PART II

THE STRATEGIC CONTEXT OF EDUCATION IN AMERICA

2000 TO 2020

by

David Pearce Snyder and Gregg Edwards

Consulting Futurists

Published in *On the Horizon*

Volume 11, Number 3, 2003

www.emeraldinsight.com • West Yorkshire U.K.

The Snyder Family Enterprise
8628 Garfield Street
Bethesda, MD 20817
phone 301-530-5807
e-mail (Snyder) david@the-futurist.com

AUTHORS' NOTE

In PART 1 of *The Strategic Context of Education in America – 2000 to 2020*, (OTH Vol. 10, No.2, 2002), we summarized a number of reliably forecastable demographic and economic realities that will confront America's educators during the first two decades of the 21st Century. In PART 2, we had originally intended to complete our survey by detailing the principal new technologies that will become commonplace in education's operating environment over the next twenty years.

Humans invent two distinctly different types of technology: physical and social. By and large, both our physical technologies – tools, machines, materials, production processes, etc. – and our social technologies – laws and institutions – are invented in response to human needs and practical problems. Many new *social* technologies are developed specifically to exploit, facilitate or regulate new *physical* technologies. As new physical technologies mature and become commonplace, they engender innovations in laws and institutions. For example, our standard national time zones – a social technology – were originally created in the mid-1800's to make it possible to establish coherent nationwide time-tables and connecting schedules for the railroads – a physical technology. History suggests that the complementary co-evolution of our physical and social technologies is the principal source of long-term economic growth and human progress.

In compiling material for PART 2, we found a number of robust five to twenty year forecasts for new information technologies (IT) with significant implications for **all** professional, managerial and technical work, including teaching and learning. We also found well-grounded projections from the U.S. Labor Department and from research institutions regarding the changing future organization of employment in America, along with extended discussions in the management literature addressing the current restructuring of both private and public enterprise and the concomitant emergence of new social technologies that have already begun to replace the hierarchical, vertically-integrated authoritarian bureaucracies that characterized industrial era business and government. Most important of all, there is a growing body of disciplined micro-economic analyses spelling out the crucial role that new social technology – in combination with new information technology – has played in more than doubling annual U.S. productivity-improvement rates since the mid-1990's.

However, other than "distance learning," we found little evidence of significant innovation or change in the social technologies by which we formally organize and deliver education. Nor did we find any serious movement to assess alternatives to teacher-mediated classroom-based learning. With a few notable exceptions, the vast majority of charter schools in the U.S. – including those that are privately owned and operated – are essentially identical to the regular public schools they replace. Although there is earnest debate today over the quality of teacher education, the instructional value of computers, how to teach reading and the effects of stringent testing, etc., essentially no one is talking about redesigning the institution itself. A school, apparently, is a school is a school.

This striking disparity between the coming decade's widely expected cornucopia of education-relevant information technologies and the widely-assumed permanence of classroom-based teacher-mediated schooling suggests one of two possibilities. Either:

1. Classroom-based, teacher-mediated education is so perfectly suited to its purposes that it is a timeless social technology – like courts of law, parish churches, or the theater – which have remained fundamentally unchanged for hundreds of years, and which will continue to do so, in spite of numerous dramatic innovations in everyday technology; or

2. Classroom-based, teacher-mediated education, like hospital-based, doctor-mediated healthcare, will eventually be rendered obsolete by information technology, but the multiple inertial forces embodied within both healthcare and education – e.g. regulations, unions, professional societies, suppliers, clientele and other stakeholders – have simply made the nation's two largest industries highly resistant to change.

If the first assumption is correct, IT will largely be applied to today's schools like a veneer or a coat of paint. Under such a scenario, high definition flat-screen computer monitors will replace white boards and every student will carry a wireless personal cyber-tutor, but classroom instructors will still be directly engaged in teaching a common standard curriculum to (relatively) small groups of students in large buildings.

If, on the other hand, the second assumption more accurately characterizes the current technologic context of education in America, the growing ubiquity of IT and its increasing potency as a learning tool, plus a combination of student preferences, public opinion, political action and workplace demands will inevitably lead to the transformation of classroom-based, teacher-mediated educational institutions to incorporate an array of new social technologies that will complement IT's largely untapped capacity to enhance the realization of human potential.

In summary, our survey of trends and forecasts depicting education's future technologic environment presented us with an intriguing dichotomy. With respect to physical technology, as we spell out in the following pages, there are ample forecasts based on a range of methodologies to give us a reliable, detailed portrait of a number of cheap, powerful, easy-to-use information products and services that the next ten years will put in the hands of all Americans, including teachers and students. Conversely, with respect to social technology in education's future, we found stasis. In particular, the widespread organizational re-structuring and job redesign that has combined with mature IT to boost U.S. workplace productivity and economic prosperity is nowhere reflected in education, either as adaptive behavior or as proposed reforms.

In the face of inexorable forces of change – demographic, economic **and** technologic – a status quo strategy by educational institutions will predictably lead to chaos once those forces of change – e.g. growing enrollment, increasing teacher shortages, rising skill requirements, pervasive computing, etc. – become sufficiently disruptive. Such disruptive dynamics will, of course, be aggravated by less-predictable short-term developments – e.g. funding cutbacks, new testing requirements, etc. – all of which are likely to place a growing number of school systems, small colleges and big universities in crisis during the next ten years. Crisis, in turn, is widely acknowledged the most common cause of significant change in both institutions and individuals, but socio-political responses to crises are impossible to predict.

Thus, while we are able to forecast the everyday workplace information products and services of the coming decade with considerable clarity and confidence, the social technology in education's future is a vexed subject; problematical, speculative and largely unconsidered. This asymmetry of content between the two halves of education's technologic future led us to conclude that it would be preferable to cover the two topics in separate articles. In this issue of *On the Horizon* we describe five mature forms of information technology that will pervade the operating environment of all educational institutions during the next five to ten years. In a subsequent article – PART 3 – we will examine recent trends in school organization, management, curriculum design and delivery, etc., and explore the potentialities for schools to adapt in response to education's changing demographic, economic **and** technologic realities.

THE TECHNOLOGIC CONTEXT OF EDUCATION

Technology is the third major component of our knowable future, along with demography and economic make-up. During the next two decades, applied technology will be the most dynamic component of the forecastable institutional operating environment.

From the late 1950s to the end of the 1970s, demographic factors – most notably, the "Baby Boom" and the subsequent "Baby Bust" – were the most powerful forces affecting system-wide growth and change in America. Throughout the 1980s to the mid-1990s, economic initiatives – including supply-side tax policies, marketplace deregulation, privatization and free trade, etc. – were the principal forces influencing national growth and change. But, in the mid-1990s, new technology became the most potent force for growth and change in America, and is likely to remain so for at least the next two decades. What's more, it is now clear that one class of technology in particular – information technology (IT) – will also accelerate the rates of discovery and innovation across the entire spectrum of scientific inquiry.

From now on, as an ongoing consequence of the increasingly pervasive application of our increasingly powerful information technologies, the veil of ignorance will be lifted much more rapidly from every frontier of knowledge. Already, breakthroughs in molecular chemistry, genetic engineering, proteomics and nano-technology routinely make the nightly news, and a growing number are finding marketplace applications. Such emerging technologies can be expected to produce dramatic headlines, and to turbulate our political and legal environments over the coming decade, but they will still be relatively immature, and unlikely to change day-to-day life for most of us anytime soon. On the other hand, newly-mature information technologies are about to do just that, BIG TIME!

We are able to reliably forecast the new mass-market technologies of the next five to ten years for much the same reason that we can accurately forecast the adult population. The "mature" technologies of the next ten years have, in a sense, already been "born" – or rather, invented – and have already passed through a period of "adolescent" development – e.g., beta testing, market trials, etc. Many have actually been in the marketplace for several years, either in U.S. niche applications or abroad, and their initial successes have demonstrated their potential to generate mass-market volumes within three to five years. Among the adolescent information technologies that will become marketplace mature during the next two or three years, five pose significant operational implications for every formal enterprise and profession in America, including education: [1] The Info-structure; [2] Distributed Computing; [3] The Wireless Web; [4] Open source software; and [5] Groupware.

Many (most?) readers will be justifiably skeptical at the notion of a coming technology-driven transformation of education – or any other institution. It has, after all, been nearly 60 years since the first computer was switched on, yet our offices are still not paperless and our commerce is still not cashless. And most of us over 30 have lived through more failed IT projects than successful ones. But economic historians tell us that new technologies don't become reliable, affordable and generally productive until they have "matured" for a half-century or so (David 1990). And in fact, in the mid-1990s, as the computer reached its 50th "birthday," the U.S. economy's annual productivity improvement rates more than doubled, and have remained at that higher rate ever since, after having stagnated for the previous 25 years. In 1987, the Nobel Laureate economist, Robert Solow, famously observed, "We can see computers everywhere in today's economy, except in the productivity statistics." But, by March 2000, Prof. Solow was able to report that "We can now see computers in the productivity statistics" (Uchitelle 2000).

The 1990's productivity boom did not vanish with the dot.bomb bubble or the 2001-2 Recession. Indeed, the fact that our productivity-improvement rates did not decline during the Recession – an unprecedented event – has helped convince the macro-economists at the merchant banking houses and the U.S. Federal Reserve that our enhanced performance reflects fundamental structural changes in the nation's workplace, and that *it is permanent*. Technology historians are equally sanguine about the future, since previous transformational technologies – the steam engine, the telegraph, electric power, etc. – have typically produced long-term surges in productivity once they have achieved marketplace maturity. Moreover, rising productivity in a free-market economy ultimately translates into higher wages. On the assumption that the U.S. will be able to average a 2% per year productivity improvement rate (instead of the 1.4% per year we averaged from 1973 to 1995), the Labor Department has projected that median household income will rise from $43,000 p.a. in 2001 to $70,000 p.a. by 2020 (Bodipo-Memba 1999).

Increasing productivity improvement will also help the nation's employers deal with our projected chronic shortage of prime-age (25-54 year old) workers. But accelerating productivity will also accelerate workforce downsizing and mid-career layoffs, boosting demand for adult education, and giving further evidence that we have finally entered the constructive-disruptive phase of the Information Revolution. The five IT innovations examined in this paper clearly have the constructive-disruptive potential to make most work processes paper-less and most commerce cash-less – and most college courses campus-less – within ten years.

1. THE INTERNET AS INFO-STRUCTURE

Back when the authors were apprentice futurists, computers were the size of convenience stores and filled with hundreds of vacuum tubes. Each time we wanted these electro-mechanical behemoths to perform a new task, we wrote the programming code from scratch, and stored it on punched cards or paper tape. Small wonder that, apart from specialized applications – e.g. crunching Census data and tax returns, or calculating the trajectories of space shots and inter-continental missiles, etc. – early applications of computers often did little to increase economic efficiency, and many turned out to be counter-productive. Since the 1950's, of course, computers have evolved through four increasingly powerful data manipulation technologies – vacuum tubes, transistors, integrated circuit boards and silicon chips. Computers now fit in our pockets, and we buy software off the shelf. Walmart is selling generic PC's for $199.00, and Linux is giving software away for free.

Since ENIAC was first switched on in 1946, computers have clearly experienced exponential improvements in size, power and cost. (Engineers commonly observe that, had the automobile experienced the same cost-performance improvements as the computer, Rolls Royces today would cost a dollar-a-dozen, and get 100,000 miles per gallon of gas.) But neither the automobile nor the computer would have had a significant impact on the economy or the society as a free-standing technology. In order for the automobile to realize its potential, there had to be paved roads to drive on, and there had to be some place to buy gasoline/petrol other than local pharmacist/chemist. The automobile required a supporting *infrastructure*, including neighborhood streets, inter-city highways and a petroleum industry.

Similarly, the steam locomotive had little practical utility without its primary infrastructure: thousands of miles of railways connecting major cities. And for the first quarter century after Edison patented the light bulb (1879), homes and offices wishing to replace their gas illumination with electric lights had to generate their own power, because there was no infrastructure to produce and distribute electricity. It wasn't until the early 20th Century that electric utilities began to build generating plants, and to string millions of miles of transmission cables and distribution lines across the countryside and down every city street and country lane. The Internet is to the computer what the electricity distribution grid is to electric power, what the railways are to the train, and what the streets and highways are to our fleets of cars and trucks.

The Internet is the infrastructure – or "info-structure" – for the information economy. From the outset of the computer age, cyberneticists assumed there would be some sort of network for sharing information among computers. But, most early computers were engaged in processing classified government data, or proprietary corporate data, and their owners had no desire to share information with anybody. With some exceptions, most computers that weren't employed by big business or big government in the 1960's worked for "big science," largely on the campuses of big universities. Unlike business and government, academics saw great value in data sharing, and the first general purpose "computer conferencing systems" were hosted by universities in the early 1970's under grants from the U.S. National Science Foundation (NSF). One such project, ALOHANET (sponsored by the University of Hawaii) was so successful that it outgrew its NSF funding base, and was subsequently underwritten by the U.S. Department of Defense as ARPANET, which was finally privatized as the INTERNET in 1981.

As an info-structure, the 1980's Internet was a modest, black & white, alpha-numeric medium. Because so few people were on the Net, the U.S. Postal Service introduced E.com "Computer Originated Mail" (1982-85), that permitted Internet users to send e-mail which the U.S.P.S. printed out, put in an envelope, and delivered to off-line addressees as regular first class mail (Hafner 2001). Conversely, because the medium was so new, people who **were** on-line never remembered to check their "in-boxes." To deal with this problem, MCI-mail, the first commercial e-mail provider, had an MCI employee telephone e-mail addressees to tell them to check their electronic mail boxes for an incoming message (1984). It took another ten years for the Net to add color, graphics and sound, and to become the World Wide Web – a comprehensive general-purpose info-structure for the information economy.

With color, graphics and sound, the Web was superficially similar enough to radio and television that the Internet's enormous potential as a mass-market medium suddenly became readily apparent to millions of people, including entrepreneurs, venture capitalists and investors. The dot.com bubble that arose from this set of circumstances was an entirely predictable event, characteristic of the introductory periods of previous innovative mass market technologies. Meanwhile, at the same time that hundreds of ill-fated e-ventures were being launched, hundreds of large existing enterprises were applying the Net's more mundane capacities for automated data transmission and assimilation to their routine, repetitive business processes, giving rise to sustained increases in total factor productivity throughout growing sectors of the workplace. The general adoption of high-speed Internet as the principal medium for internal communication and external transactions by both private and public enterprise is widely expected to extend the recent rise in U.S. productivity improvement rates well into the future.

Broadband: the high speed Internet

For most Americans, Internet access is available in a variety of speeds. Of the roughly 60% of all U.S. households who are on-line, around 80% have a slow speed – or "narrow band" – link to the Internet, transmitting 28 to 56 kilobits of data per second (28-56Kbps), and costing typically $10 to $15 per month. High speed or "broadband" Net access can cost residential subscribers between $45 and $90 a month, and enables them to send and receive information over the Web at speeds of 1.5 to 10 megabits per second (1.5-10Mbps). Households with slow-speed, dial-up access to the Web send billions of e-mails and make $millions of e-tail purchases every day. But, the average wait/response times of the standard residential narrowband Internet access are unacceptably slow for most workplace use. Thus, while fewer than 20% of U.S. households have been willing to pay the premium subscription rates for high-speed access to the Web, essentially **all** large and medium-sized firms, and most large public institutions have broadband Internet access, including more than two-thirds of all schools, up from one-half in 1998 (Thomas 2001).

Because broadband is fast, it is also capacious; it can "stream" moving video images, instead of sending them one frame at a time. It takes 20 to 40 hours to download a feature length film over narrowband Net access, but only 7 1/2 to 15 minutes over a broadband link. High speed, real time video-streaming over broadband also makes video-conferencing so cheap, easy and effective that "virtual travel" has actually replaced at least 10% of actual business travel since 9/11, while spurring a 30% to 40% p.a. increase in the sales of video conferencing equipment and services. In fact, only high-speed Internet links can pass enough data to fill the five- and six-foot wide, high-resolution flat-screen display monitors that the corporate world is quickly making the defacto standard for their video-conferencing suites and management training facilities.

Currently, the big, flat-screen video monitors favored by business cost $5,000 to $20,000 apiece. But the unexpected demand for these big-ticket displays is already drawing more competitors into the marketplace, and prices should fall by 75% over the next 36 to 60 months. Participants in on-line schooling programs – both teachers and students, K-12 and adult – overwhelmingly agree that high speed Internet access is absolutely crucial for successful distant learning: instructional material downloads instantly; dialogue occurs in real time; sounds are transmitted faithfully, visuals are crystal clear and can be made three-dimensional. With the advent of low-cost, wide-screen flat-panel color display monitors, the high speed Internet will become a teaching/learning/entertainment medium of unparalleled potential.

"Frictionless" Commerce

While educators have, as yet, done little to integrate the potentialities of the high speed Web into our formal learning processes, the broadband Internet is already proving itself a highly productive tool of commerce, even without benefit of color or graphics. The Giga Information Group, which monitors e-commerce, estimates that the total overhead cost of an average private sector paper purchase order in the U.S. ranges between $50.00 and $70.00, including all archival, retrieval, review, error correction and internal audit expenses (Technology 2000). In the public sector – including education – average overhead costs for paper purchase orders have been variously estimated at $100.00 to $150.00 (Jones 2000). By comparison, the average overhead cost for on-line purchase orders ranges between $1.00 and $5.00; $25.00 for the public sector. Similarly, the consulting firm Booz Allen Hamilton estimates that the average overhead costs for a paper (check) transaction is $1.07, while the same transaction over the Internet has an average overhead cost of $0.01 (Lerner 2000). The Yankee Group, another consultancy, estimates that the capacity to timely handle telephone inquiries from the public typically costs an organization $25 to $33 per call, while the equivalent response capacity over the Internet costs about $1.50 per inquiry (Stewart 2001).

Because the achievement of such commodity-scale efficiencies will pose insurmountable competitive advantages in the marketplace, the great majority of private and public enterprises – including small organizations – will be forced by their circumstances to transfer their commercial transactions to the Internet over the next five years. Meanwhile, the financial services industry will coerce most consumers into adopting on-line banking and bill-paying by charging consumers outrageous fees for handling checks or for providing paper statements. Investment banker Goldman Sachs has projected that the straight-forward transactional efficiencies of the Internet, **by themselves**, will be sufficient to raise the long-term average annual economic output of the five largest free-market democracies – the U.S., Japan, Germany, France and the U.K. – by 5%! (Adams 2000)

"Smart" Equipment

The broadband Internet's superior capacity to lubricate the wheels of daily commerce is in part due to the fact that, unlike narrowband access, broadband lines are always connected – "24/7," as they say – rather than being dialed up when needed. This permits the entire stream of commerce to be "info-mated," as financial transactions can be recorded, shipments verified, claims validated, and payments posted as they are processed by restaurants, ATM's, toll booths, mini-marts, e-tail clerks, and customs officers, etc. What's more, "Web-enabled" vending machines with broadband access can notify their service managers whenever they are out of stock or vandalized. The H-P Laserjet 4100 printer automatically goes on-line to order ~~a~~ new toner cartridge *for itself* from the supply contractor in time for the replacement to arrive just before the old cartridge runs out. Remote diagnostics over the Net will ultimately eliminate all of our gas, water and electric meter readers, and reduce the numbers of office equipment and home appliance service calls by more than 50%.

2. DISTRIBUTED COMPUTING: THE INFORMATION UTILITY

In addition to frictionless commerce and smart machines, the adoption of high speed Internet by private and public sector organizations will also foster the growth of distributed – or "utility" – computing. Because broadband circuits are always on, computers with high speed access can always be reached from the Web, even after business hours when offices are closed. When such computers are not in use, their owners can arrange for their idle computing capacity to be tapped by other parties with broadband Net access. A prominent example of distributed computing is the UC/Berkeley's SETI@home project, which uses the Internet to mobilize the unused computing capacity of 3.5 million home and business computers in 224 countries on all seven continents to [S]earch for [E]xtra-[T]errestrial [I]intelligence in the universe.

The University e-mails participating computers packets of new data from the world's largest radio-telescope at Arecibo, Puerto Rico, plus the software needed to sift through the signals received by the telescope in search of purposeful patterns in the random cosmic background noise of the universe. In its first twenty-four months, SETI@home generated over a **quarter-million years** of free computing time to analyze radio emissions from deep space (Broad 2000). Other distributed computing lash-ups around the world are currently searching for anti-AIDS drugs, modeling protein folding, and exploring long-term climate change (Johnson 2002).

Inspired by the success of SETI@home and other ad hoc distributed super-computing arrangements, academic and government scientists around the world have promoted the creation of several dozen similar on-line arrangements – commonly called "grids" – since the late 1990's. "Grids" function like "computer co-operatives," in which participants share each other's data, software, memory and processing capacity, as available, over the Internet. While most of these grids are dedicated to use by specific scientific tasks – e.g. particle physics analysis, gravitational field modeling, etc. – some grids are intended for on-demand use by researchers throughout an entire field of study or scientific discipline – e.g. earthquake engineering, planetary science, etc. (Waldrop 2002).

The U.S. National Science Foundation (NSF), which has been involved with creating many of these grids, is currently setting up what will be the world's most powerful grid system, for the general-use of U.S. science. But, unlike the voluntarily-shared computing capacity of the ad hoc distributed computing arrangements like SETI@home, the NSF's new general use grid, TeraGrid <www.teragrid.org>, will have access to the additional capacity of four clusters of micro-processors, scattered around the U.S. and linked over the Web to function as a super-computer. When it goes on line, (late 2003), TeraGrid will give the American scientific community on-demand access to small amounts of super-computing capacity for a modest, time-share service cost. Similar grids have been established by Japan, the UK, the EU and Singapore.

The supporters of grid computing expect NSF's TeraGrid to transform *computing* in the same way that NSF's Internet is transforming *communicating*. Certainly, a compelling strategic business case can be made for adopting grid computing. In the decade ahead, the expected chronic shortage of skilled IT personnel, plus continued rapid rates of IT innovation, will make it increasingly difficult for any but the largest enterprises to provide their own first class information services in-house. Moreover, in most large organizations, there is an enormous amount of under-utilized computing capacity. Meanwhile, as we gather growing amounts of data about the steadily increasing numbers of consequential factors in the human environment, the complexity of day-to-day business decisions and policy issues, plus simulations, risk assessment, impact statements, etc. – even police investigations and court cases – will make the need for supercomputing routine. Grids will make super-computing widely available, and affordable.

The business case for grid computing was **so** compelling, in fact, that IBM began offering a comprehensive range of rentable computing services over the Net on July 1, 2002, well **before** NSF had gotten its TeraGrid up and running. Subscribers to IBM's new "utility computing" service, dubbed "Blue Angel," don't need to have excess memory or computing capacity to contribute to a grid co-op. All they need are terminals and printers, they get everything else from the utility – secure data storage, computer operating time, software, etc. – all metered and billed per actual use. IBM estimates that utility computing will save an average client-subscriber between 20% to 55% over the cost of an equivalent in-house computer operation. IBM also projects that on-demand computing services of all kinds will capture "between 10% and 15% of the entire U.S. IT market in just five years" (Bulkeley 2002). Other major purveyors of utility computing include H-P, Gateway, Microsoft, Sun and Cisco.

Meanwhile, grid operators around the world have agreed on a single systems development standard – the "Globus Toolkit" – that will facilitate the creation of numerous grids, all able to share computing services with each other. Within five years, proponents believe, grid computing cooperatives and commercial information utilities will combine to transform information services over the Internet into a commodity utility, – like water, gas or electricity – supplying software, data storage and computational services to institutions and individuals on demand.

By 2010, it is likely that most small and medium enterprises – private and public – plus a number of large institutions – will have outsourced their in-house data processing operations to a utility service. Some operators of large computing systems, on the other hand, will find it makes more economic sense to retain their in-house computing capabilities and participate with others in their own grid. For educational institutions, the preceding scenario is likely to hold true. Small and medium sized schools – and school systems – will find it increasingly expedient – fiscally and operationally – to lease their information systems and services from grid providers that specialize in the educational market. At least some of these providers will be grids operated by consortia of large school districts or by universities, who will compete on-line with utilities and other grid providers. UC/San Diego, for example, is linking all 500 computers on its campus with fiber-optic lines to function as a single, super fast supercomputer (Markoff 2002).

A Broadband Divide?

With generic PC's selling for under $200 and the open source movement giving away free software, it might seem as though the concern over a socio-economic "digital divide" has been mooted by plunging technology prices. But without high speed access onto the information highway, computers will possess relatively limited value-adding productive potential – like cars before there were streets and roads, or electric appliances before there were electric utilities. For millions of U.S. households, however, broadband is prohibitively expensive. And 1/3 of U.S. households – mostly in rural areas or low income urban neighborhoods – have no broadband access at all. Given the value-adding functions specifically dependent upon broadband access – e.g. distant learning, flex-place employment, remote medical care, video-streaming and utility computing – people without broadband access may not exactly be information "have-nots," but they are at a serious disadvantage.

3. THE WIRELESS WEB

During the past five years, while growing numbers of Americans were logging onto the Web from their homes and offices, millions of Europeans and Asians were logging on from their Web-enabled cellphones. Since Europeans and Japanese produce and use cellphones in greater numbers than Americans, their industries and government regulators developed tariffed uses of the radio frequency spectrum intended to promote the cellphone as a "platform" technology to which a wide array of features would be added, including Web-access, instant-messaging, data-transmission, digital photography, etc. In the U.S., cellphones remained primarily verbal communications devices, and the more aggressively innovative IT industry provided American consumers with a **separate** appliance for their portable computing needs – the PALM®. As soon as the Palm proved to have "legs" as a mass-market product, it found itself in a race with a half-dozen copy-cats, several of which quickly sprouted "wings," by offering wireless links to the Web. The Personal Digital Assistant (PDA) had been born (1998).

By 2000, U.S. telecommunications companies saw that the European and Asian telecom providers were on the right track. Cellphones were beginning to capture market share from traditional, land-line telephones both in the U.S. and the rest of the world; but in Europe and Japan Web-enabled cellphones were also cutting into the sales of PCs. American vendors swallowed their pride and began to offer services and handsets using the GSM (Global Standard-Mobile) digital wireless transmission protocol that the rest of the world had adopted over a decade previously. Initial U.S. sales of web-enabled cellphones since first offered (July 2002) have been promising. And, in the Spring of 2003, cellphone vendors began to offer combined PDA/cellphones, whose larger screens and keyboards make them much better suited for Web work. The PDA has entered mainstream life in America.

Industry experts project that 80% to 90% of Internet accesses will be made by mobile devices – cellphones, PDA's, etc. – by 2010. Most such connections – billions a day – will be instant messages, transaction authorizations, GPS location checks, and information requests (stock prices, cricket scores, etc.) rather than long text messages, technical diagrams, or journal articles. While web-enabled cellphones may become the principal "on-ramp" to the "information highway," they are ill suited for data-rich applications, like medical diagnostics, academic research, on-line collaboration or web publishing. Not only are they too small for such use, they are too slow, downloading data at roughly the same rate as narrowband dial-up desk-tops. While 3rd and 4th generation cellphones promise to offer high speed web access during the second half of the decade, web-enabled cellphones do not currently provide a means for bridging the broadband divide that currently isolates most of rural and low-income urban America from the high speed Internet. But Wi-Fi does!

Wi-Fi to the Rescue!

The technology called Wireless Local Area Networks (WLANs) or "Fixed Wireless," uses the free, public access portion of the radio broadcast spectrum (802.11) to provide wireless high speed Internet access to anyone within 300 feet of a WLAN transponder connected to the broadband Internet. Originally, "Wireless Fidelity" was designed to provide wireless Musak-like services throughout large buildings. But computer hobbyists quickly discovered that it would also send and receive data … at 9-11 Mbps: high speed broadband rates! Now the technology – popularly known as "Wi-Fi" – is being used by airports, hotels, libraries, restaurants and universities to provide high speed wireless access to the Web for anyone within their facility with a suitably-equipped laptop or palmtop computer (Mossberg 2002).

From now on, any school building or college campus with access to a single high-speed Internet circuit will be able to share that access wirelessly with all of its faculty and students for a single, modest monthly fee -- $40 to $60. For an added $40, Apple Computer sells an antenna that will extend the range of a Wi-Fi transponder up to five miles (Talacko 2002). Two Silicon Valley firms – SmartBridges and Etherlinx – have announced transponders for under $400.00 that will permit a single Broadband circuit to provide wireless Internet access over a twenty mile radius! (Markoff 2002). This means that a single school will now be able to provide high speed Internet access to its entire neighborhood or community at a trivial cost. Most laptops and palmtops will come equipped with a Wi-Fi "card" from now on. Existing machines can currently be retro-fitted for $40-$50. (Last year it cost $70-$90; next year, it's expected to drop under $20.00.)

At school, WiFi will permit students with laptop or palm computers to download projects from their personal home pages to classroom monitors, and to participate in learning teams with students in other schools, or to work with mentors in the workplace. Extended WLANs will enable educational institutions to deliver on-the-job learning to the work site, better support students in home schooling, and reach underserved housebound learners throughout the community. In a broader, socio-economic context, schools can use extended WLANs to give not only their students, but all the residents of the neighborhoods and communities they serve a bridge over the "digital divide" between the broadband "haves" and "have-nots." This technology can truly re-establish schools as *educational centers with civic circumferences.*

Schools – whether K-12 or post-secondary – that choose to extend their presence into their immediate communities by providing them with free wireless high speed Internet access will be joining a doughty band of pioneers, including local governments, commercial business districts and non-profits, that are committed to using Wi-Fi both to promote local economic activity and to eliminate the high cost of high speed Web access as a matter of fundamental social equity. An MIT graduate student has installed a free Wi-Fi network for a low-income housing project in Roxbury, Massachusetts. On the Island of Hawaii, a retired high school physics teacher has engineered a network of overlapping home, small business and school Wi-Fi transponders to provide free wireless broadband Internet access over a 300 square mile rural area (Drucker, Angwin 2002). Today, there are an estimated 1200 free, public wireless Web access gateways – or "hot spots" in city parks, libraries, airports and on university campuses across the country.

For every free Wi-Fi gateway in the U.S., there are two commercial gateways in locations like Starbucks, Borders or Schlotzky's Deli, that charge fees ranging from $2.99 per 15 minutes to $30 to $50 per month. The Gartner organization, a Cambridge, Massachusetts firm that monitors the Internet, projects that the total numbers of free and commercial Wi-Fi hot-spots will grow 10-fold during the next 5 years, to nearly 40,000 locations serving roughly 80% of the markets currently served by cellphones. Fearful that they would loose business to PDA's equipped with high speed Wi-Fi Web access, cellphones began to add Wi-Fi chips to their hand sets (Delaney 2003). Simultaneously, Intel, Texas Instruments (TI) and Motorola, have each announced the introduction of computer chips incorporating mobile phone circuitry (Foremski 2003). The long anticipated integration of communications and computation is now under way.

The crucial strategic reality for all educators in those IT industry expectations is that Wi-Fi is here to stay. It is not a passing fad. Today, while WLANs are cheap and largely unregulated, schools of every type should be experimenting with this technology on and off campus, as a constructive means of re-connecting educators with their students and educational institutions with the society they serve. Over the long term, the successful new collaborative arrangements that arise from these experiments can be assimilated into the processes of education just as Wi-Fi is already being assimilated into the universal information appliance. Back here in the present, however, schools can use Wi-Fi to help their teachers and students gain access to the future right now.

In a recent survey of teenagers, the Pew Internet and American Life Project was told that most teachers do not give students homework requiring use of the Internet simply because not all students have Web access outside of school. (McCarthy 2002) By providing their communities with low cost universal wireless broadband access, schools can substantially reduce that barrier, and make the Net a much more powerful presence throughout education. In fact, with the confluence of wireless Internet access **and** the widespread faculty-student use of cheap, Web-enabled palmtop computers, the functional capacities of our IT hardware will, for the first time since the early 1980s, greatly exceed the programmed educational applications available for that hardware. It will be a time of exploration, discovery and invention in educational software …, and in education.

4. Open Source Software

The unexpected rapid "roll-out" of low-cost, wireless Internet access is widely expected to force down the broadband subscription fees charged by the Bells and the cable companies. In much the same way, the rapidly expanding use of *open-source software* could reduce Microsoft into a mere shadow of its former quasi-monopolistic self. In the Fall of 2001, Forrester Research, a Cambridge, Massachusetts IT industry research firm, found that 56% of the Global 2500 (largest world firms) were using open source software, compared to zero % in 1998 (Hrebejk, Boudreau 2001). During the past two years, most U.S. IT equipment makers – IBM, H-P, Compaq, Intel, Oracle, Dell, etc. – have announced new products compatible with, or exclusively for, open architecture operating systems. What's more, the major equipment makers have also put $billions worth of their previously proprietary software tools into the public domain to be used free by anyone, including their competitors (Acohido 2002).

Most – though not all – IT industry experts expect open source programming to dominate all commercial software markets by 2010. Since 90+% of business programming in use today is *proprietary*, or "closed source" software, these forecasts imply a BIG CHANGE for somebody. For people unfamiliar or unconcerned with the technical details of computing, the recent emergence of fierce marketplace competition between the proponents of "open source" vs. proprietary software comes across either as high-tech esoterica or a philosophical disagreement between populist computer geeks and billionaire software moguls. In fact, the schism between open and closed computer code goes back to the early years of the computer age, and the resolution of this debate will have a great deal to do with the future of computing, … and education.

The Roots of Rebellion

Programming a 1950s – 1960s mainframe computer was (metaphorically) like training a dinosaur. We were all new at it, and most programmers generally weren't in competition with each other. We were a diverse confraternity with a common set of problems, quick to share everything that we learned about how to get our dinosaur to do what we wanted; almost all software was "open".

In the early 1970s, the first mini-computers appeared in offices, and the world's computer population went from hundreds to thousands. With the introduction of desktop-computers – Apples, PCs – in 1981, the numbers of computers needing programs to carry out common tasks – word processing, scheduling, accounting, games, graphics, etc. – quickly reached the millions. Computer programming went from being a custom craft to being an industry that mass-produced sophisticated goods for large commercial and consumer markets. Particularly successful programmer outputs, components and techniques suddenly acquired substantially greater marketplace value than they had before, and thus merited the same legal protection as those of any mass production process. From the outset, the market for desktop applications software has been dominated by proprietary – copyrighted – products, led ultimately by Microsoft.

During this time, software development for bigger computer systems – now numbering in the hundreds of thousands – largely converged on Unix, a proprietary programming language originally created at Bell Labs. But in the late 1980s, MIT computing pioneer Richard Stallman mobilized a number of programmers from around the world to create a powerful Unix-like **non**-proprietary software development language, which was subsequently placed in the public domain by Linus Torvalds, a member of the open source movement, for whom the new language has been named "Linux."

Since its publication in the mid-1990s, Linux has been expanded and improved by volunteer programmers who believe that software – computer language – should be freely available to all, like human language. Linux has also become the "standard" for the *open software movement* –growing numbers of individuals and institutions worldwide who have concluded that the only way to assure rapid improvement and continued innovation in information systems is to agree upon a single common software language whose source codes are freely available to all programmers and users worldwide. If they are successful, the world's machines will have a common language long before the world's peoples.

By comparison, the vendors of proprietary software – like Microsoft and Unix – believe that a program's particular source codes are what give it distinctive marketplace value, and thus, should remain the property of the company that developed it. (Users don't "buy" software from Microsoft and other proprietary vendors; they pay for a "license" to use it for a fixed period of time.) The financial implications of choosing between proprietary or open-source software are substantial. In 1998, a Mexican government task force recommended that the nation's public schools adopt Linux primarily because Microsoft's costs, at US $885 per school lab, **plus** periodic license renewals – typically $100 to $200 per computer – were simply too high to install throughout Mexico's 140,000 public schools. The Linux setup cost is $50 per lab, with no future fees required for software that will be continuously improved by the Linux community (Kahney 1998).

Not only is proprietary software more costly to acquire and use than open source software, but correcting, refining and adding to proprietary software involves considerably more time and overhead expense than changing open source programs. A single application written in open code, for example, can be run on PCs, PDAs, laptops, system servers and mainframe computers, while the same application composed in a proprietary language must be rewritten for every brand and type of machine on which it is used. Most important of all, when open source programmers discover a problem – a security fault, dissonant feedback loop, etc. – they notify the entire open source programming community, from which a team of volunteers is selected to immediately develop and test a solution to the problem, which is subsequently shared with all open source software writers.

Problems that occur in proprietary software, on the other hand, can only be corrected by the proprietor, and only as soon as the proprietor is able to work the correction effort into its production schedule. As a consequence, while open source software is continuously up-dated and improved, upgrades of proprietary software are published periodically, at two to three year intervals. The upgrades themselves are often costly to install, routinely requiring both programmers and system users to be retrained. And, while each upgrade of an individual proprietary software product is supposed to be compatible with previous and succeeding upgrades, incompatibilities invariably arise, creating new problems that are generally not resolved until the **next** upgrade.

SoftWars!

Eager to get out from under the yoke of proprietary operating systems and exorbitant software licensing fees, computer users around the world began converting to open source programming as soon as it became available for their applications. In some cases, entire industries have agreed to convert to open software, from New York merchant banks and brokerage houses to Hollywood film studios. In January, 2002, the South Korean government ordered nearly one-fourth of their agencies computer systems to switch to Linux operating systems, with the expectation of saving 80% over the Microsoft systems they will replace (Cullen 2002). At the same time, half a world away, the German Interior Ministry cited lower costs, system inter-operability, and increased system security in announcing that the German government had contracted with IBM to convert all Federal, State and local public sector computer systems to Linux (Selby 2002). By the end of 2002, over 75 governments, including Britain and France, had announced their commitment to open software standards.

In January, 2002, thirty pro-open source educational organizations on five continents formed an on-line coalition – called "Schoolforge" – to promote the use of free software throughout K-12 education <http://www.schoolforge.net>. As has already been observed, the advent of wireless, high speed Internet access (WLANs) **plus** the wide availability of low cost, Web-enabled palmtop computers will present educators with powerful new teaching/learning tools for which very few practical classroom applications will have been developed. Using open source programming codes, teachers, librarians, counselors and students will be able to create, share and refine instructional software based on classroom needs and experiences. Not only is this collaborative, grass-roots activity likely to produce better, cheaper software in less time than that developed by proprietary vendors, but participation in the creative process itself is likely to make the school experience more exciting – and engaging – for everybody involved at every level of education.

In light of the substantial savings to be derived from the adoption of open-architecture programming, industry analysts uniformly expect Linux-based systems to have captured at least half of the U.S. commercial software market by 2010, up from 5% today. Vendors of the proprietary software that currently controls 85% of that market are already mobilizing the community of programmers and users who are proficient in proprietary software to resist any wholesale abandonment of the existing systems. The Mexican government's decision to standardize on Linux instead of Microsoft, for example, provoked a massive grassroots opposition campaign by teachers, students and the business community in support of the proprietary software that they already use. While the Mexicans ultimately relented, the IT industry trade press reports that Microsoft has offered governments in many developing nations, including Mexico and Pakistan, discounts of over 90% to keep them from adopting open source standards (Ahmad 2002).

It is important to understand that, in the minds of its proponents, the open source movement transcends financial considerations. As a spokesman for the Schoolforge Coalition told an interviewer when the organization launched its Website, "We want to put behind us the days when schools teach students how to use branded products, and vendors lock hapless school districts into a never-ending treadmill of hardware and software spending. And we don't ever want another teacher to have to learn a proprietary interface, only to have his or her experience rendered useless by the next product upgrade or vendor failure" (Schoolforge 2002).

As difficult as it may be to imagine today, the open source programming movement and the retention of proprietary software will become increasingly fractious issues in education over the next 36 months, as emotional and vituperative as the fights over phonics, vouchers and affirmative action. Because $billions in cash-flow will be at stake, the software wars – "SoftWars" – will get mean. Microsoft officials have already called the open software movement "a cancer" and "un-American" (Krim 2002). A company spokesman later apologized, but Linux' success has forced Microsoft to post a warning to investors with the U.S. Securities and Exchange Commission (SEC), January 31, 2003, in which the company said, in part:

> "To the extent the open source model gains increasing market acceptance, sales of the company's products may decline, the company may have to reduce the prices it charges for its products, and revenues and operating margins may consequently decline" (Galli 2003).

While the outcome of the SoftWars is not predictable with certainty, it is reasonable to speculate that both forms of programming are likely to survive this decade to serve respective marketplace segments. Open source software will be used for all activities or functions that are common across many organizations and/or cultures, including accounting, scheduling, cataloguing, mathematical calculations, scientific procedures, air traffic control, statistics, simulations, etc. Proprietary software, on the other hand, will continue to dominate in popular mass media markets – e.g. games, entertainment, etc. – and in high value adding, special purpose business applications – e.g. Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Product Life Cycle Management (PLM), Predictive Modeling (PM), etc.

In the foregoing scenario, educational software is likely to remain a hotly-contested battlefield for the forecastable future. During the decade ahead, circumstances will argue strongly for educational institutions to use and to teach **both** proprietary **and** open source programming. But the extremists in both camps will demand nothing less than total victory. The resolution of these issues will pose a test of leadership on every campus, and in every school of education, every school district and every school building in America.

5. GROUPWARE

As the name suggests, "groupware" is software specifically designed to enable a group of computer users to collaborate on a shared task or operation over a network. The first groupware was created by software shops in the late 1960s, to enable hundreds of individual programmers to contribute simultaneously to a single piece of software involving millions of lines of code. Forty years later these early improvisations have evolved into distributed supercomputers like NSF's new TeraGrid. But, while we have gotten better and better at using networked IT to crunch numbers, move data and share software, we have not gotten much better at using IT to communicate ideas, share expertise, debate judgments or collaborate on work. Now, *peer-to-peer file-sharing* programs are about to change how we all do our jobs, . . . especially educators.

Peer-to-peer (P2P) file-sharing programs, such as Groove, Aimster, and Gnutella not only permit the members of any self-selecting group direct access to each others' designated computer files, but also enable the members of such groups to communicate verbally in real-time, share text and graphic materials, and jointly visit other Websites. Most important of all, communications using P2P groupware do not pass through a central processor or system server; they move directly – "peer-to-peer" – among the individual computers participating in the file-sharing group. Because processors or servers are not involved in P2P networking, on-line work groups can be established on the spur of the moment, without having to submit a system change request or budget for programming costs. Moreover, P2P groups need not be limited to in-house participants. Vendors can set up on-line groups of people who buy their products, and manufacturers can establish groups among their potential suppliers. Using P2P, scholars and scientists can quickly mobilize on-line research teams from around the world, and begin conferring immediately.

From now on, any teacher or professor will be able to use P2P groupware to create an on-line group for each class or project, where schedules, assignments, tests and resources can be posted, and where the teacher and students can interact in real time. Of course, students are just as likely to set up their own P2P groups to collaborate on class projects, and in which the involvement of 3rd parties – e.g. mentors, experts, etc. – can be facilely engaged. Anecdotally , P2P has already significantly enhanced a variety of distant learning projects, like the Florida Virtual High School, in which most student-faculty dialogue had previously been restricted to asynchronous e-mails, and student-to-student interaction had been limited to chat-rooms.

Frankly, peer-to-peer networking is so cheap and easy to use that, whether or not educators employ P2P in the formal learning process, the students will! Unfettered by privacy, security or intellectual property concerns, tens of millions of young people made Napster an overnight threat to the world's music industry. Aimster, AOL's P2P program, picked up 20,000 subscribers in its first three days on line, and over 2.5 million in its first six months (Klein 2001). Unlike Napster, which only shared music files among its subscribers, Aimster, Groove, Ipswitch, and their ilk share any kind of digital file, all of which are searchable by title, author, or keyword. Over the next 36 months, growing numbers of Net-connected students of every age will use freely-downloadable P2P software – e.g. groove.net, ipswitch.com, and osafoundation.org – to develop a rich array of on-line mutual support groups and learning co-ops whose more successful features and functions will rapidly be copied by students throughout the nation and around the world.

Peer-to-Peer-to-Peer-to-etc.

P2P groupware will greatly increase the capacity of the already powerful youth peer culture to promote **or to contravene** the purposes of formal education, (and of most other formal institutions.) If educators do not take the initiative in establishing standards and protocols regarding the academic use and abuse of P2P systems, we can be reasonably certain that young people themselves will invent a wide variety of on-line collaborations, some of which will absolutely subvert the formal learning process. Students in Scandinavia, and at the University of Maryland, for example, have been caught using the instant messaging features of their Web-enabled cell-phones to send each other correct answers to questions during tests (Lewis 2000, Argetsinger 2003).

Students of all ages are also very likely to invent some P2P learning arrangements that will synergize with classroom instruction to produce dramatic improvements in student achievement. If educators are to make constructive use of this powerful new medium, they must quickly develop policies and procedures for schools to take the lead in introducing P2P and its applications to young people. The 2002 Pew survey of computer-competent teenagers cited earlier (McCarthy 2002), reflected considerable student frustration at the inability of most teachers to tap the instructional power of IT, and at the failure of schools to provide teachers with the training to master computers. And, among K-12 teachers responding to a 2002 National School Boards Foundation Survey on school technology, 55% reported their students provide technical support for school computers, while 43% said students troubleshoot hardware/software/infrastructure problems. In 39% of the school districts, respondents indicated that the students set up the equipment and wired the schools (Thomas 2002).

Teachers, professors and trainers in every field should already be working closely with their students to specifically explore the features of groupware, and to jointly develop effective patterns of on-line student collaboration and scholarship that can be incorporated into formal study plans. P2P will become an even more compelling medium as high speed Internet access becomes common, and groupware permits real-time video-conferencing in addition to the audio-conferencing it now offers. This is a once-in-a-millennium window-of-opportunity for education. By using extended wireless LANs to offer students and faculty otherwise unavailable or unaffordable high speed Internet access, the WLANs will serve as a legitimate extension of school infra-structure – "info-structure" – into cyberspace, enabling educators to retain some legitimate authority over the unruly creative potential of P2P.

In post-secondary settings, on campuses where individual classes are already being supported by interactive Web sites, there are extensive (anecdotal) reports of benefits, including greater student-teacher interaction, increased learner efficiency, improved instructional techniques through better student feedback, and higher grades. Meanwhile, out in the workplace, software firms have begun to sell specialized types of P2P programs, including Collaborative Product Development (CPD) and Customer Relations Management (CRM) as management tools. Simultaneously, as most large businesses transform themselves into distributed enterprises, trans-organizational work teams and "communities of practice" are already increasingly important modes of work, and participation in peer-to-peer on-line groups will quickly become a sought-after employee competency.

Educators from middle schools to graduate schools can use P2P groupware to assimilate the proven learning efficiencies of project work, peer teaching and team learning into their formal classroom-based curriculum. For the millions of older employees who are expected to need re-skilling on and off the job during the next ten to fifteen years, groupware promises to make distant learning a less solitary, and therefore, a more effective, sustainable activity. For internships and apprentice programs, and for the 600-plus post–secondary institutions in North America offering a co-operative work/study curriculum, P2P offers a means to better integrate workplace experience with classroom teaching. Finally, P2P offers teachers and students an unprecedented – and intriguing – opportunity to remain in contact with each other later on in life.

By offering an on-line venue for ongoing collegial contact between faculty and alumni, both secondary and post-secondary institutions will be able to provide graduates with a greater sense of continuity and security in a world made less secure by ongoing techno-economic change. (Suicide rates are elevated among recent high school and college graduates.) In return, this relationship can provide educators with an unprecedented avenue for instructive feedback from graduates, plus revenue derived from refresher courses, on-line continuing education, career planning services, etc. P2P groupware on the Internet can provide educators a "window" on real life-long learning, and a means by which they may, if they choose, participate in it. This singular new capacity of teachers and students to maintain casual long-term contact with one another after graduation poses, by itself, a multitude of potentialities for transforming education through long-term personal relationships in a disconnected society.

On the Threshold of . . .?

While there is nothing to prevent a cruel combination of plausible near-term developments – e.g. clumsy U.S. leadership, a wave of pandemics, a terrorist counter-offensive, etc. – from dragging the U.S. and world economics back into recession, the macro-economists at the Federal Reserve and the merchant bankers in New York and London are seriously bullish on the long-term prospects for the world economy in general, and the U.S. economy in particular. There is every indication that the U.S. has actually entered the historically "hyper-productive" phase of our assimilation of information technology, and that the economy is likely to sustain the increased productivity improvement rates of the past six or seven years for another two decades or more, **provided the nation's educational institutions can deliver sufficient numbers of appropriately-skilled human resources**.

Since the mid-1990s, when the high tech boom first became evident in U.S. employment and personal income statistics, public opinion polls have reflected serious growing concern that American education – from top to bottom – is not up to the challenges posed by the high tech revolution. Education has been the number one domestic voter concern in U.S. national opinion polls since 1995, ahead of healthcare costs, taxes, Social Security and campaign finance reform by at least a three to one margin until 2003, when rising medical costs returned to the top spot for the first time in a decade. Alan Greenspan clearly gave voice to a national consensus when he testified before Congress in June 1999, "I am hard-pressed to see how we can maintain what is increasingly an intellectually-based output system without a better education system" (Schlesinger 1999).

Thirty months after that testimony, Congress passed the "No Child Left Behind" Act, which essentially *orders* America's public schools to "get better, or else!" Unfortunately, the costly annual tests by which the Congress intends its mandate to be enforced will further deplete the resources of public schools, most of whose revenue bases have been sapped by ill-considered tax cuts enacted by most state legislatures during the late 1990s surge in prosperity. The leadership of American public education, whiplashed by more than a decade of inept local political leadership and failed fad reforms, no longer has a consensus vision for the future. In response to Washington's raising the performance bar, most public school leaders can only seek to drive their existing personnel to work harder to produce the mandated improvements in student achievement, often with fewer resources.

Meanwhile, as America's public schools and their students gear up to deal with the realities of benchmarked accountability, some U.S. States have begun phasing in uniform assessments of student achievement in public university systems (New York, South Dakota, Utah and Virginia). And, while future political developments cannot be reliably forecast, the faculty and students of the nations public colleges and universities should be aware that the

Bush Administration and members of Congress from both parties have proposed that renewal of the Higher Education Act be modeled on the Federal reforms for K-12 schools, requiring institutions to use standardized tests to demonstrate student achievement as a condition for receiving Federal funds (Zernike 2002).

Long-term vision for a short-term world

When the world is filled with short-term imperatives, it is easy to regard long range thinking as a luxury, if not a foolish waste of time. Yet only the reliably forecastable realities of the long-term future can provide leadership with coherent guidance and sound long-term assumptions in the face of the short-term turbulence of the present and the uncertainty of the near-term future. For example, getting more money out of alumni or the political process just at this moment is far more problematical than the resources that can be freed up by:

- moving all commercial transactions to the Internet;
- shifting from expensive proprietary software to free, open source software for all routine administrative and business operations
- installing WLANs to provide faculty, administrators and students with high speed wireless Internet access in lieu of any further hard-wiring of classrooms, dormitories, etc.
- outsourcing in-house computing operations to an outside utility.

Just adopting the first two measures would save U.S. educational institutions $billions a year. But, as we observed in our PART I discussion of demographics, even if the money were available, there are unlikely to be sufficient numbers of new warm bodies to replace the 1.76 million teachers who will retire during the first decade of the 21st Century, plus the 1.57 million additional faculty positions that will be required for our labor-intensive educational institutions to meet the growth demand implicit in the Baby Boom Echo and the technologic transformation of our workplace.

To educate the projected increase in K-16 students and work-place/life-long learners in the face of a significant shortfall in the teacher supply will make it necessary to substantially improve the total factor productivity of the resources that we devote to education. Educators now have at their disposal powerful new technologies with which to accomplish this essential task. To use those physical technologies productively, we will need to re-invent the basic social technologies of our education system: schools filled with classroom based instruction. The fiscal crisis currently confronting American education appears to pose so severe a degree of necessity that, to paraphrase Plato, it will be the mother of education's re-invention.

The Snyder Family Enterprise • 8628 Garfield Street, Bethesda, MD 20817 • phone 301-530-5807
e-mail (Snyder) david@the-futurist.com

REFERENCES

Acohido, Byron, "Microsoft hasn't been able to stifle Linux's growth" *USA Today*, March 20, 2002, p.2B.

Argetsinger, Amy, "U-Md. Says Students Use Cell Phones to Cheat," *The Washington Post,* January 28, 2003, p A-8.

Adams, Christopher, "Low-inflation growth from Internet predicted," *Financial Times*, February 7, 2002.

Ahmad, Naveed, "Pak Govt may choose Linux as platform instead of Windows," *Pakistani News*, September 6, 2002.

Bodipa-Memba, Alejandro, Wessel, David, "Productivity Rose at 4% Rate is 1st Period," *The Wall Street Journal*, July 1, 2002, p. B-1

Broad, William J., "1.6 Million Cyberlings Go a-Hunting for Aliens," *The New York Times*, February 8, 2000.

Bulkeley, William M., "New IBM Service Will Test Vision of Computing Power as Utility," *The Wall Street Journal,* July 1, 2002, p B1.

Cullen, Drew, "Korea migrates 120K civil servants to Linux desktop," *The Register* <http://www.theregister.co.uk/content>, January 14, 2002.

David, Paul A., "Computer and Dynamo: The Modern Productivity Paradox in a Not-Too-Distant Mirror," The Center for Economic Policy Research, Stanford University, Stanford, California, 1989, pp. 29-32.

Delaney, Kevin, "Dial Wi-Fi, Cellular on New Phones," *The Wall Street Journal,* February 19, 2003, p. D-4.

Drucker, Jesse, Angwin, Julia, "New Way to Surf the Web Is Giving Cell Carriers Static" *The Wall Street Journal*, November 29, 2002, p. A-1.

Foremski, Tom, "New toys for mobile phone makers," *Financial Times,* February 13, 2003.

Galli, Peter, "Microsoft Warns SEC of Open-Source Threat, *e-Week*, February 3, 2003.

Hafner, Katie, "Billions Served Daily, and Counting," *The New York Times*, December 6, 2001, p. F-1.

Hrebejk, Petr, Boudreau, Tim, "The coming "open monopoly' in software," *CNET.News.com* <http://news.cnet.com/news>, October 24, 2001.

Johnson, George, "Super computing '@Home' Is Paying Off," *The New York Times*, April 23, 2002, p. 51.

Jones, Del, "Some schools to surf Net to cut costs of supplies," *USA Today*, March 20, 2000.

Kahney, Leander, "Mexican Schools Embrace Linux," *Wired*, November 6, 1998.

Klein, Alec, "Going Napster One Better," *The Washington Post*, February 25, 2001, p. A1, A14-15.

Krim, Jonathan, "Open-Source Fight Flares At Pentagon," *The Washington Post*, May 23, 2002, p.E-1.

Lerner, Dan, "Internet spreads its web to interactive e-government," *Financial Times*, May 26, 2000.

Lewis, Peter H., "Wireless Valhalla: Hints of the Cellular Future," *The New York Times,* July 13, 2000, p. 1.

Markoff, John, "2 Tinkerers Say They've Found A Cheap Way To Broadband," *The New York Times*, June 10, 2002.

Markoff, John, "Supercomputer To Utilize Optical Fibers," *The New York Times,* November 18, 2002.

McCarthy, Ellen, "Wanted: Web-Savvy Schooling," *The Washington Post*, August 15, 2002, p. E-7.

Schlesinger, Jacob M., "Greenspan Warns on Productivity Gains," *The Wall Street Journal*, June 15, 1999, p. A2.

Selby, Nick, "IT Managers cite security and competition when choosing a Linux system,' *The International Herald Tribune,* September 9, 2002

Talacko, Paul, "A connection without wires," *Financial Times*, January 22, 2002.

Thomas, Karen, "Arizona pupils escape the tech desert," *USA Today*, November 20, 2001, p. 30.

Thomas, Karen, "At U.S. schools, students are technology teachers," *USA Today,* June 5, 2002, p. 13D.

Uchitelle, Louis, "Productivity Finally Shows the Impact of Computers," *The New York Times*, March 12, 2000.

Waldrop, M. Mitchell, "Grid Computing Could Put the Planet's Information-Processing Power On Tap," *Technology Review*, May, 2002, pp. 31-37.

Zernike, Kate, "Tests Are Not Just for Kids," *The New York Times, Education Life*, August 4, 2002, p. 26.

__________________, "Schoolforge Coalition Formed to Advance Open Resources in Education," *linuxtodfay.com* <http://linuxtoday.com/news>, January 8, 2002.

__________________, "Technology and increased productivity," *USA Today*, January 31, 2000, p. 3B