the past when practitioners faced electronic machines.

In this paper I will argue that the spread of telecommunications in businesses, industries, the military, and other organizations make comparisons to getting teachers to use computers in their classrooms facile but misguided because the classroom as a workplace, the nature of teaching groups of children, and public expectations for schools differ substantially from other institutions.

Such casual comparisons, I will argue, are driven more by a mind-set that frames the problem of snail-like progress in getting teachers to use the technology as an engineering problem. That is, the organization is basically in good order; what it needs is a heavy dose of efficient managing and quality control. If teachers are not using the damn machines, get more of them, train the teachers to use them, provide continuous hardware maintenance and technical assistance to teachers and, by God, there will be more students on those machines. Framing the problem this way is popular and dominates the thinking of many advocates for telecommunications in schools.

A less popular way of framing the problem is seeing the very slow (and, as partisans would say, unimaginative) use as a problem of poor design and stubborn traditional beliefs. That is, the present school structures (e.g., age-graded schools) and cultures (e.g., norms of teacher self-reliance rather than collaboration) that dominate the teacher's workplace need to be redesigned with teaching and learning kept foremost in mind for innovative technologies to be used in classrooms routinely. Second, the redesign will have to take into consideration dominant popular beliefs about what teaching is, how learning occurs, what knowledge is proper in schools, and the teacher-student relationship. These traditional beliefs inform mainstream views of a proper schooling. It is, however, the engineering approach, not the redesign approach, to getting teachers to use telecommunications that currently dominates the popular and research literature on teacher use of technologies.[2]

There are very good reasons why the problem of limited teacher use of technology is framed less often in design terms. Previous school reforms that swept across the nation largely ignored technology. Moreover, the entangled impulses that drive reformers to press teachers to use new technologies seemingly mirror those very same impulses in manufacturing, banking, medical science, the armed forces, and other organizations that have automated many of their essential operations. Engineered solutions worked there. Why not in schools?

I then turn to three scenarios that I constructed as credible alternative futures and assess which one is likely to occur. To make this entire argument concrete and coherent I will concentrate on teacher use of computers.

THE SPREAD OF COMPUTERS IN SCHOOLS: CONFUSION OVER ACCESS, USE, AND INNOVATION

School use of computers has spread swiftly, widely, and, on occasion, deeply. In 1981, for example, there were, on average, 125 students per computer; in 1991, there were 18. As new schools are built that are wired for information technologies

[2] See, for example, U.S. Congress, Office of Technology Assessment, *Power On!: New Tools for Teaching and Learning*, OTA-SET-379 (Washington, DC: U.S. Government Printing Office, 1988); Office of Technology Assessment, "Project Proposal: Teachers and Technology," 1993, pp. 1-12.

and the ratio of machines to students drop to 4:1 or even less, hopes escalate for wider and more sophisticated uses of the machines.[3]

A closer inspection of those and other figures commonly used to display the swift penetration of the technology into schools, however, reveals the frequent confusion between access and use. For those individual students who use computers (and not all do) they spend, on average, a little more than one hour a week (or 4 percent of all instructional time). Moreover, what students do with computers varies greatly. For 11th grade students who use the machines, to offer another example, computers were seldom used in subject areas; where they were used, the purpose was to teach about computers. An Office of Technology Assessment (OTA) study concluded that students from high-income families have far more access to computers in schools than peers from low-income families. Black students use computers in schools less than white, 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.[4] What appears as a rampaging innovation threatening to reform the conduct of teaching and learning, then, is much less than meets the eye. And that has been the case with earlier technologies groomed as tools for reforming traditional classrooms.

TECHNOLOGIES AND SCHOOL REFORM

What is curious about current information technologies and their earlier incarnations 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 19th century, none were dependent upon instructional technologies beyond a 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 where students could 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—a systems perspective—was present in the organizing of age-graded elementary schools

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[3] U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of The United States, 1991* (Washington, DC: U.S. Government Printing Office, 1991), p. 150; Quality Education Data, "Technology in Public Schools, 1991-1992: Extract (Denver, CO: Quality Education Data, 1992), pp. 1-2. For examples of new schools there is 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. See "Computers in School: A Loser? Or A Lost Opportunity," Business Week, July 17, 1989, p. 108.

[4] *Power On!*, op. cit., footnote 2, p. 6. 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. See The Alliance for Technology Access, a network of resource centers that specializes in using computers to help individuals with disabilities. They publish an occasional newsletter, *CompuCID*, the Computer Classroom Integration Project; also see Susan Russell, Rebecca Corwin, Janice Mokros, and Peggy Kapisovsky, Beyond Drill and Practice: Expanding the Computer Mainstream (Reston, VA.: The Council for Exceptional Children, 1989).

Such figures also ignore the massive computerization of administrative work in districts and schools previously done by typewriters and telephone. Computerized data processing, for example, has converted the making of district bus schedules, high school course selections, payroll operations and the reporting of grades into routine activities that take a fraction of the time formerly used for these tasks. Increasingly, teachers use software to prepare lessons, notes to students and parents, classroom newsletters, attendance and grade-report records. In libraries, card catalogues are electronically available. The overall picture after the introduction of the personal computer a decade ago and persistent efforts to improve schooling suggest, at best, that computers are an expanding but marginal activity in schools with wide variation in administrative, teacher, and student use.

and subject-centered, departmentally-focused high schools with their multi-period daily schedule of recitations.[5]

A half-century later, another generation of reformers sought to transform schools into instruments of social reform. These progressive education reformers wanted schools to turn millions of immigrants into Americans and reduce the corrosive effects of slum housing, urban crime, and poverty. Moreover, reformers wanted these schools to focus on more than the child's mind; their psychological and social development were part of the educator's responsibility. Furthermore, what children studied had to change because they learned best when their interests were harnessed to what occurred in the home, community, and nation. Throughout the early 20th century, progressive educators sought ways of transforming schools to secure these aims. Many educators in pre-World War II schools saw the invention of 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.[6]

Since 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 and programmed learning in the 1950s and 1960s and computer-assisted instruction in the 1960s and 1970s), but the center of gravity to any of these national reforms was nontechnological. Machines were mere blips on the outer edges of reformers' radar screens.[7]

This has not been the case in the 1980s and 1990s. With massive technological changes in the workplace and daily life, school reformers throughout the last decade increasingly have turned to putting computers in schools as a high-tech, engineered solution for ineffective, even primitive, teaching by textbooks. Hundreds of formal reports from corporate leaders, foundations, professional associations, and federal agencies consistently have underscored how schools have failed in achieving their academic purposes and how, in that failing, have contributed to the nation's economic decline.[8]

Thus, in the 1980s and early 1990s, strong impulses to introduce higher quality control into public schools moved these coalitions of 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 LATEST TECHNOLOGIES IN SCHOOLS

Basically, three impulses converged in reforming schools through electronic technologies. Al-

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

[6] For general history of progressive movement in education, see Lawrence Cremin, The Transformation of the School (New York, NY: Vintage, 1961); for the penetration of these ideas into schools and classrooms, see Larry Cuban, *How Teachers Taught*, 2d edition, (New York, NY: Teachers College Press, 1993) and Arthur Zilversmit, *Changing Schools: Progressive Education Theory and Practice* (Chicago, IL: University of Chicago Press, 1993).

[7] For post-World War reforms, see Diane Ravitch, *The Troubled Crusade* (New York, NY: Basic Books, 1983).

[8] T*he Nation at Risk* (1983) report, for example, forged the linkage between economic decline as a nation and decline in standardized achievement test scores. The report recommended a half-year of computer science as a high school graduation requirement. See National Commission on Excellence in Education, *A Nation at Risk* (Washington, DC: U.S. Government Printing Office, 1983), p. 26. Also see, for example, David Hornbeck, "Technology and Students at Risk of School Failure" in Arthur Sheekey (Ed.) *Education Policy and Telecommunication Technologies* (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, 1991), pp. 1-2.

though I offer them separately, they are entangled and technological enthusiasts often combine one or more of these impulses in their advocacy for a particular technology.

First, there is the drive to bring schools technologically in step with the workplace because of the fear that students will be unprepared both to compete in the job market and adjust to the changing marketplace where bank teller machines, bar codes on products, answering machines, and other electronic devices prevail. The computerized workplace 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. Computers, in other words, are the future and schools must prepare students for it.[9]

A second impulse has come from a diverse coalition of academics, educators, and foundation officials who have neoprogressive values of children engaged in self-directed learning. This coalition, leaning upon the work of American (John Dewey and Jerome Bruner), European (Maria Montessori), and Russian (Lev Vygotsky) scientists and educators, seeks to overhaul classrooms where learning is tediously absorbing knowledge largely unconnected to daily life. They want schools where teachers help students construct their own understanding. Neoprogressives view students as active learners creating knowledge that makes sense to them. They want schools where such knowledge is shared by all members of the community; schools where diverse mixes of adults and children work easily together in varied groupings. Hence, interactive computers and telecommunications are mind-tools that help students grasp concepts, use all of their senses, and practice what they have learned creating self-directed learning communities, according to such advocates.[10]

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 19th century and has been a consistent goal for schooling ever since.[11]

Advertisements for computers make similar points today without hesitation or subtlety. IBM has run an ad for the last few years that has a clever set of photos showing the same teacher working with different students in her class simultaneously. The caption reads: "With IBM, there's a practical way for teachers to be everywhere at once." The ad copy says:

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[9] In examining the impulses driving recent reform coalitions, I read the reasons reformers used in explaining why new technologies were crucial in improving schools. I 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. For a more exact delineation of the specific impulses for computers in schools, see Israel Scheffler, "Computers at School?," *Teachers College Record*, 87(4), Summer 1986, pp. 514-528.

[10] I use the word "neoprogressive" to link the ideas of these reformers with those of 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 reformers. See Lawrence Cremin, *The Transformation of the School* (New York, NY: Vintage, 1961); David Tyack, The One Best System (Cambridge, MA.: Harvard University Press, 1974).

For instances of these ideas in print, see Howard Gardner, *The Unschooled Mind: How Children Think and How Schools Should Teach* (New York, NY: Basic Books, 1991; John Seely Brown, Allan Collins, Paul Duguid, "Situated Cognition and the Culture of Learning," *Educational Researcher* (Jan.-Feb., 1989), pp. 32-41. For a clear portrayal of the neoprogressive view insofar as using computers, 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 (February 1989) and "Responses to 'Visions for the Use of Computers in Classroom Instruction'" (May 1989) in *Harvard Educational Review*, 59(3), pp. 206-225.

[11] See, for example, Carl Kaestle, (Ed.) *Joseph Lancaster and the Monitorial School Movement* (New York, NY: Teachers College Press, 1973); Raymond Callahan, Education and the Cult of Efficiency (Chicago, IL: University of Chicago Press, 1962) Arthur Melmed, "Productivity and Technology in Education," *Educational Leadership*, February 1983, pp. 4-6; *Power On!*, op. cit., footnote 2, pp. 171-172.

> With an IBM network, teachers are discovering how to do the impossible: deliver quality, individual instruction to every student. It is possible because students are working with a tool that is infinitely patient . . . teachers are free to evaluate student progress and help when a need arises. [12]

"Faster, better, and cheaper" is the drumbeat of the productivity impulse.

These interlocking impulses have fueled the surge in school purchases of information technologies in the 1980s and early 1990s. But as the figures cited earlier revealed, teachers' use of computers and telecommunications have yielded mixed results.

Some obvious questions arise. Is 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 like earlier ones, 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, within time, most classrooms will become more machine-friendly?

These questions ask about the future so I will sketch out three scenarios of what might be 10 years from now. Each storyline is plausible and has substantial evidence to support it. After describing each I will pick one that I believe is likely to be dominant a decade from now.

THREE SCENARIOS

The Technophile's Scenario: Electronic Schools of the Future, Now

A decade from now schools will have enough machines, software, accessories, and wiring to accommodate varied groups of students in classrooms, seminar rooms, and individual workspace. The technophile's vision driving such schools is anchored in making teaching and learning far more productive and meaningful than both are now. [13]

Better machines and software are central to this vision; they are seen as tools for both teachers and students to liberate themselves from inflexible ways of teaching and learning. Students will come to rely on the machines and one another to teach each other; teachers will become coaches to help students with what needs to be learned. Frequent lectures, recitation, textbook assignments, and 50-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. Technophiles believe in 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 vivid. 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 Dickin-

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[12] *The School Administrator*, May 1989, between pages 15 and 18.

[13] What I call "technophiles" Thomas P. Hughes calls "technological enthusiasts." His study of American inventions and growth of systems for using technology (electrical industries, manufacturing, etc.) between 1870 and 1970 makes clear that the present moment of vibrant hope for the future that technophiles aspire to is part of a larger enthusiasm that is typically American. See Thomas P. Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm* (New York, NY: Viking, 1989).

son' 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. . . .'

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. . . .[14]

Other technophiles offer neoprogressive flights into the future to dramatize how new technologies can create student-centered schools. One example will give a distinct flavor for this version of the scenario. In this instance, a high school senior from a fully computerized school is applying for a job at a TV station.

She looked through her portfolio for the hundredth time. She hoped she had everything that she needed and that the battery on her notebook computer held up. She had her early work from the other clusters too. She had even brought her ID disk, in case Mr. Martin wanted her to see the hologram that showed the paths she chosen to reach Mastery [in the curriculum].

'Come on in, Laura. . . .' Laura sat nervously on the edge of the chair next to Mr. Martin. "Well, Laura, how are you? Are you ready to show me what you've accomplished?'

'Yes, sir, I sure am!' Laura relaxed as she began to talk about her projects. . . . 'I'm interested in long-range weather planning and its implications on international relations. . . .' Laura handed Mr. Martin her disk as he activated the laser wall display. As the images of her data began to appear, she described in detail the steps she had taken in the completion of her prediction simulation. . . .

'Well, Laura, you've done a good job. Tell me about some of your other activities in school.'

'I did my first rotation when I was eight. It was at the Materials and Manufacturing Cluster. We compared the differences between bread baked in a bakery and bread baked at home. Boy, did we eat a lot of bread!' Laura showed Mr. Martin the IBM floppy disk that she had kept all these years. . . .

Laura left the interview with a good feeling. . . . She knew he appreciated her computer skills. She just hoped he looked at the hologram so he could see all the other things she had done.[15]

The Preservationist's Scenario: Maintaining While Improving Schooling

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.

The vision buried within the preservationist's story is one of schools continuing to do for society

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[14] Dustin Heuston, "The Future of Education: A Time of Hope and New Delivery Systems," unpublished paper, WICAT systems, Orem, UT, 1986, cited in Royal Van Horn, "Educational Power Tools: New Instructional Delivery Systems" Phi Delta *Kappan*, March 1991, pp. 527-533, quote is on p. 533.

[15] Draft of *Texas Technology Model for 2061 Project*, 1991, pp. 2-4; For another example of older students using technologies in an early 21st century "school," see Christopher Dede, "Imaging Technology's Role in Restructuring for Learning," in Karen Sheingold and Marc Tucker (eds.) *Restructuring for Learning and Technology* (New York, NY: Center for Technology and Education, Bank Street College of Education, 1990), pp. 51-52.

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 that can be bought with available funds. Skepticism towards major changes, hammered out of these traditional aims for schooling, leads to adding-on to what exists now.[16]

Much evidence makes this scenario plausible. Some examples: mandating computer literacy as another graduation requirement; adding computer science courses to the curriculum; creating computer labs where teachers bring their classes; placing one computer in each classroom; buying software that is part of a textbook adoption; finally, a school buying an integrated learning systems (ILS) that centralizes daily math and reading lessons for each student with results of the students' work being reported the next day. [17]

In this scenario, computers and other forms of technology are seen as important but peripheral to the main business of teaching students. 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 believe that putting computers into classrooms will yield a steady but very slow movement towards fundamental changes in teaching and schooling. Advocates of this scenario see it occurring slowly but inexorably, much like a turtle crawling towards its pond. It is slow because schools, as organizations, take time for their teachers to learn how to use computers to guide student learning. It is inexorable because, as Allan Collins says, "[T]he nature of education must inevitably adapt to the nature of work in society." [18]

Here again appears reformers' productivity-driven dream of efficient machines freeing students from the tedium of traditional teaching—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 but slow application of technologies to schooling.

There is some evidence for this scenario. 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 for example, David K. Cohen, "Educational Technology and School Organization," in Raymond Nickerson and Philip Zodhiates (eds.) *Technology in Education: Looking Toward 2020* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1990), pp. 231-264. Cohen examines

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[16] The essays of David K. Cohen describe well this scenario. He has analyzed elegantly why electonic technologies are marginal to the conduct of schooling. See, for example, David K. Cohen, "Educational Technology and School Organization," in Raymond Nickerson and Philip Zodhiates (Eds.) Technology in Education: Looking Toward 2020 (Hillsdale, NJ: Lawrence Erlbaum Assosiates, 1990), pp. 231-264. Cohen examines the fit between innovative technolieges—in general—and the scarcity of incentives for changes within public education. HIs emphasis on the social organization of the school mirrors my own and has enriched my anlaysis. Also see David Tyack and Elisbaeth Hansot, "Futures That Never happened: Technology and the Classroom, " *Education Week*, Sept 4, 1985, p. 40. My first foray in this subject, *Teachers and Machines*, offered an argument and evidence for this scenario also. Brian Winston makes the preservationist's point by his "law of suppression of redical 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 thay are already doing. See *Misunderstanding Media* (Cambridge, MA: Harvard University Press, 1986).

[17] *Power On!*, op. cit., footnote 2, pp. 201-202.

[18] Allan Collins, "The Role of Computer Technology in Restructuring Schools" in Sheingold and Tucker, *Restructuring for Learning with Technology*, op. cit., footnote 15, p. 36.

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*, Sept. 4, 1985, p. 40. My first foray in this subject, Teachers and Machines, offered an argument and evidence for this scenario also. Brian Winston makes the preservationist's point by his "law of suppression of radical potential." A individualized options) and how students learn (e.g., they come to rely upon one another and themselves to understand ideas and to practice skills). In schools where the numbers of computer-using teachers and hardware reach a critical threshold, different organizational decisions get made. Teachers from different departments or grades begin to work together and move towards changing the regular time-schedule. Schoolwide decisions on using technologies become routine, as do decisions on nontechnological matters. Hybrids of the old and the new, of teacher-centered and student-centered instruction, proliferate in this scenario. [19]

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

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. . . .[20]

Now, which of these scenarios is likely to occur, that is, has a 75 percent chance of happening in most schools across the country?[21]

WHICH IS THE LEAST LIKELY SCENARIO?

The least likely scenario is the electronic school of the future. While such schools will be built, they

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[19] 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. 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 support this neoprogressive vision of teaching, learning, and slow change in organizing of instruction. See Jane David, "Partnerships for Change," ACOT Report #12, Apple Computer, Inc., Cupertino, CA, 1992; Robert Tierney, Ronald Kieffer, Laurie Stowell, Laura Desai, Kathleen Whalin, and Antonia Moss, "Computer Acquisition: A Longitudinal Study of the Influence of High Computer Access on Students' Thinking, Learning, and Interactions," ACOT Report #16, Apple Computers, Inc., Cupertino, CA, 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 multi-subject 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 not only includes 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; Centre for Educational Technology, "Annual Report," November 1992, Tel Aviv, Israel. Also see Trish Stoddart and Dale Niederhauser, "Technology and Educational Change," *Computers in Schools* 9(2/3) 1993, pp 5-22.

[20] Karen Sheingold and Martha Hadley, "Accomplished Teachers: Integrating Computers into Classroom Practice" (Center for Technology in Education: Bank Street College of Education, September 1990), pp. 1, 13.; Also see Decker Walker, Bruce Keepes, and George Chang, "Computers in California High Schools: Implications for Teacher Education," (unpublished paper, 1991) and their designation of teachers who were "pioneers."

[21] As I said earlier, "predicting" walks the thin line between risk and foolishness but, for purposes of prodding discussion, I will do so. In doing so, 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 to occur, a severe economic depression, or grave urban disturbances requiring sustained military intervention, popular views of what schools ought to do would probably alter and calls for fundamental changes in the purposes and organization of schools would ensue. Under such conditions, the notion of "likely scenarios" would be foolish.

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 within districts or to most other schools.

First, technophiles typically underestimate the influence of the age-graded school organization in shaping teachers' workplace routines. Furthermore, they often minimize the power of social beliefs that have endured for centuries and perform important functions in society. Beliefs 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 much popular and practitioner thinking. Most parents expect their schools to reflect those centuries-old beliefs.

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 teacher teach, how students learn, and the relationships between adults and children in each classroom are especially difficult to alter after a century of popular and practitioner acceptance. Because of these factors, school practitioners 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 beliefs and organizational traditions.

Second, previous experiences of instructional television, language laboratories, and programmed learning in the 1960s and 1970s suggest caution to policymakers. Districts built new schools, purchased and installed hardware for those technologies. In less than a decade administrators found that the machinery was either unused by teachers, obsolete, or could not be repaired after breakdowns.[22]

These reasons suggest strongly that districts will be reluctant to make major investments in new hardware beyond a model program or demonstration school. Thus, the technophile's scenario is least likely to occur.

HOW LIKELY ARE THE PRESERVATIONIST AND CAUTIOUS OPTIMIST SCENARIOS?

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

Preservationists argue that schools are durable institutions, taking any new technology and tailoring it to fit millennia-old social beliefs about the nature of teaching, learning, and knowledge. Thus, when IBMs and Apples appear in schools they get drafted to continue what is deemed important. Even when a few teachers creatively use computers, preservationists acknowledge such pioneers but see them as mutants, exceptions far removed from the evolutionary trajectory of technology in schools.

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 contours of the age-graded school and its self-contained classroom. Thus, this scenario will continue for the immediate future, given the power of social beliefs and organizational forms.

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[22] Cuban, op. cit., footnote 1, pp. 27-50.

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 teacher mixes of the old and the new in schools and classrooms.

Optimists point to hybrids of teacher-centered and student-centered instruction and see them as the leading edge of an evolving movement—rather than mutants—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 early signs of the near and vital 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—e.g., not enough money to buy machines, teacher resistance, inadequate preparation of teachers, and little administrative support—gradually will evaporate as the hybrids slowly spread and take hold. It is an evolutionary scenario using a clock that measures 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, prudent optimists recognize that these familiar realities continually undergo imperceptible changes. They acknowledge that the age-graded school needs to be transformed into a more flexible, ungraded, collaborative organization. They see it occurring steadily albeit at a glacial pace. 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, and, in doing so, ever so slightly altering school structures.

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 practitioners to alter their circumstances and make students grin rather than groan over school work.

WHICH SCENARIO IS MOST 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.

Public elementary and secondary schools differ markedly in the complexity of content students face in classrooms, teachers' formal training, allocation of time to instruction, and external arrangements imposed upon both levels from other institutions.[23]

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 high school, not only are more sophisticated skills required of students,

[23] Note that I use the phrase "secondary schools." In doing so, I refer to both middle (or junior) and high schools. I draw sharp distinctions between elementary and high school because the structures, roles, and teacher cultures are obviously different. For those middle schools that have embarked on fundamental changes, i.e., eliminated departments, created interdisciplinary teaching teams, teacher advisers, and large blocks of time where students and teachers work together, then they have recreated an elementary-like school. For such middle schools, what I say about elementary schools applies. Many middle schools, however, have adopted only one or two of these reforms and still resemble a junior high school or a miniature version of senior high school. Such places, then, would be counted in my analysis of high schools. See Larry Cuban, "Why Reforms Last: The Case of the Junior High," *American Educational Research Journal*, summer 1992.

but these skills are embedded in complex subject matter that in and of itself must be learned. Literary criticism, historical analysis, solving 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, often turn to didactic methods because content often drives classroom teaching practices.

Also, student and teacher contact time differ 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 25 or more students. They see far more of a child's strengths, limitations, capacities, and achievements than a high school teacher who sees five groups of 25 students less than an hour a day. Over a nine-month school year, the elementary school teacher sees her 25 children nearly 1,000 hours; a high school teacher sees 125 students about 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 because the teacher has more contact time with the same children than high school teachers do with their students. 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 changes in elementary school classrooms.

Finally, external pressures from accrediting associations, college entrance requirements, and job market qualifications have a far more direct, 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 Boards, Scholastic Aptitude, Advanced Placement, state and national standardized achievement exams, certifying agencies, and other external constraints.

While some urgencies 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 four structural differences—emphasis on subject matter, teachers' prior training, contact time, and external pressures—may well account for why I found many shifts in elementary school teaching practices and fewer changes 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 50-minute classes, have created a durable, practical pedagogy that researchers have documented consistently in English, history, science, and math over the last century.[24]

In elementary school classrooms, I also 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,

[24] Cuban, *How Teachers Taught*, op. cit., footnote 6; Also see Ernest Boyer, *High School* (New York, NY: Harper and Row, 1983) Theodore Sizer, *Horace's Compromise* (Boston, MA: Houghton-Mifflin, 1984), and Arthur Powell, Eleanor Farrar, and David Cohen, *The Shopping Mall High School* (Boston, MA: Houghton-Mifflin, 1985).

newer forms of grouping began to appear in elementary schools to teach reading and math. A growing array of instructional materials made it possible for teachers to tailor teaching to student differences. 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.

Also teachers' repertoire of classroom practices have 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, new materials and technologies. While field trips, films, videocassettes, television, and computer labs may not yet be mainstays of most classroom instruction, they testify to the slow growth of instructional hybrids. Such instances of changes in classroom practice provide additional evidence for the cautious optimist's scenario of technological hybrids slowly changing the conduct of schooling.[25]

The point that 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 most likely occur. The preservationist's scenario is most likely in high schools where academic subjects reign, teachers' training was in disciplinary content, and the number of classes and students teachers teach remain high. The cautious optimist's scenario is more likely to occur in elementary schools where organizational differences make shifts in practice possible and where hybrids of teacher-centered and student-centered instruction have, indeed, evolved slowly over the last century.[26]

There are, however, emerging national policies that may influence both the pace and direction of these scenarios materializing in the 1990s. One is the current movement (and legislation) 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, the movement may largely channel new technologies to fit existing patterns of teaching and learning because what fuels the drive

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[25] Cuban, *How Teachers Taught*, op. cit., footnote 6, pp. 135-136; 199-200.

[26] One way to assess this prediction of what will occur in high schools, for example, is to compare the penetration of computers into college and university classrooms. High school teachers are much closer to college professors in their training and allegiance to subject matter than elementary school teachers. Hence, one would expect, given my interpretation, that professors would use computers for their classroom teaching about as much as high school teachers, which would be less than elementary ones.

While there is much evidence that individual professors across most disciplines, including the humanities, have adapted with gusto the use of the computer for their writing (as word processors), research (for statistical analysis), and communication (e-mail, internet bulletin boards) there is much less evidence that in their weekly teaching the presence of the computer has altered traditional lectures or seminars. See Donald R. McNeil, "Technology in College: Where Is the Impact?" *The Chronicle of Higher Education*, June 7, 1989, p. A44; Robert Jacobson, "As Instructional Technology Proliferates, Skeptics Seek Hard Evidence of Its Value," *The Chronicle of Higher Education*, May 5, 1993, p. A27. In a survey of its 32,000 members, the Modern Language Association found extensive computer usage among its English and foreign language professors in preparing manuscripts (95 percent) and routine correspondence (84 percent). Almost 80 percent said they used the computer to prepare teaching materials. But there was no category for responses of whether professors used computers in classroom instruction—an amazing omission. See *The Chronicle of Higher Education*, Apr. 21, 1993, p. A27. Stanford University Professor Patrick Suppes, an early advocate of computer-assisted instruction in the 1960s and a teacher whose courses in logic and math were taught wholly by computer in the 1970s and 1980s answered a reporter's question about the future impact of the machine on teaching at Stanford by saying it would be "substantial over the next half-century." When the reporter expressed surprise at the length of time, Suppes replied: "[T]he actual structure of universities is extraordinarily conservative." The Stanford University *Campus Report*, Jan. 12, 1994, p. 4. In short, for all the organizational and governance differences between colleges and high schools, there is a striking similarity in the limited use of computers in both sets of classrooms.

toward national goals, standards, and testing is the lure of increased student productivity. Concentration on quantitative standards reinforced by high-stake test results usually diminish practitioners' appetites for taking risks in classroom and school innovations. My guess would 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.

SUMMARY

With all the talk of school reform and computers over the last decade, why has electronic technology been used far less on a daily basis in classrooms than in other organizations? My answer is that schools are different from those organizations in which telecommunications have spread swiftly. Moreover, technological innovations never have 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. Yet after all has been said and done, more has been said than done.

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

There are at least three plausible stories for what the next decade holds in store for teachers' use of computers. The likely scenarios point to little substantial change in the closing years of the 20th century. Where two scenarios differ is that cautious optimists see hope in the hybrids that have emerged, a hope that over the ensuing 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 it currently is. The most likely scenario is the one predicting slow but dynamic changes in both teaching and school structures that will occur as more hybrids of old and new forms of instruction are merged with the next generation of computers. Those changes will seem glacially slow to impatient reformers but, perhaps, just the right pace for those aware of the complexities of changing unique places called schools.

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